BID DOCUMENTS: October 13, 2026

PROJECT MANUAL

VOLUME 2 OF 2: Divisions 19 - 28

Newburgh Enlarged City School District

Newburgh Free Academy North Campus Auditorium Renovation

SED No. **44-16-00-01-0-002-016**

CSArch Project # 108-2504



REGISTRATION EXPIRATION DATE 12/31/2026

The design of this project conforms to applicable provisions of the New York State Uniform Fire Prevention and Building Code the New York State Energy Conservation Construction Code and the Manual of Planning Standards of the New York State Education Department

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SECTION 191000 - PERFORMANCE SOUND & AV SYSTEMS

PART 1 - GENERAL

1.1 PROJECT INFORMATION:

A. Owner: Newburgh Free Academy North Campus
301 Robinson Ave
Newburgh, NY 12550

B. Architect: CSArch
19 Front Street
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 theatrical contractor, 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 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 they 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 provide all required small items required install specified equipment. Provide small Items such as rack rails, din rails, power cords, connectors, wall wart power supplies, crimps, nicopress, and other items that may not be called out on drawings or in specs as 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" Equivalents 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 Owners and construction manager’s approval. Provide all work and equipment required for a professional, workmanlike installation.

1.5 SECTION INCLUDES BUT IS NOT LIMITED TO:

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

B. Provision of audio and AV system and related work scope as indicated on drawings.

C. Furnishing some equipment for install by others

D. Wiring, Set up, 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 16 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 SECTION INCLUDES BUT IS NOT LIMITED TO: RELATED WORK NOT INCLUDED:

A. The contractor is responsible for all work on the TS series drawings and written specifications. Specific coordinated work is to be provided by the electrical contractor

1. Electrical Removals Work See Drawings
2. Electrical: See Drawings

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-drawing/drawing-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.

E. Painting: The speakers are to be painted to match the ceiling. The contractor will be responsible for obtaining paint from the painting contractor to match the color after the room has been finished. The contractor shall be responsible for all prep work required for painting of the enclosures. The contractor shall warranty the painting of the speakers for 5 years. All mounting hardware shall be painted to match.

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.

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 owners 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.

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 for 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. ASTME - American Society for Testing Materials
7. FCC - Federal Communications Commission
8. IEC - International Electronics Commission

9. NEC - The National Electric Code
10. NEMA - National Electrical Manufacturers Association
11. NFPA - National Fire Protection Association
12. OSHA - Occupational Safety and Health Association
13. SAE - Society of Automotive Engineers
14. TIA – Telecommunications Industry Association
15. SMPTE - Society of Motion Picture and Television Engineers
16. 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.)
17. 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. All equipment will be furnished with the proper labels for New York State.

C. Provide only equipment that is standard new equipment, the latest model of regular stock product, and is furnished 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.

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 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. Submit seven (7) copies of submission package, unless quantity of submission packages differs in front end contract documents. Contractor shall submit quantity of submission packages for each discipline as directed in front end documentation (or as indicated here if no quantities are indicated in front end contract documentation).

C. Submit seven (7) copies of material schedules and shop drawings for approval by the architect, consultant and owner prior to any fabrication or installation as follows:

1. Manufacturers cut sheets for all equipment
2. Drawings of proposed mounting methods for all equipment.
3. Samples or cut sheets for proposed marking systems for wire and equipment labeling.
4. Rack layouts, panel layouts and proposed labeling.
5. Schedule for submission of drawings for fabrication and site work.

6. The full set of submitted drawings and data sheets must be presented in a professional manner.
7. 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.
8. 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. No data sheets shall be acceptable that are illegible, poorly photocopied or hand marked up with scribbles, etc.

D. Intents:

1. 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 shop drawings that shows flow diagrams, rack layouts, wiring label samples & intents, plan, section and elevation views and details of the entire audio and A/V systems. There should be plan view drawings detailing speaker locations & dimensions, projection screen and other device locations. There should be detail drawings that show all typical attachment details, etc. as well as all custom fabricated devices, suspension intentions, etc. The intent of the 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 audio and A/V systems equipment. 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 SYSTEM GENERAL DESCRIPTION

A. Auditorium Audio & AV System

1. Automated and Manal Controls
2. Loudspeakers and processing
3. ADA Hearing Assistance System
4. Wireless microphones
5. Wired Microphones
6. Video Projectors
7. AV Switching Matrix
8. AV Control System
9. Motorized Projection Screen
10. Racks
11. Wiring
12. Tuning, Commissioning training and closeout.

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 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, 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. Equivalent Criteria:

1. Loudspeakers Equivalents require proof that the substituted product meets all performance requirements including but not limited to:
    a. Frequency Response – On and off axis
    b. Directivity by frequency
    c. Distortion
    d. Phase response
    e. Number of Drivers
    f. Power Handling Capacity and Maximum Output
    g. Weight
    h. Physical size
    i. Rigging options
    j. Powering method

2. Amplifiers require proof Equivalents require proof that the substituted product meets all performance requirements including but not limited to:
    a. Power at all impedances.
    b. Damping Factor
    c. Slew rate
    d. Terminal types
    e. Indicator and control capabilities
    f. Ability to install with security covers
    g. Sonic Character
    h. Input Power requirements
    i. Cooling Method – Fan speed and air flow direction.
    j. Weight
    k. Physical size
    l. Heat Output

3. Digital Signal Processors Equivalents require proof that the substituted product meets all performance requirements including but not limited to:
    a. A/D Converters type and sampling rate
    b. Number of Processors, Mixers, automixer, feedback Suppressors, equalizers, and dynamics devices.
    c. FIR Capability where required by design.
    d. Expandability where applicable
    e. Configuration Capability – Ability to configure as per the specified model.
    f. Interface to other devices digitally where applicable.
    g. Physical Size
    h. Terminals
    i. Input delay
    j. Control software and ability to be controlled via wireless.
4. Mixing Console Equivalents require proof that the substituted product meets all performance requirements including but not limited to:
    a. A/D Converters type and sampling rate
    b. Number of inputs/outputs and types
    c. Number of EFX processors, equalizers, and dynamics devices.
    d. Ability to create custom pages and configuration via preset scene change.
    e. Input Delay
    f. Fade Rate by scene
    g. Expandability where applicable
    h. Configuration Capability – Ability to configure as per the specified model.
    i. Interface to other devices digitally where applicable.
    j. Physical Size
    k. Connect ability
    l. Control software and ability to be controlled via external computer and wireless.
5. Microphone Equivalents require proof that the substituted product meets all performance requirements including but not limited to:
    a. Frequency response
    b. Pattern Consistency
    c. Capsule Type
    d. On/Off switch (or the lack of one).
    e. Physical Size.
    f. Color options
    g. Connector size, type and connections
6. Wire Equivalents 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. Capacitance and resistance conductor-to-conductor as well as single conductor.

D. No contractor-manufactured products will be acceptable in place of referenced items except for those items enumerated in this specification as "custom".

E. The current manufacturer's data sheet for each referenced piece of equipment in force at the date of printing of this specification will be the basis for the specifications of the referenced equipment.

F. Specification details are provided only for the features required for current and intended future uses of the products.

2.2 ELECTRONICS:

A. All AC or DC powered hardwired electronic equipment is to meet the following minimum specifications unless otherwise noted:

1. All inputs and outputs will be floating active balanced or transformer balanced. All transformer balancing is to be integral not via outboard transformers. Quasi balanced, ground referenced, or other configurations are not acceptable under this specification.
2. All electronics must carry UL and or CSA approval.
3. All electronics are to employ RFI filtration on inputs and outputs.
4. Input Impedance Range: 10K - 50 K Ohms Balanced
5. Microphone Inputs: ≤150 Ohms Balanced
6. Input Levels: Line inputs +18dB with No Overload
7. Output Levels: Line Outputs + 18dB with No Overload. Output Impedance Range: 50 - 600 Ohms Balanced
8. THD + Noise: < .05 % typical. Hum & Noise > 105dB A
9. EIN: -90 dB (-128 dB Microphone inputs) typical
10. S/N Ratio: 90 dB typical
11. Phantom Power Systems: +48V typical
12. Modular Construction: All equipment is to be provided as serviceable modular style circuitry: i.e. replaceable parts, modules, etc. Devices which utilize a single circuit board for all parts without provision for socketed chips, removable sub assemblies etc. are not allowable under this specification.
13. Multi function units may not be substituted for individual equipment types. i.e. a cassette/CD unit may not be substituted for a separate cassette and CD player. Mixer amplifiers may not be substituted for mixers with separate amplifiers. multi

unit (common power supply) wireless systems may not be substituted for single unit wireless systems.

2.3 DIGITAL CONSOLES

A. 33 FADER DIGITAL CONSOLE: REFERENCED PRODUCT ALLEN & HEATH SQ7+

1. The mixer shall be a standalone digital mixer built around a 96kHz XCVI FPGA core with 48 input sources mixing to 44 busses, with a system latency of <0.7ms.
2. All input and mix processing, routing options and system configuration shall be accessed and adjusted via a 9-inch capacitive touchscreen with associated screen menu keys along with a dedicated rotary control for 'touch and turn' operation.
3. The surface shall include moving faders with 6 layers, each having dedicated keys, giving easy access to input channels, mixes, FX sends, FX returns, DCA masters and MIDI control.
4. Each fader strip shall have dedicated Select, Mute and PAFL buttons with indicators, a variable LED meter, a peak indicator LED and a coloured backlit LCD display.
5. There shall be dedicated physical controls which allow for adjustment of key processing parameters, and which follow the select button for the input and mix channels.
6. Send levels to mixes shall be displayed and adjusted using the faders in conjunction with dedicated Mix keys.
7. A 'CH to All Mix' key will be provided to allow viewing and
8. adjustment of all send levels from the selected channel.
9. Quick access to assignment and switching of Pre/Post send points will be provided using dedicated keys.
10. The fader and rotary controls shall include a white skirt in contrast to the colour of the surface for visibility during operation in low light conditions.
11. 16 user-assignable SoftKeys with multi-colour LED illumination shall be provided for quick access to switched functions such as Input/Mix/DCA/Group Mutes, Tap Tempo, Scene Controls, MMC and SQ-Drive Controls.
12. 8 user-assignable Soft Rotary controls with associated backlit LCD displays and keys shall also be provided for adjustment of variable parameters, including processing values and routing levels.
13. There shall be dedicated Copy/Paste/Reset keys for parameter data.
14. A footswitch connection shall be provided to allow assignable control from an optional single or dual footswitch.
15. A view key shall allow the temporary display of channel number and patching on the channel strip LCD displays.
16. Local analogue inputs shall use balanced XLR sockets and connect to fully recallable, digitally controlled preamplifiers. These shall be able to provide up to +60dB of gain, with a switchable -20dB Pad for use with line level signals. Industry standard 48V phantom power shall be switchable per socket.

17. The number of local preamps will match the number of faders, to allow a simple, standalone, analogue-like 1-to-1 setup.
18. An extra, fully patchable, XLR socket with preamp specification matching that of the other XLR inputs shall be provided for default Talkback use.
19. Two stereo input connections will be provided, each using 2 balanced TRS ¼ inch Jack sockets that can be freely patched.
20. Local analogue outputs shall be provided on XLR sockets and 2 balanced TRS ¼ inch Jack sockets. These will have a nominal line output of +4dBu.
21. A stereo digital, professional AES3 output shall be provided via an industry standard 110ohm XLR connection with options for sample rate conversion.
22. A high-power headphone output shall be provided for monitoring using a TRS ¼ inch Jack socket, with associated level control and dual 12 segment LED meter.
23. There shall be a USB Type-A connector to allow use of standard USB storage for firmware updating, data-transfer and uncompressed stereo or multichannel audio recording/playback.
24. There shall be a USB-B connection following the USB 2.0 standard for class compliant multi-channel, bi-directional audio streaming and MIDI control between the mixer and a host device such as a computer.
25. There shall be an intelligent “SLink” Ethernet audio expansion port with locking EtherCON connector, supporting multiple A&H digital protocols and providing access to 128x128 digital channels, connected over a single cable and allowing remote preamp control of Allen & Heath Everything I/O expanders, connection to Allen & Heath ME Personal Mixing Systems and direct connection to other A&H mixers wherever supported.
26. An I/O Port shall be provided to allow the fitting of option cards for interoperability between the mixer and third party protocols including Dante, Waves and MADI.
27. All Input channels shall contain the following processing: Polarity, Trim, High Pass Filter, Gate or Expander, Insert point, Parametric EQ, Compressor, Delay, Pan/Balance.
28. All Input channels will have the ability to send a direct output signal, with global source point and follow options along with independent level trim.
29. All FX Return channels shall contain the following: Parametric EQ, Pan/Balance.
30. All Mix channels shall contain the following processing: Insert point, Graphic EQ, Parametric EQ, Compressor, Delay, Balance.
31. 8 user-assignable effect racks shall be provided with a library of factory preset FX emulations. The FX racks shall be individually configurable as send/return with a dedicated stereo return channel and sourced from a dedicated FX send bus, a Mix bus or directly from an Input channel, or a unit may be inserted directly into any input or mix channel.
32. A further 4 effect racks shall be provided with the same capabilities and function as the other 8, along with the power to run RackUltra FX algorithms.

33. The mixer will allow the insertion of Allen & Heath DEEP processing models to channels, without affecting latency or overall processing abilities.
34. Two 24 channel Automatic Mic Mixers shall be provided for automatic and dynamic assignment of gain in spoken word applications. These may be combined into a single 48 channel Automatic Mic Mixer if desired.
35. There shall be 8 DCA groups and 8 Mute groups.
36. A Talkback facility shall be provided with the ability to send to any mix with on screen status indication. An option to enable talkback latching and HPF shall be provided.
37. A signal generator shall be provided with the ability to send a variable level signal to any mix with visual assignment status on-screen. The following types of signals shall be available: Sine, White Noise, Pink Noise, and Band-Pass.
38. Comprehensive input, mix, and FX channel and RTA metering shall be provided on-screen.
39. A PAFL sub-mix shall be provided, for the purposes of monitoring one or more signals and at different points in the signal path.
40. All signal delays in the system shall be adjustable in Samples, Milliseconds, Meters or Feet. Metric or imperial temperature adjustment will be included to account for changes in the speed of sound through air when using units of Meters or Feet.
41. MIDI Transport Control shall be available via the touchscreen and as SoftKey options.
42. MIDI messaging to and from common core parameters including send levels and muting will use MIDI NRPN messaging. Scene recall will send and respect standard MIDI Program Change and Show Control messaging.
43. The mixer shall provide a Fast Ethernet (100 Mbit/s) port for Cat5 cable connection to a wireless router, access point, existing network or direct connection to a computer for live
44. mixing control using control apps supported on multiple popular platforms, and for MIDI over TCP/IP messaging.
45. Input and mix channel processing and parameters in the mixer shall be saved on demand as a user library item for recall in other channels. Library items shall be transferrable to USB drive as portable data to be used in other units.
46. The mixer shall provide the facility to save 300 scenes of the settings of the mixing system and these scenes shall be nameable.
47. All mixer config settings, Scenes, Library items and the current state of the mixer shall be archived with a Show file.
48. The mixer shall allow the recall of data stored on earlier versions of the SQ hardware/firmware.
49. Channel ‘safes’ shall be provided to prevent selected items from being changed by a scene recall from their state when the safe was enabled. A suitable selection of global and per-scene filters shall be provided to Allow / Block each parameter saved in a scene from being changed as that scene is recalled.

50. An option shall be provided for password protection for log- in of several users with different levels of system access and permissions. A particular scene may be chosen to be recalled per change of user-login if desired.
51. The mixing system shall periodically record all current settings and return the mixer to that state after reboot following a power-cycle.
52. The mixer shall have a built-in power supply accepting AC mains voltages of 100~240V, 50/60 Hz via an earthed 3-pin IEC male connector mounted on the rear chassis. A two pole push-button power switch shall be provided near the mains input.
53. Recommended operating temperature for the mixer shall be between 5 to 40 degrees Celsius (41 to 104 degrees Fahrenheit).

2.4 DIGITAL STAGEBOXES

A. 16X8 CHANNEL DIGITAL STAGE BOX: REFERENCED PRODUCT ALLEN & HEATH DT168

1. The unit shall be a portable remote audio device for dLive, Avantis, SQ and AHM-64 mixing systems. The remote audio unit shall provide 16 XLR inputs with individually configured Phantom Power and 8 XLR outputs. Phantom power LED indicators shall be provided per input socket on the remote audio rack.
2. Two Ethercon DX link connectors shall be provided for transport of the digital audio and control signals. The unit shall be able to operate in 'redundant' or 'cascade' mode by means of a mechanical switch. In 'redundant' mode the unit shall provide full redundant connection to a dLive S Class Surface or Mixrack. In 'cascade' mode the unit shall allow series connection of two units with a single cable connection to the dLive, Avantis, SQ or AHM-64 mixing system.
3. The Ethernet protocol shall provide control to the remote preamp, and all mic preamps are scene recallable by the digital mixing system. Unit firmware shall automatically be updated when connected to the digital mixing system.
4. The remote audio rack shall have a robust steel chassis and shall be designed to be portable and to be placed horizontally or vertically on the stage or performance environment.
5. A carrying handle shall be provided to facilitate lifting and holding the device when moving and an optional padded dust cover shall be available.
6. The remote audio rack shall also be mounted in a 19" equipment rack or case using an optional remote audio rack kit. The remote audio rack shall have a built-in power supply accepting AC mains voltages of 100~240V, 50/60 Hz, 35W max via an earthed 3-pin IEC male connector mounted on the rear chassis.
7. Recommended operating temperature for the remote audio rack shall be 0 to 35 degrees Celsius.

2.5 DSP PROCESSORS

A. DIGITAL MATRIX PROCESSOR: REFERENCED PRODUCT ALLEN & HEATH AHM-32

1. The unit shall be a 1u rack-mountable digital matrix processor, capable of 32 input channels and 32 output channels, all independently assigned.
2. The unit shall operate at 96kHz sample rate and employ FPGA technology for digital signal processing. The system latency from analogue input to output shall not exceed 1ms.
3. All input channels shall be configurable mono/stereo and have access to any local or remote input. Output channels shall be configurable as mono/stereo zones or as speaker processing outputs with 2, 3 or 4-way Crossovers, allowing up to 32 mono zones / 16 stereo zones, or any combination of zones and speaker processing outputs not exceeding 32 total channels.
4. All input channels shall provide the following processing: Trim, Polarity, Gate, Insert point, 8- band Parametric EQ, Compressor, Delay and Automatic Mic Mixing (AMM).
5. All zones shall provide the following processing:
   a. Source Selector, Insert point, 8-band Parametric EQ, 28-band GEQ, Compressor, Delay, Ambient Noise Compensation (ANC) and Limiter.
6. All speaker processing outputs shall provide the following processing: Crossover filters with selectable filter type and slope, PEQ/GEQ, Delay and Limiter.
7. All output channels shall be routable to any local or remote output.
8. The 8-band Parametric EQ shall provide Bell, Constant Q, Shelving, LPF, HPF and Notch filter types selectable per band.
9. The unit shall have 12 balanced inputs on pluggable Phoenix terminal blocks. Each input shall have independent gain control with +60dB of gain, a -20dB active PAD and +48V phantom power.
10. The unit shall have 12 balanced outputs on pluggable Phoenix terminal blocks with a nominal level of +4dBu.
11. The routing matrix mixer shall be capable of mixing all inputs to all zones, as well as all zones to other zones.
12. The unit shall provide Automatic Mic Mixing (AMM) of up to 32 microphone sources into 1, 2 or 4 zones. The AMM shall be capable of running in classic gain sharing mode or optionally as a NOM (Number of Open Microphones) algorithm. The unit shall offer a slot for optional processing modules including Acoustic Echo Cancellation.
13. An RJ45 Control Network port shall be provided on the rear of the unit for connection to System Manager software, IP remote controllers, Custom Control app and TCP control.
14. One 128x128 I/O port for optional digital interface
15. modules shall be provided. A Dante optional module shall provide a minimum of 32x32 I/O at 96kHz, and be compliant with AES67 and Dante Domain Manager. An

SLink optional module shall be available for Ethernet audio expansion, supporting multiple Audio-over-Ethernet protocols and providing access to up to 128x128 I/O.

16. The unit shall provide the facility to save 500 presets. The presets shall be nameable and a descriptive text entry per preset provided. A crossfade of up to 20 seconds shall be available to apply to any combination of Inputs, Zones, Groups, Input/Zone Crosspoints and Zone/Zone Crosspoints.
17. The unit shall provide the facility to save 50 events. The events shall be nameable and should allow for the scheduled recall of presets at a specified time on specific days, or every day, with the option for the event to be triggered repeatedly or just once.
18. The unit shall allow the creation and storage of up to 16 user profiles, each with an editable name and password.
19. The unit shall allow the connection of two general purpose inputs, and two general purpose relay outputs, via pluggable Phoenix connectors on the rear of the chassis. Each input connector shall allow analogue control of Mutes, Levels, Preset Recall, Custom MIDI via a 0-10V control signal. Output 1 shall support normally closed and normally open operation, and output 2 shall support normally open operation. The outputs shall be configurable to respond to Mutes, Preset Recalls, and Level Sensing. An optional 8x8 networkable GPIO interface shall be available for expansion of the GPIO functionality.
20. Networkable, PoE-enabled remote controllers shall be available to complement the unit, including wallplate controllers in both US and EU formats, and desktop controllers with a minimum of 8 motorised faders and 8 LCD displays.
21. The unit shall have an integrated power supply accepting AC mains voltages of 100-240V, 50/60Hz, 70W max via an earthed 3-pin IEC male connector mounted on the rear chassis.

B. EXTERNAL CONTACT CLOSURE INTERFACE: REFERENCED PRODUCT ALLEN & HEATH AH-GPIO

1. The unit shall be a portable General Purpose Input Output network device used for 3rd party integration to a dLive, Avantis or AHM system.
2. The unit shall have 8 switched to ground inputs with optoisolation between inputs. There shall be 7 Normally Open relay outputs and 1 switchable Normally Open or Normally Closed relay output available on industry standard Phoenix connectors. The relays shall have a maximum 10 Watt contact rating and a 0.4 Amp switching current. In addition, the device shall also provide two +10V outputs with a maximum total current of 500mA. IO parameters shall be software assignable via AHM System Manager or dLive Director Software (PC or Mac), or via an Avantis mixer or dLive Surface.
3. The device shall be connected to a dLive Surface or MixRack, Avantis mixer, or AHM-64 matrix processor via standard cat5 cabling via an RJ45 connector located

on the rear panel. A reset button should be available to reinstate factory default network settings if so required.

4. The unit shall be freestanding, desk-mounted or rack-mounted and optional mounting accessories shall be available. When rack-mounted the unit shall utilise 1U in height and ½ width of a standard 19" rack. The optional mounting unit shall be of a robust construction and allow for two units to be installed in a single rack unit. It should also allow for the blanking of one half if only one unit is installed. There shall be a maximum of 8 units supported in any system.
5. The unit shall have a built-in power supply accepting 12V DC via the supplied power supply. The unit shall also be PoE (IEEE 802.3af-2003) compliant and can be powered via the network port from an external switch or PoE injector. Recommended operating temperature for the unit shall be 5 to 35 degrees Celsius.

C. MOTORIZED REMOTE FADER STATION: ALLEN & HEATH IP-8

1. The remote controller shall be compact and portable with 8 motorised faders, 8 LCD displays, 23 backlit softkeys and a dimmable pre-set control for all displays.
2. The faders shall be fully assignable, configured individually or part of a vertical strip. There shall be 6 layers of control, accessed via softkeys, allowing control of 48 individual channels.
3. There shall be a fast Ethernet connection via a locking Neutrik EtherCon connector and a 12V DC inlet connector on the rear of the unit.
4. Connection of the controller shall be direct to the dLive Mixrack/Surface, Avantis mixer or AHM-64 Matrix Processor via standard Cat5 data infrastructure.
5. Alternatively, it shall be capable of multiple parallel connections using an Ethernet switch.
6. Configuration and programming of the controller shall be via AHM System Manager or dLive Director Software (PC or Mac), or via an Avantis mixer or dLive Surface.
7. The controller shall be powered using a supplied 12V 2.1A power supply or by the Cat5 control cable via a PoE+ enabled device. The controller shall be compatible with PoE+ standard 802.3at (30W at source). The maximum power consumption of the controller shall be 25W.
8. The remote controller shall be used free standing or there shall be provision made to fix the unit permanently into furniture via six captive screws located on the underside of the unit.
9. Recommended operating temperature for the controller shall be 0 to 35 degrees Celsius.
10. The controller shall weigh no more than 2.5kg

2.6 HIGH RESOLUTION LED-BACKLIT HANDHELD DISPLAY: REFERENCED PRODUCT APPLE IPAD

A. Provide the latest generation iPad device (color TBD by owner). Provide the storage capacity and configuration for the iPad as indicated on the contract drawings.

B. Physical:

1. Size: 9.56″ H x 7.47″ W x 0.5″ D (242.8 mm x 189.7 mm x 13.4 mm)
2. Weight: 1.5 pounds (0.68 kg) Wi-Fi model; 1.6 pounds (0.73 kg) Wi-Fi + 3G model

C. Display:

1. 9.7-inch (diagonal) LED-backlit glossy widescreen Multi-Touch display with IPS technology
2. 1024-by-768-pixel resolution at 132 pixels per inch (ppi)
3. Fingerprint-resistant oleophobic coating
4. Support for display of multiple languages and characters simultaneously

D. Wireless and cellular:

1. Wi-Fi model:
   a. Wi-Fi (802.11a/b/g/n)
   b. Bluetooth 2.1 + EDR technology
2. Wi-Fi + 3G model
   a. UMTS/HSDPA (850, 1900, 2100 MHz)
   b. GSM/EDGE (850, 900, 1800, 1900 MHz)
   c. Data only
   d. Wi-Fi (802.11a/b/g/n)
   e. Bluetooth 2.1 + EDR technology
3. Location:
   a. Wi-Fi
   b. Digital compass
   c. Assisted GPS (Wi-Fi + 3G model)
   d. Cellular (Wi-Fi + 3G model)
4. Environmental:
   a. Arsenic-free display glass
   b. BFR-free
   c. Mercury-free LCD display
   d. PVC-free Recyclable aluminum and glass Enclosure
5. Capacity: 16GB, 32GB or 64GB flash drive
6. Processor: 1GHz Apple A4 custom-designed, high performance, low-power system-on-a-chip
7. Sensors:
   a. Accelerometer
   b. Ambient light sensor

8. Audio playback:
    a. Frequency response: 20Hz to 20,000Hz
    b. Audio formats supported: HE-AAC (V1), AAC (16 to 320 Kbps), Protected AAC (from iTunes Store), MP3 (16 to 320 Kbps), MP3 VBR, Audible (formats 2, 3, and 4), Apple Lossless, AIFF and WAV.
    c. User-configurable maximum volume limit.
9. TV and Video:
    a. Support for 1024 by 768 pixels with Dock Connector to VGA Adapter; 576p and 480p with Apple Component AV Cable; 576i and 480i with Apple Composite AV Cable.
    b. H.264 video up to 720p, 30 frames per second, Main Profile level 3.1 with AAC-LC audio up to 160 Kbps per channel, 48kHz, stereo 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, 48kHz, stereo 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.
10. 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).
11. 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.

12. Accessibility:
    a. Support for playback of closed-captioned content
    b. Voice Over screen reader
    c. Full-screen zoom magnification
    d. White on black display
    e. Mono audio
13. Battery and power:
    a. Built-in 25-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
14. 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)
15. External buttons and controls: On/off, Sleep/wake, Mute, Volume and Up/down
16. Mac system requirements:
    a. Mac computer with USB 2.0 port
    b. Mac OS X v10.5.8 or later
    c. iTunes 10.1 or later
    d. iTunes Store account
    e. Internet access
17. Windows system requirements:
    a. PC with USB 2.0 port
    b. Windows 7; Windows Vista; or Windows XP Home or Professional with Service Pack 3 or later
    c. iTunes 10.1 or later
    d. iTunes Store account
    e. Internet access
18. Environmental requirements:
    a. Operating 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)

19. 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.

2.7 24 PORT GIGABIT POE+ MANAGED SWITCH: REFERENCED PRODUCT LUXUL SW505-24P-R

A. Standards

1. IEEE 802.3, IEEE 802.3u, IEEE 802.3z, IEEE 802.3ab, IEEE 802.3af, IEEE 802.1D, IEEE 802.3x IEEE 802.1P, IEEE 802.1Q, IEEE 802.1X

B. Interface

1. RJ-45
   a. 10 Base-T: Cat.5 UTP /STP
   b. 100 Base-TX: Cat.5 UTP /STP
   c. 1000Base-T: Cat.5, Cat.5e or Cat.6 UTP/STP
2. Gigabit Fiber Uplinks on SFP ports
3. Ethernet Cable Recognition for Straight-through or Crossover Cables

C. Surge Protection

1. The RJ45 port surge protection is tested to: EN61000-4-5 (for RJ45 Port, Surge 6KV)

D. LEDS

1. Front
   a. Per Unit: Power
   b. Per Port: Link/Activity
   c. Dual color, user selectable
2. Back
   a. Per Port: Link/Activity
   b. 10/100/1000

E. Power Budget

1. 250 Watts

F. Max Power Consumption

1. 337W

G. Power

1. Internal Switched Power, AC 100-240V, 50-60Hz input

H. VLAN

1. 802.1Q Max 4094 VIDs & VLAN Trunking
2. Supports 1 Management VLAN

I. Quality of Service (QoS)

1. 4 Queues per port
2. Queue Handling: Strict, Weighted Round Robin (WRR)
3. CoS Based on DCSP, 802.1P
4. Port- based Bandwidth Control

J. Network Data Transfer Rate

1. Ethernet: 10Mbps (Half-duplex)
2. Ethernet: 20Mbps (Full-duplex)
3. Fast Ethernet: 100Mbps (Half-duplex)
4. Fast Ethernet: 200Mbps (Full-duplex)
5. Gigabit Ethernet: 1000Mbps (Half-duplex)
6. Gigabit Ethernet: 2000Mbps (Full-duplex

K. Layer 3

1. Layer 3 Static Routing

L. Operating Temperature

1. 32°F to 104ºF (0°C to 40°C)

M. Operating Humidity

1. 10% to 90% (Non-condensing)

N. Dimensions LxWxH in. (mm)

1. 17.3”(439.5) x 8.25”(209.5) x 1.75”(44.5)

O. Weight lbs (kg)

1. 8.75 (3.96)

P. Certification

1. FCC, CE, RoHS

2.8 16 PORT GIGABIT POE+ MANAGED SWITCH: REFERENCED PRODUCT LUXUL SW505-16P-R

A. Standards

1. IEEE 802.3, IEEE 802.3u, IEEE 802.3z, IEEE 802.3ab, IEEE 802.3af, IEEE 802.1D, IEEE 802.3x IEEE 802.1P, IEEE 802.1Q, IEEE 802.1X

B. Interface

1. RJ-45
   a. 10 Base-T: Cat.5 UTP /STP
   b. 100 Base-TX: Cat.5 UTP /STP
   c. 1000Base-T: Cat.5, Cat.5e or Cat.6 UTP/STP
2. Gigabit Fiber Uplinks on SFP ports
3. Ethernet Cable Recognition for Straight-through or Crossover Cables

C. Surge Protection

1. The RJ45 port surge protection is tested to: EN61000-4-5 (for RJ45 Port, Surge 6KV)

D. LEDS

1. Front
   a. Per Unit: Power
   b. Per Port: Link/Activity
   c. Dual color, user selectable
2. Back
   a. Per Port: Link/Activity
   b. 10/100/1000

E. Power Budget

1. 250 Watts

F. Max Power Consumption

1. 337W

G. Power

1. Internal Switched Power, AC 100-240V, 50-60Hz input

H. VLAN

1. 802.1Q Max 4094 VIDs & VLAN Trunking
2. Supports 1 Management VLAN

I. Quality of Service (QoS)

1. 4 Queues per port
2. Queue Handling: Strict, Weighted Round Robin (WRR)
3. CoS Based on DCSP, 802.1P
4. Port- based Bandwidth Control

J. Network Data Transfer Rate

1. Ethernet: 10Mbps (Half-duplex)
2. Ethernet: 20Mbps (Full-duplex)
3. Fast Ethernet: 100Mbps (Half-duplex)
4. Fast Ethernet: 200Mbps (Full-duplex)
5. Gigabit Ethernet: 1000Mbps (Half-duplex)
6. Gigabit Ethernet: 2000Mbps (Full-duplex

K. Layer 3

1. Layer 3 Static Routing

L. Operating Temperature

1. 32°F to 104ºF (0°C to 40°C)

M. Operating Humidity

1. 10% to 90% (Non-condensing)

N. Dimensions LxWxH in. (mm)

1. 17.3”(439.5) x 8.25”(209.5) x 1.75”(44.5)

O. Weight lbs (kg)

1. 8.75 (3.96)

P. Certification

1. FCC, CE, RoHS

2.9 WIRELESS ROUTER: REFERENCED PRODUCT LUXUL XWR-1200

A. Hardware Features

1. Standards Compliance
   a. 2.4GHz: IEEE802.11n, IEEE802.11g, IEEE 802.11b;
   b. 5.xGHz: IEEE 802.11n, IEEE 802.11a; 802.11ac
2. Interface

a. One 10/100/1000M WAN Port
b. Four 10/100/1000M LAN Ports
c. One USB 2.0 Port

3. Antenna
   a. Two Dual-Band Detachable Omni-Directional Antennas
4. Button
   a. Power Button/Reset Button
5. Power
   a. Input: 12V/2A DC Power Jack
6. Max Power Consumption
   a. 18W
7. Environmental
   a. Temperatures 0-40c
8. Dimensions
   a. LxWxH in. (mm) 8.1”x5.6”x1.5” (206x142x38)
9. Weight
   a. lbs
10. LEDs
    a. Power, SYS, USB, WAN, LAN (4), 5GHz, 2.4GHz

B. Wireless & Other Features

1. Wireless Speed
   a. 2.4GHz: 300Mbps;
   b. 5GHz: 866Mbps.
2. Frequency
   a. Concurrent 2.4GHz and 5GHz
3. Wireless Security
   a. WPA-PSK/WPA2-PSK, WPA/WPA2
4. Operating Modes
   a. Wireless Router, Wireless Controller
5. Other Functions and Features
   a. Quality of Service (QoS)
   b. Guest Network Support
   c. VPN Support: PPTP, L2TP, IPSEC
   d. Port Forwarding
   e. MAC Address Cloning
   f. DHCP Server, Client, Address Reservation

g. Backup & Restore Configurations
h. Firmware Upgradeable via Browser
i. Secure Remote Access via VPN

6. Certifications
   a. CE, FCC, RoHS, IC, RCM

2.10 DIGITAL MEDIA PRESENTATION SYSTEM: REFERENCED PRODUCT CRESTRON DMPS3-4K-350-C

A. Operating System

1. Crestron 3-Series; real-time, preemptive, multi-threaded/multitasking kernel; Transaction-Safe Extended FAT file system; supports up to 10 simultaneously running programs; preloaded DMPS3 .AV Framework Base Program

B. Memory

1. SDRAM 512 MB
2. Flash 4 GB

C. Communications

1. Ethernet 10/100/1000 Mbps, auto-switching, auto-negotiating, auto-discovery, full/half duplex, industry-standard TCP/IP stack, UDP/IP, CIP, DHCP, SSL, TLS, SSH, SFTP (SSH File Transfer Protocol), FIPS 140-2 compliant encryption, IEEE 802.1X, SNMP, BACnet™/IP [10], IPv4 or IPv6, Active Directory authentication, IIS v.6.0 Web Server, SMTP e-mail client, RSTP, Private Network Mode
2. Control Subnet 10/100/1000 Mbps Ethernet, auto-switching, auto-negotiating, auto-discovery, full/half duplex, DHCP server, DNS Server, port forwarding, Isolation Mode, IEEE 802.3at Type 1 compliant PoE PSE
3. AirMedia [1] (Via Ethernet) 10/100 Mbps, IPv4, DHCP, TLS, AES, mDNS, HTTPS web server
4. Streaming (Via Ethernet) 10/100 Mbps, DHCP, H.264 decoding, MJPEG decoding, HDCP 2.2, RTP, RTSP, SDP
5. Cresnet Cresnet master mode
6. USB USB signal routing via select DM transmitters and receivers, or via USB-EXT-DM series extenders [9]; USB device port for computer console (setup)
7. RS-232 2-way device control and monitoring up to 115.2k baud with hardware and software handshaking
8. IR/Serial 1-way device control via infrared up to 1.2 MHz or serial TTL/RS-232 (0-5 Volts) up to 115.2k baud; supports CNXRMIRD IR Receiver [6]
9. DigitalMedia DM 8G+, HDCP 2.2, EDID, CEC, PoDM+ [8], Ethernet
10. HDBaseT HDCP 2.2, EDID, CEC, RS-232, PoE+ [8], Ethernet
11. HDMI HDCP 2.2, EDID, CEC

D. Video

1. Switcher 9x4 matrix, Crestron QuickSwitch HD technology
2. Scalers (HDMI outputs) (2) 4K video scalers with motion-adaptive deinterlacing, intelligent frame rate conversion, Deep Color support, 3D to 2D conversion [5], content-adaptive noise reduction, and widescreen format selection (zoom, stretch, maintain aspect-ratio, or 1:1)
3. Input Signal Types HDMI w/Deep Color, 3D [5], & 4K (DVI & Dual-Mode DisplayPort compatible [4]) on Inputs 1-6; DM 8G+ & HDBaseT w/Deep Color, 3D [5], & 4K on Inputs 7 & 8; streaming & AirMedia on Input 9 (LAN)
4. Output Signal Types HDMI w/Deep Color & 4K (DVI compatible [4]) on Outputs 1 & 2; DM 8G+ & HDBaseT w/Deep Color, 3D, & 4K on Outputs 3 & 4

E. Streaming Decoder

1. Video Formats H.264 (MPEG-4 part 10 AVC), MJPEG
2. Audio Format AAC stereo
3. Bitrates Up to 25 Mbps
4. Resolutions Up to 1080p60

F. AirMedia [1]

1. Users Supports up to 32 users (presentation device connections)
2. Client Software OS Support Windows 7, Windows 8, Window 10, Mac® OS X® (versions 10.10 through 10.13)
3. Client Software Video Frame Rate 30 fps, audio supported
4. Mobile App OS Support Apple® iOS, Android
5. Full Screen Device Mirroring Shares the screen image and audio from an Apple iOS, Android, Mac OS X, or Windows device
6. Resolutions 800x600@60Hz, 1024x768@60Hz, 1280x720@60Hz (720p60), 1280x768@60Hz, 1280x800@60Hz, 1280x1024@60Hz, 1360x768@60Hz, 1400x1050@60Hz, 1440x900@60Hz, 1600x1200@60Hz, 1920x1080@60Hz (1080p60), 1920x1200@60Hz
7. Audio Format Stereo

G. Audio – General

1. Switcher/Mixer 14x5 stereo source matrix switcher, digital & analog source inputs, streaming & AirMedia source input, 6-channel gated mic mixer w/DSP, independent mixer per analog output (6-ch mic + 1 stereo source), independent stereo DSP per analog output, integrated power amplifier, two independent digital output mixers (6-ch mic + 1 stereo source), 2x1 digital output mix selector per digital output
2. Analog-To-Digital Conversion 24-bit 48 kHz
3. Digital-To-Analog Conversion 24-bit 48 kHz

4. Frequency Response, Digital & Analog Line Outputs 20 Hz to 20 kHz ±0.5 dB (digital source);
   a. 20 Hz to 20 kHz ±0.5 dB (analog line source);
   b. 20 Hz to 20 kHz ±0.7 dB (microphone source)
5. Frequency Response, Speaker Output 20 Hz to 20 kHz ±1 dB @ 25 Watts into 8 Ohms;
6. 100 Hz to 20 kHz ±2.5 dB @ 70 or 100 Volts
7. S/N Ratio, Digital & Analog Line Outputs >108 dB, 1 kHz, A-weighted (digital source);
8. >103 dB, 1 kHz, A-weighted (analog line source)
9. S/N Ratio, Speaker Output 98 dB @ 25 Watts into 8 Ohms, 1 kHz, A-weighted;
10. 96 dB @ 25 Watts into 4 Ohms, 1 kHz, A-weighted
11. THD+N, Digital & Analog Line Outputs <0.002%, 20 Hz to 20 kHz (digital source);
12. <0.005%, 20 Hz to 20 kHz (analog line source);
13. <0.05%, 20 Hz to 20 kHz (microphone source)
14. THD+N, Speaker Output
    a. <0.1%, 1 kHz @ 25 Watts into 4 or 8 Ohms;
    b. <0.7%, 20 Hz to 20 kHz @ 25 Watts into 4 or 8 Ohms
15. Stereo Separation, Digital & Analog Line Outputs
    a. >108 dB (digital source);
    b. >103 dB (analog source)
16. Stereo Separation, Speaker Output >65 dB @ 25 Watts, 1 kHz
17. Channel Separation, Digital Outputs
    a. >108 dB (digital source);
    b. >103 dB (analog source)
18. Channel Separation, Analog Line Outputs >103 dB
19. Speaker Output Modes 4Ω/8Ω stereo, 70V mono, or 100V mono
20. Speaker Amplifier Output Power 25 Watts RMS per channel @ 8 Ohms, 4 Ohms tolerant;
21. 50 Watts RMS @ 70 or 100 Volts

H. Audio – Microphone Inputs

1. Typical of 6 microphone input channels (Mic/Line 1 – 6)
2. Input Signal Types Mono analog mic or line level
3. Phantom Power Enable/Disable per channel
4. Gain 0 to +60 dB Gain adjustment in 3 dB increments, plus Mute
5. Delay 0.0 to 85.0 ms
6. EQ Center Frequencies 50 to 200 Hz (Band 1), 200 to 800 Hz (Band 2), 800 to 3.2k Hz (Band 3), 3.2k to 12.8k Hz (Band 4)

7. EQ Gain ±12.0 dB per band
8. High-Pass Filter On or Off
9. Gating Threshold -80 to 0 dB
10. Gating Depth (Attenuation) -80 to 0 dB
11. Gating Attack 1 to 250 ms
12. Gating Release 1 to 1000 ms
13. Compression Threshold -80 to 0 dB
14. Compression Ratio 1:1 to 10:1
15. Compression Attack 1 to 250 ms
16. Compression Release 1 to 1000 ms
17. Compression Curve Hard or soft knee

I. Audio – Source Inputs

1. Input Signal Types HDMI (Dual-Mode DisplayPort compatible [4]) on Inputs 1-6, DM 8G+ & HDBaseT on Inputs 7 & 8, streaming & AirMedia on Input 9 (LAN), analog 2-channel on Aud In 1-5
2. Analog Formats Stereo 2-channel
3. Digital Formats 2-channel LPCM
4. Input Compensation ±10.0 dB, adjustable per input

J. Audio – Analog Line & Speaker Outputs

1. Typical of 1 analog line/speaker output (Program Out & Speaker Outputs) and 2 analog line outputs (Aux Out 1 – 2)
2. Output Signal Type/Format Stereo 2-channel
3. Mic 1 – 6 -80 to +10 dB Level adjustment range, plus Mute and Pan
4. Mics Master -80 to +10 dB Level adjustment range, plus Mute
5. Source -80 to +10 dB Level adjustment range, plus Mute and Balance
6. Master Volume -80 to +10 dB Level adjustment range, plus Mute and Mono
7. Mixer Presets 1 through 5
8. Bass ±12.0 dB
9. Treble ±12.0 dB
10. Equalization 10-band graphic + 4-band parametric
11. GEQ Center Frequencies 31.5, 63, 125, 250, 500, 1k, 2k, 4k, 8k, 16k Hz
12. GEQ Gain ±12.0 dB per band
13. PEQ Center Frequencies 10 to 22000 Hz per band
14. PEQ Gain -36.0 to +24.0 dB per band
15. PEQ Bandwidth 0.02 to 3.50 octaves per band
16. PEQ Types Peaking EQ, High Pass, Low Pass, High Shelf, Low Shelf, Notch
17. Delay 0.0 to 85.0 ms
18. Limiter Threshold -80 to 0 dB
19. Limiter Ratio 1:1 to 10:1
20. Limiter Attack 1 to 250 ms

21. Limiter Hold 1 to 200 ms
22. Limiter Release 1 to 1000 ms
23. Limiter Curve Hard or soft knee
24. EQ Presets 1 through 10 (includes Delay and Limiter settings)

K. Audio – Digital Outputs

1. Typical of 4 digital outputs (HDMI Output 1 – 2 & DM Output 3 – 4)
2. Output Signal Types HDMI (DVI compatible [4]) on Outputs 1 & 2, DM 8G+ & HDBaseT on Outputs 3 & 4
3. Formats 2-channel LPCM
4. Digital Output Mix Select 1 – 2 Selects which mix is routed to the corresponding output
5.
6. Typical of 2 digital output mixers:
7. Mic 1 – 6 -80 to +10 dB Level adjustment range, plus Mute and Pan
8. Mics Master -80 to +10 dB Level adjustment range, plus Mute
9. Source -80 to +10 dB Level adjustment range, plus Mute and Balance
10. Master Volume -80 to +10 dB Level adjustment range, plus Mute
11. Mixer Presets 1 through 5

L. Connectors – Audio/Video Inputs

1. AUD IN 1 – 5
   a. (5) 5-pin 3.5 mm detachable terminal blocks;
   b. Balanced/unbalanced stereo line-level analog audio inputs;
   c. Input Impedance: 24k Ohms balanced/unbalanced;
   d. Maximum Input Level: 4 Vrms balanced, 2 Vrms unbalanced
2. MC1/LN1 – MC6/LN6
   a. (6) 5-pin 3.5 mm detachable terminal blocks;
   b. Comprises (6) balanced microphone/line audio inputs;
   c. Balanced Mic Input Level: -60 to 0 dBV, 1 Vrms maximum;
   d. Balanced Line Input Level: -31 to +11 dBV, 3.7 Vrms maximum;
   e. Unbalanced Line Input Level: -37 to +5 dBV, 1.85 Vrms maximum;
   f. Mic Input Impedance: 3.9k Ohms balanced;
   g. Line Input Impedance: 19k Ohms balanced, 9.5k Ohms unbalanced;
   h. Phantom Power: 48 Volts DC, software enabled/disabled per channel
3. HDMI 1 – 6 INPUTS
   a. (6) HDMI Type A connectors, female;
   b. Digital video/audio inputs;
   c. (DVI and Dual-Mode DisplayPort compatible [4])
4. DM INPUT 7 – 8

a. (2) 8-pin RJ45 connectors, female, shielded;
b. DM 8G+ inputs, HDBaseT compliant;
c. PoDM+ PSE ports (HDBaseT PoE+ compatible) [8];
d. Each connects to the DM 8G+ output of a DM transmitter or other DM device, or to an HDBaseT device, via CAT5e, Crestron DM-CBL-8G, or Crestron DM-CBL-ULTRA cable [7]

M. Connectors – Audio/Video Outputs

1. SPEAKER OUTPUT
   a. 4Ω/8Ω L – R (2) 2-pin 7.62 mm 15A detachable terminal blocks;
   b. 4-8 Ohm stereo speaker-level audio output;
   c. Wire Size: Terminals accept up to 14 AWG (2.5 mm^2);
   d. Output Power: 25W RMS per channel stereo at 8 Ohms, 4 Ohms tolerant
2. SPEAKER OUTPUT
   a. 70/100V (1) 2-pin 7.62 mm 15A detachable terminal block;
   b. Transformer-isolated 70 or 100 Volt mono speaker-level audio output;
   c. Wire Size: Terminals accept up to 14 AWG (2.5 mm^2);
   d. Output Power: 50W RMS mono at 70 or 100 Volts;
   e. Note: 4Ω/8Ω and 70/100V outputs are mutually exclusive
3. PROG OUT (1) 5-pin 3.5 mm detachable terminal block;
   a. Balanced/unbalanced stereo line-level audio output;
   b. Output Impedance: 200 Ohms balanced, 100 Ohms unbalanced;
   c. Maximum Output Level: 4 Vrms balanced, 2 Vrms unbalanced
4. AUX OUT 1 – 2 (2) 5-pin 3.5 mm detachable terminal blocks;
   a. Balanced/unbalanced stereo line-level audio outputs;
   b. Output Impedance: 200 Ohms balanced, 100 Ohms unbalanced;
   c. Maximum Output Level: 4 Vrms balanced, 2 Vrms unbalanced
5. HDMI 1 – 2 OUTPUTS (2) HDMI Type A connectors, female;
   a. Digital video/audio outputs;
   b. (DVI compatible [4])
6. DM OUTPUT 3 – 4 (2) 8-pin RJ45 connectors, female, shielded;
   a. DM 8G+ outputs, HDBaseT compliant;
   b. PoDM+ PSE ports (HDBaseT PoE+ compatible) [8];
   c. Each connects to the DM 8G+ input of a DM receiver or other DM device, or to an HDBaseT device, via CAT5e, Crestron DM-CBL-8G, or Crestron DM-CBL-ULTRA cable [7]

N. Connectors – Networking, Control, & Power

1. IR/SERIAL OUT 1 – 4 (4) 2-pin 3.5 mm detachable terminal blocks;
   a. IR/Serial output ports;

b. IR output up to 1.2 MHz;
c. 1-way serial TTL/RS-232 (0-5 Volts) up to 115.2k baud

2. IR IN (1) 3-pin 3.5 mm detachable terminal block;
   a. For connection of the CNXRMIRD IR Receiver [6];
   b. Allows control from IR wireless remotes using RC-5 command set

3. INPUT 1 – 4 (1) 5-pin 3.5 mm detachable terminal block;
   a. Comprises (4) programmable digital inputs;
   b. Input Voltage Range: 0 to 24 Volts DC, referenced to GND;
   c. Logic Threshold: 2.5 Volts DC nominal with 1 Volt hysteresis band;
   d. Input Impedance: 10k Ohms at >5 Volts, 1M Ohms at <5 Volts;
   e. Pull-up Resistor: 2.2k Ohms per input

4. RELAY 1 – 4 (1) 8-pin 3.5 mm detachable terminal block;
   a. Comprises (4) normally open, isolated relays;
   b. Rated 1 Amp, 30 Volts AC/DC;
   c. MOV arc suppression across contacts

5. COM A – B (2) DB9 connectors, male;
   a. Bidirectional RS-232 ports;
   b. Up to 115.2k baud, hardware and software handshaking support

6. NET (4) 4-pin 3.5 mm detachable terminal blocks;
   a. Cresnet Master ports, paralleled;
   b. Available Cresnet Power: 10 Watts

7. PoDM+ INPUT PWR (1) Combo D-Sub 7w2 connector, male;
   a. 48 Volt DC power input for PoDM power supply [8];
   b. Enables PoDM+ power sourcing on each DM INPUT/OUTPUT port;
   c. Enables PoE power sourcing on the CONTROL SUBNET port

8. SERVICE (1) USB Type B connector, female;
   a. For factory use only

9. 100-240V~ 6.0A 50/60Hz (1) IEC 60320 C14 main power inlet;
   a. Mates with removable power cord, included

10. G (1) 6-32 screw;
    a. Chassis ground lug

11. CONTENT LAN IN 9 (1) 8-pin RJ45 connector, female;
    a. 10Base-T/100Base-TX Ethernet port;
    b. Provides a dedicated LAN connection for streaming input & AirMedia [1]

12. CONTROL SUBNET (1) 8-pin RJ45 connector, female;
    a. 10Base-T/100Base-TX/1000Base-T Ethernet port;
    b. PoE PSE (Power Sourcing Equipment) port [8];
    c. Provides a dedicated local network for Crestron devices

13. LAN (1) 8-pin RJ45 connector, female;
    a. 10Base-T/100Base-TX/1000Base-T Ethernet port
14. COMPUTER (front) (1) USB Type B connector, female;
    a. USB computer console port (for setup only)

O. Controls & Indicators

1. PWR (1) Green LED, indicates operating power supplied from AC power line
2. NET (1) Yellow LED, indicates Cresnet bus activity
3. LAN (1) Yellow LED, indicates Ethernet activity
4. HW-R (1) Recessed pushbutton for hardware reset, reboots the control system
5. SW-R (1) Recessed pushbutton for software reset, restarts the software program
6. LCD Display (1) Green LCD alphanumeric; adjustable backlight; 2 lines x 20 characters per line; displays input/outputs by name, volume levels, setup menus, signal routing, device info, and other system information
7. SOFTKEYS (4) Pushbuttons for activation of LCD driven functions and passcode entry
8. MENU (1) Pushbutton, steps menu back one level
9. Λ, V (2) Pushbuttons, for scrolling up or down through the menu and adjusting menu parameters
10. ENTER (1) Pushbutton, executes the highlighted menu or value
11. VOLUME (1) Continuous turn rotary encoder, adjusts menu parameters, defaults to Program audio volume
12. MUTE (1) Pushbutton and red LED, mutes the Program audio output
13. INFO (1) Pushbutton and red LED, selects INFO mode to view AV and device info
14. ROUTE (1) Pushbutton and red LED, selects ROUTE mode to allow routing changes
15. VIEW (1) Pushbutton and red LED, selects VIEW mode to view current routing
16. INPUT 1 – 9 (9) Pushbuttons and red LEDs, each selects the corresponding video input for routing
17. OUTPUT 1 – 4, PROG, AUX 1 – 2 (7) Pushbuttons and red LEDs, each selects the corresponding video or audio output for routing
18. SPEAKER OUTPUT (rear) (1) 3-position slide switch, selects the amplifier output configuration
19. DM INPUT 7 – 8 (rear) (4) LEDs, green LEDs indicate DM link status, amber LEDs indicate video and HDCP signal presence, for each corresponding port
20. DM OUTPUT 3 – 4 (rear) (4) LEDs, green LEDs indicate DM link status, amber LEDs indicate video and HDCP signal presence, for each corresponding port
21. CONTENT LAN IN 9 (rear) (2) LEDs, (1) green and (1) amber, for indication of Ethernet speed, activity, and link status
22. CONTROL SUBNET (rear) (2) LEDs, (1) green and (1) amber, for indication of Ethernet speed, activity, and link status

23. LAN (rear) (2) LEDs, (1) green and (1) amber, for indication of Ethernet speed, activity, and link status

P. Power

1. Main Power
   a. 6 Amps @ 100-240 Volts AC, 50/60 Hz
2. Power Consumption
   a. 93 Watts typical;
   b. 72 Watts idle
3. Available Cresnet Power
   a. 10 Watts
4. Power over DM (PoDM)
   a. IEEE 802.3at compliant PoDM+ PSE (Power Sourcing Equipment), each DM INPUT/OUTPUT port supplies up to 30 Watts to power one PoDM (Class 0-3) or PoDM+ (Class 4) PD (Powered Device) [8]
5. Power over HDBaseT
   a. IEEE 802.3at PoE+ compliant PSE (Power Sourcing Equipment), each DM INPUT/OUTPUT port supplies up to 30 Watts to power one HDBaseT PoE or PoE+ PD (Powered Device) [8]
6. Power over Ethernet (PoE)
   a. IEEE 802.3at compliant PoE PSE (Power Sourcing Equipment), the CONTROL SUBNET port supplies up to 15.4 Watts to power one PoE (Class 0-3) PD (Powered Device) [8]
7. PoDM Power Supply
   a. Compatible with model PW-4830DUS or DM-PSU-3X8-RPS [6]

Q. Environmental

1. Temperature 41° to 104° F (5° to 40° C)
2. Humidity 10% to 90% RH (non-condensing)
3. Heat Dissipation
   a. 317 BTU/hr typical;
   b. 246 BTU/hr idle

R. Enclosure

1. ChassisMetal, black finish, fan-cooled, vented sides
2. Front Panel Metal, black finish with polycarbonate label overlay
3. Mounting Freestanding or 3 RU 19-inch rack-mountable (adhesive feet and rack ears included)

S. Dimensions

1. Height 5.20 in (133 mm) without feet
2. Width
   a. 17.28 in (439 mm);
   b. 19.00 in (483 mm) with rack ears
3. Depth 15.75 in (400 mm)

T. Weight

1. 15.5 lb (7.1 kg)

U. Compliance

1. UL Listed for US & Canada, IC, CE, FCC Part 15 Class A digital device

2.11 WIRELESS PRESENTATION GATEWAY: REFERENCED PRODUCT CRESTRON AM-3200

A. Features

1. Users Supports up to 32 users (presentation device connections)
2. Quad View Allows simultaneous display of up to four presentation sources in a quad window
3. Remote View Allows up to 40 remote users to connect via a Web browser to view and save images of the presentation
4. Display Control Controls the display device over IP as part of the presentation [2]
5. Control System Integration Allows communication over IP with a Crestron® Control System for remote control and integration with other equipment and Crestron Fusion™ software

B. Windows® and OS X® Client Software

1. OS Support Windows XP, Vista, 7, or 8; Mac® OS X (versions 10.5 thru 10.8)
2. Video Frame Rate 15 fps (typical), audio supported

C. Mobile Apps

1. OS Support Apple® iOS®, Android™
2. Supported Files MS PowerPoint® (.ppt, .pptx), MS Word (.doc, .docx), MS Excel® (.xls, .xlsx), PDF (.pdf), JPEG (.jpd, .jpeg)
3. Shot&Show Shares a static image of any app by using the screen shot function

D. Video

1. Output Signal Types HDMI®, RGB

2. Output Formats HDMI, DVI[3], HD video up to 1080p60, computer up to UXGA
3. Output Resolutions, Progressive 800x600@60Hz, 1024x768@60Hz, 1280x720@60Hz (720p60), 1280x768@60Hz, 1280x800@60Hz, 1360x768@60Hz, 1440x900@60Hz, 1600x1200@60Hz, 1920x1080@60Hz (1080p60)
4. Output Resolutions, Interlaced 1920x1080@30Hz (1080i30)
5. Underscan Up to 7.5%

E. Audio

1. Output Signal Types HDMI, analog stereo
   a. Formats, HDMI PCM 2-channel
   b. Formats, AnalogStereo 2-channel

F. Communications

1. Ethernet 10/100 Mbps, auto-switching, auto-negotiating, full/half duplex, DHCP, Web server

G. Connectors

1. 5VDC 2.6A
   a. (1) 2.0 x 3.0 mm DC power connector;
   b. 5 Volt DC power input;
   c. Universal power pack included
2. AUDIO
   a. (1) 3.5mm TRS mini phone jack;
   b. Unbalanced stereo line-level audio output
3. HDMI
   a. (1) 19-pin Type A HDMI female;
   b. HDMI digital video/audio output;
   c. Also supports DVI[3]
4. VGA
   a. (1) DB15HD female;
   b. RGBHV (VGA) video output
5. LAN
   a. (1) 8-wire RJ45, female;
   b. 10Base-T/100Base-TX Ethernet port
6. SERVICE
   a. (1) USB Type A female;
   b. For factory use only

H. Indicators

1. PWR
   a. (1) dual-color LED, red indicates booting, flashing red indicates updating firmware, green indicates operating normally
2. LAN (rear)
   a. (2) LEDs, green LED indicates Ethernet link status, amber LED indicates Ethernet activity

I. Power Requirements

1. Power Pack
   a. 2.6 Amps @ 5 Volts DC;
   b. 0.3 Amps (maximum) @ 100-240 Volts AC, 50/60 Hz power pack included

J. Environmental

1. Temperature 32° to 104°F (0° to 40°C)
2. Humidity 10% to 90% RH (non-condensing)
3. Heat Dissipation 16 BTU/hr

K. Enclosure

1. Chassis Metal, black
2. Mounting Freestanding or surface mount (surface mount bracket included)

2.12 HD SINGLE CABLE TRANSMITTERS: REFERENCED PRODUCT CRESTRON DM-TX C-SERIES

A. The signal transmitters shall extend HDMI video and audio, DVI-I, RGBHV, YPbPr, Y/C, Composite, Analog 2-channel audio, and USB HID (Human Interface Device) data to compatible transmission receiver modules or ports.

1. Switching:
   a. Multiple input transmitters shall include integrated switching with signal sensing.
   b. Switching modes:
      1) Automatic: switcher shall switch to the last detected input.
      2) Controlled: control processor controls source switching and audio break-away switching.

B. TRANSMITTER: CRESTRON DM-TX-4KZ-100-C-1G

1. Description

a. The wall mount signal transmitters shall extend 4K HDMI video and audio over a single UTP/STP cable to compatible transmission receiver modules or ports. The following source formats shall be supported:

1) 4K HDMI, HDCP2.2 compliant.
2) DVI-I
3) Dual-Mode Display Port.

b. Performance

1) The transmitter shall meet the following minimum requirements:

a. One (1) HDMI video, audio, and control input:

1) Supports 4K HDMI.
2) Supports HDCP 2.2
3) Supports Dolby Digital, Dolby Digital EX, DTS, DTS-ES, DTS 96/24, up to 8 channel PCM.
4) Supports DVI-D with adaptor.
5) Supports Dual-Mode DisplayPort with adaptor.
6) CEC device control.

b. Single UTP/STP cable transmission connection

1) Supports HDBaseT signal specifications.
2) Supports remote power injection through matrix switcher.
3) Supports CAT5e.
4) Signal transmission up to 330 feet.

c. Power supply modes:

1) Remote power supplied by matrix switcher through UTP/STP transmission cable.
2) Local or remote DC power source.

d. Mounting:

1) 1-gang wall box mount
2) Surface mount
3) Rack rail mount
4) One (1) bidirectional RS-232 port:

2) One (1) 5-pin 3.5mm detachable terminal block

a. GND, TX, RX, CTS, RTS support
b. Up to 115.2k baud, hardware and software handshaking support.

3) One (1) IR/Serial port:

a. One (1) 2-pin 3.5mm detachable terminal block.
b. IR output up to 1.1 MHz.
c. 1-way serial TTL/RS-232 (0-5 Volts) up to 19200 baud.

C. TRANSMITTER: CRESTRON DM-TX-4KZ-302-C

1. Description
   a. The signal transmitters shall extend 4K HDMI video, audio, and data over a single UTP/STP cable to compatible transmission receiver modules or ports. The following source formats shall be supported:
      1) 4K HDMI, HDCP2.2 compliant
      2) DVI-I
      3) Dual-Mode Display Port
      4) RGBHV
      5) YPbPr
      6) VGA
      7) Y/C
      8) Composite
      9) Analog 2-channel audio
      10) USB HID (Human Interface Device)
   b. Switching: Transmitter shall include integrated switching with signal sensing.
      1) Switching modes:
         a. Automatic: switcher shall switch to the last detected input.
         b. Controlled: control processor controls source switching and audio break-away switching.

2. Performance
   a. The transmitter shall meet the following minimum requirements:
      1) Two (2) HDMI video, audio, and control input:
         a. Supports 4K HDMI
         b. Supports HDCP 2.2
         c. Supports Dolby Digital, Dolby Digital EX, DTS, DTS-ES, DTS 96/24, up to 8 channel PCM.
         d. Supports DVI-D with adaptor.
         e. Supports Dual-Mode DisplayPort with adaptor.
         f. CEC device control
      2) One (1) DB15 input:
         a. Component (YPbPr)

b. RGB
c. S-Video (Y/C)
d. Composite Video

3) One (1) analog stereo audio input:
   a. (1) 3.5mm TRS (L/R unbalanced)
4) One (1) USB HID port.
   a. Supports USB HID class devices
5) HDMI digital video/audio output
   a. One (1) 19-pin Type A HDMI female connector
   b. Supports 4K HDMI
   c. Supports HDCP 2.2
6) Ethernet Port
   a. One (1) 8-wire RJ-45
   b. 10/100 Mbps, auto-switching, auto negotiating, auto-discovery, full/half duplex, DHCP
   c. Single UTP/STP cable transmission connection
   d. Supports HDBaseT signal specifications.
   e. Supports remote power injection through matrix switcher.
   f. Supports CAT5e.
   g. Signal transmission up to 330 feet.
7) Power supply modes:
   a. Remote power supplied by matrix switcher through UTP/STP transmission cable.
   b. Local or remote DC power source.
8) Mounting:
   a. Freestanding.
   b. Surface mount.
   c. Rack rail mount.
9) One (1) bidirectional RS-232 port:
   a. One (1) 5-pin 3.5mm detachable terminal block.
   b. GND, TX, RX, CTS, RTS support.
   c. Up to 115.2k baud, hardware and software handshaking support.
10) One (1) IR/Serial port:
   a. One (1) 2-pin 3.5mm detachable terminal block.
   b. IR output up to 1.1 MHz.
   c. 1-way serial TTL/RS-232 (0-5 Volts) up to 19200 baud.

2.13 SINGLE CABLE 4K HDMI TRANSMITTER

A. Crestron HD-TX-101-C-1G-E

1. Device Architecture

a. Physical Form factor
   1) Wall mount device, mounts in a 1-gang (or larger) 2-1/4 inch (57 mm) deep U.S. electrical box
b. Functions
   1) Single UTP/STP cable transmission
   2) Signal transmission up to 230 feet.
   3) Minimum cable type supported: UTP/STP CAT5e

2. Connectors
   a. The device shall include the following connectors:
      1) One (1) HDMI input with support for the following:
         a. CEC Pass-through and CEC management
         b. HDMI with Deep Color, 3D and 4K
         c. HDCP 1.4 compliant
         d. DisplayPort Dual-Mode
         e. Dolby Digital, Dolby Digital EX, DTS, DTS-ES, DTS 96/24, LPCM up to 8 channels
         f. DVI-D with adaptor
         g. EDID
         h. Common resolutions: 1920x1080 30Hz to 4096x2160 DCI 4K 4:4:4 30Hz
         i. Custom resolutions: pixel clock rates up to 300 MHz
      2) One (1) RJ45 shielded female connector with support for the following:
         a. Link port for connection to compatible transmission device by same manufacturer
         b. Power sharing option for connected remote transmission device
      3) One (1) DC power input jack with support for:
         a. Power connection shall support power sharing with connected transmission device
      4) One (1) USB Type A connector with support for:
         a. USB power port (500 mA maximum output)
         b. Supplies power to a USB powered device

3. Power
   a. Power supply modes:
      1) Local or remote DC power source
      2) Remote power supplied by opposite end of TX/RX pair.

4. Compliance
   a. UL Listed for US & Canada, CE, IC, FCC Part 15 Class B digital device

2.14 SINGLE CABLE 4K HDMI TRANSMITTER

A. Crestron HD-TXC-4KZ-101

1. Device Architecture
    a. Physical Form factor
        1) Device enclosure to be composed of black finish metal with vented sides
        2) Device weight: 11.92 oz (338 g)
    b. Mounting Options
        1) Freestanding
        2) Surface mount via attachable mounting bracket
        3) Attachment to single rack rail
    c. Environmental Operating Conditions
        1) 32° to 104° F (0° to 40° C)
        2) 20% to 90% RH (non-condensing)
2. Functions
    a. Single UTP/STP cable transmission
        1) Signal transmission up to 230 feet.
        2) Minimum cable type supported: UTP/STP CAT5e
3. Controls and Indicators
    a. The device shall include the following indicators:
        1) One (1) Green LED indicating a valid link to device by same manufacturer
        2) One (1) LED indicating that power is provided to device with the following modes:
            a. Green - device is operational
            b. Amber - device is booting
        3) One (1) Green LED indicating device is receiving HDMI signal
        4) Two (2) LEDs on RJ-45 connector with the following modes:
            a. Green - Connection established to device by same manufacturer
            b. Flashing Amber - non-HDCP video
            c. Amber - HDCP video
4. Connectors
    a. The device shall include the following connectors:
        1) One (1) HDMI input with support for the following:
            a. CEC Pass-through
            b. HDMI with HDR10, HDR10+, Dolby Vision, Deep Color and 4K60 4:4:4
            c. HDCP 2.3 compliant
            d. DisplayPort Dual-Mode
            e. Dolby Digital, Dolby Digital EX, Dolby Digital Plus, Dolby True HD, Dolby Atmos DTS, DTS-ES, DTS 96/24, DTS HD High Res, DTS HD Master Audio, DTS:X, LPCM up to 8 channels

f. DVI-D with adaptor
g. EDID
h. Common resolutions: 1920x1080 30Hz to 4096x2160 DCI 4K60 4:4:4
i. Custom resolutions: pixel clock rates up to 600 MHz

2) One (1) RJ45 shielded female connector with support for the following:
a. Link port for connection to compatible transmission device by same manufacturer
b. Power sharing option for connected remote transmission device

3) One (1) 2.1 x 5.5 mm DC power connector supporting the following characteristic:
a. 24 VDC 1.25 A power input

4) One (1) 4-pin 3.5 mm detachable terminal block IR input/output control port supporting the following characteristics:
a. IR input connects to IR signal source and transmits signal to IR out port on receiver device from same manufacturer
b. IR output connects to IR emitter and transmits IR signal from source connected to receiver device from same manufacturer
c. IR up to 60 kHz

5) One (1) 3-pin 3.5 mm detachable terminal block Serial control port supporting the following characteristics:
a. Bidirectional RS-232 up to 115.2k baud
b. Passes RS-232 TD/RD data to/from RS-232 port on receiver device from same manufacturer

5. Power
a. Power supply
1) Power supply shall support device and connected equipment
b. Power supply modes
1) Local or remote DC power source
2) Remote power supplied by opposite end of TX/RX pair.

6. Compliance
a. UL Listed for US & Canada, CE, IC, FCC Part 15 Class B digital device
b. Regulatory Model M202047002

2.15 SINGLE CABLE 4K HDMI RECEIVER

A. Crestron HD-RX-4KZ-101-1G

1. Device Architecture
a. Physical Form factor
1) Device enclosure and bracket to be composed of metal with black polycarbonate front label overlay

2) Device weight: 5.33 oz (152 g)

b. Mounting Option
   1) Wall mount device, mounts in a 1-gang (or larger) 2-1/4 inch (57 mm) deep U.S. electrical box or plaster ring (not included)
   2) Environmental Operating Conditions
      a. 32° to 104° F (0° to 40° C)
      b. 20% to 90% RH (non-condensing)

c. Functions
   1) Single UTP/STP cable transmission receiver
      a. Signal transmission up to 230 feet.
      b. Minimum cable type supported: UTP/STP CAT5e
   2) Remote control via control processor by same manufacturer

2. Controls and Indicators
   a. The device shall include the following indicators:
      1) One (1) Green LED indicating a valid link to device by same manufacturer
      2) One (1) LED indicating that power is provided to device with the following modes:
         a. Green - device is operational
         b. Amber - device is booting
      3) One (1) Green LED indicating transmission of HDMI signal
      4) Two (2) LEDs on RJ-45 connector with the following modes:
         a. Green - Connection established to device by same manufacturer
         b. Flashing Amber - non-HDCP video
         c. Amber - HDCP video

3. Connectors
   a. The device shall include the following connectors:
      1) One (1) HDMI output with support for the following:
         a. CEC Pass-through
         b. HDMI with HDR10, HDR10+, Dolby Vision, Deep Color and 4K60 4:4:4
         c. HDCP 2.3 compliant
         d. Common resolutions: 1920x1080 60Hz to 4096x2160 DCI 4K 4:4:4 60Hz
         e. Custom resolutions: pixel clock rates up to 600 MHz
         f. DVI-D with adaptor
         g. EDID
      2) One (1) RJ45 single cable HDMI transmission input with support for the following:

a. Link port for connection to compatible transmission device by same manufacturer
b. Power sharing option for connected remote transmission device

3) One (1) 2-pin 3.5 mm detachable terminal block supporting the following characteristic:
a. 24 VDC 0.75 A power input
4) One (1) Chassis grounding lug

4. Power
a. Power supply
1) Power supply shall support device and connected equipment
b. Power supply modes
1) Local or remote DC power source
2) Remote power supplied by opposite end of TX/RX pair.

5. Compliance
a. UL® Listed for US and Canada, CE, IC, FCC Part 15 Class B digital device
b. Regulatory Model M202045001

2.16 HD SINGLE CABLE RECEIVERS: REFERENCED PRODUCT CRESTRON DM-RX C-SERIES

A. HDR RECEIVER: REFERENCED PRODUCT CRESTRON DM-RMC-4KZ-100-C
1. Description
a. The signal receiver shall receive long distance 4K60 4:4:4 HDR HDMI transmission from compatible transmitter modules or ports. Receiver shall include the following outputs types and connections:
1) 4K60 4:4:4 HDR HDMI, HDR and HDCP2.2 compliant
a. Deep Color
b. 3D
2) DVI
b. Receiver shall include the following control port types for remote device control.
1) Serial RS-232 communication.
2) Infrared (IR) control.
c. Input card shall utilize VESA Display Stream Compression (DSC) to handle the extreme bandwidth requirement of resolutions beyond 4K30 4:4:4 and 4K60 4:2:0. DSC shall be applied only to 4K60 4:4:4 and HDR input signals. All other signals shall be transported uncompressed. The HDMI output port of receiver shall always be an uncompressed signal.
d. Receiver unit shall be a direct replacement for non 4K60 4:4:4 HDR version of same device type by the same manufacturer.
2. Performance

a. HDMI digital video, audio, and control output:
    1) One (1) 19-pin Type A HDMI female connector
    2) Supports 4K60 4:4:4 HDR HDMI
    3) Deep Color
    4) 3D
    5) Supports HDCP 2.2
    6) HDMI audio Support:
        a. Dolby Digital, Dolby Digital EX, Dolby Digital Plus, Dolby TrueHD, Dolby Atmos, DTS, DTS ES, DTS 96/24, DTS HD High Res, DTS HD Master Audio, DTS:X, LPCM up to 8 channels
    7) CEC device control.
b. Ethernet Port
    1) One (1) 8-wire RJ-45
    2) 10/100 Mbps, auto-switching, auto negotiating, auto-discovery, full/half duplex, DHCP
c. Single UTP/STP cable transmission connection
    1) Supports HDBaseT signal specifications.
    2) HDR10
    3) Deep Color
    4) 3D
    5) 4K60 4:4:4 support
    6) Supports remote power over UTP/STP cable through matrix switcher or midspan injector.
    7) The receiver shall support transmissions over manufacturer suggested STP cable, CAT5e or CAT6 cable, or better.
d. Power supply:
    1) Supports remote power over UTP/STP cable through matrix switcher or midspan injector.
    2) Local DC power source.
e. Mounting:
    1) Freestanding.
    2) Surface mount.
    3) Rack rail mount.
f. One (1) bidirectional RS-232 port:
    1) One (1) 5-pin 3.5mm detachable terminal block.
    2) GND, TX, RX, CTS, RTS support.
    3) Up to 115.2k baud, hardware and software handshaking support.
g. Two (2) IR/Serial ports:
    1) One (1) 4-pin 3.5mm detachable terminal block.
    2) IR output up to 1.1 MHz.
    3) 1-way serial TTL/RS-232 (0-5 Volts) up to 19200 baud.

B. 4K HD AUDIO/VIDEO SINGLE CABLE RECEIVER: REFERENCED PRODUCT CRESTRON DM-RMC-4KZ-SCALER-C

1. Input
   a. Signal Types
      1) DM 8G+, HDBaseT
   b. Output Signal
      1) Type HDMI, analog stereo
   c. Digital Formats
      1) Dolby Digital®, Dolby Digital EX, Dolby Digital Plus, Dolby® TrueHD, DTS®, DTS-ES, DTS 96/24, DTS-HD High Res, DTS-HD Master Audio™, LPCM up to 8 channels
   d. Analog Formats
      1) Stereo 2-Channel
   e. Digital-To-Analog Conversion
      1) 24-bit 48 kHz
   f. Analog Performance
      1) Frequency Response:
         a. 20Hz to 20kHz ±0.5dB;
      2) S/N Ratio:
         a. >95dB 20Hz to 20kHz A-weighted;
      3) THD+N:
         a. <0.005% @ 1kHz;
      4) Stereo Separation:
         a. >90dB
      5) Analog Volume Adjustment
         a. -80dB to 0dB

2. Communications
   a. Ethernet 10/100 Mbps, auto-switching, auto-negotiating, auto-discovery, full/half duplex, DHCP
   b. RS-232 2-way device control and monitoring up to 115.2k baud with hardware and software handshaking
   c. IR/Serial 1-way device control via infrared up to 1.1 MHz or serial TTL/RS-232 (0-5 Volts) up to 19.2k baud
   d. DigitalMedia DM 8G+, HDCP 2.2, EDID, CEC, PoDM+, Ethernet
   e. HDBaseT HDCP 2.2, EDID, CEC, Ethernet
   f. HDMI HDCP 2.2, EDID, CEC

3. Connectors
   a. COM (1) 5-pin 3.5mm detachable terminal block, bidirectional RS-232 port; Up to 115.2k baud, hardware and software handshaking support

b. IR 1 – 2 (1) 4-pin 3.5mm detachable terminal block comprising (2) IR/Serial ports; IR output up to 1.1 MHz; 1-way serial TTL/RS-232 (0-5 Volts) up to 19200 baud
c. AUDIO OUT L, R (1) 5-pin 3.5mm detachable terminal block; Balanced/unbalanced stereo line-level audio output; Output Impedance: 200 Ohms balanced, 100 Ohms unbalanced; Maximum Output Level: 4 Vrms balanced, 2 Vrms unbalanced
d. RELAY 1 – 2 (1) 4-pin 3.5mm detachable terminal block comprising (2) normally open, isolated relays; Rated 1 Amp, 30 Volts AC/DC; MOV arc suppression across contacts
e. Ground (1) 6-32 screw, chassis ground lug
f. LAN (1) 8-wire RJ45 female, shielded; 10Base-T/100Base-TX Ethernet port
g. HDMI OUT (1) 19-pin Type A HDMI female; HDMI digital video/audio output; Also supports DVI
h. DM IN (1) 8-pin RJ45 female, shielded; DM 8G+ input, HDBaseT compliant; PoDM+ PD (Powered Device) port; Connects to the DM 8G+ output of a DM switcher, transmitter, or other DM device, or to an HDBaseT device, via CAT5e, Crestron DM-CBL-8G, or Crestron DM-CBL-ULTRA cable
i. 24VDC 1.25A MAX (1) 2.1 x 5.5 mm DC power connector; 24 Volt DC power input; PW-2412WU power pack included

4. Controls & Indicators
   a. ACT (1) green LED, indicates activity
   b. SETUP (1) red LED and (1) miniature recessed pushbutton, for Ethernet setup
   c. RESET (1) miniature recessed pushbutton, for hardware reset
   d. LAN (2) LEDs, green LED indicates Ethernet link status, amber LED indicates Ethernet activity
   e. HDMI (1) green LED, indicates video signal presence at the HDMI output
   f. DM IN (2) LEDs, green LED indicates DM link status, amber LED indicates video and HDCP signal presence
   g. 24VDC (1) green LED, indicates operating power supplied via PoDM+ or local power pack Power Requirements Power Pack 1.25 Amps @ 24 Volts DC; 100-240 Volts AC, 50/60 Hz power pack, model PW-2412WU included Power over DM (PoDM) PoDM+ PD (Powered Device), capable of being powered by a PoDM+ PSE (Power Sourcing Equipment), conforms to IEEE 802.3at Type 2 Class 4 (25.5W) Note: May be powered via power pack or PoDM+, not both.

5. Environmental
   a. Temperature 32° to 104°F (0° to 40°C)
   b. Humidity 10% to 90% RH (non-condensing)
   c. Enclosure Chassis Metal, black finish, with (2) integral mounting flanges, vented top, front, and bottom

d. Mounting Freestanding, surface mount, or attach to a single rack rail

6. Dimensions
   a. Height 12.51 in (318 mm)
   b. Width 5.37 in (137 mm)
   c. Depth 1.08 in (28 mm)
   d. Weight 1.38 lb (625 g)

2.17 10.1″ TOUCH PANEL USER INTERFACE: REFERENCED PRODUCT CRESTRON TSW 1070

A. Crestron TSW-1070

1. Touch Screen Display
   a. Display Type TFT active matrix color LCD
   b. Size 10.1 inch (257 mm) diagonal
   c. Aspect Ratio 16:10 WXGA
   d. Resolution 1280 x 800 pixels
   e. Brightness 400 nits (cd/m^2)
   f. Contrast 950:1
   g. Color Depth 24-bit, 16.7M colors
   h. Illumination Edgelit LED w/auto-brightness control
   i. Viewing Angle ±80° horizontal, ±80° vertical
   j. Touch Screen Projected capacitive, 5-point multi-touch capable

2. Buttons
   a. Hard Keys (5) Projected capacitive pushbuttons, backlit w/auto-brightness control, per-button show/hide (backlight enable/disable), pre-labeled with icons for “Power”, “Home”, “Lights”, “Up”, and “Down”
   b. Reset (1) Miniature pushbutton on rear panel for hardware reset

3. Graphics Engine
   a. Crestron Smart Graphics, multi-language web browser [1], multi-language on-screen keyboard, screensaver, single scalable streaming video window, native Sonos app [1], native room scheduling application [4], setup and diagnostics via web browser or onscreen UI

4. Languages
   a. Smart Graphics
      1) Arabic, Chinese (Simplified), Chinese (Traditional), Czech, Danish, Dutch, English (UK), English (US), Finnish, French, German, Greek, Hebrew, Hungarian, Italian, Japanese, Korean, Norwegian, Polish, Portuguese, Portuguese (Brazilian), Romanian, Russian, Slovak, Spanish, Swedish, Thai

5. On-Screen Keyboard

a. Arabic, Chinese (Simplified), Croatian, Czech, Danish, Dutch, English (UK), English (US), Finnish, French (Canada), French (Switzerland), German, Hebrew, Hungarian, Italian, Japanese, Norwegian Bokmal, Polish, Portuguese, Russian, Serbian, Spanish, Swedish, Turkish

6. Voice Recognition
   a. Afrikaans (South Africa); Chinese, Mandarin (China, Simplified); Chinese, Mandarin (Hong Kong, Simplified); Chinese, Mandarin (Taiwan, Traditional); Chinese, Yue (Hong Kong, Traditional); Czech (Czech Republic); Dutch (Netherlands); English (Australia); English (Canada); English (Generic); English (India); English (New Zealand); English (South Africa); English (UK); English (US); French (France); German (Germany); isiZulu (South Africa); Italian (Italy); Japanese (Japan); Korean (South Korea); Polish (Poland); Portuguese (Brazil); Russian (Russia); Spanish (Spain); Turkish (Turkey)
7. Web Browser
   a. Arabic, Bulgarian, Catalan, Chinese, Croatian, Czech, Danish, Dutch, English, Filipino, Finnish, French, German, Greek, Hebrew, Hindi, Hungarian, Indonesian, Italian, Japanese, Korean, Latvian, Lithuanian, Norwegian Bokmal, Pashto, Persian, Polish, Portuguese, Romanian, Romansh, Russian, Serbian, Slovak, Slovenian, Spanish, Swedish, Thai, Turkish, Ukrainian, Vietnamese
8. Room Scheduling
   a. Chinese (Simplified), Chinese (Traditional), Danish, Dutch (Netherlands), English (US), English (UK), French, German, Hebrew, Italian, Japanese, Korean, Norwegian, Portuguese (Brazil), Portuguese (Portugal), Russian, Spanish, Swedish
9. Memory
   a. RAM 2 GB DDR3L
   b. Storage Firmware/Application: 4 GB Class 10 microSD card; System: 4 GB eMMC
   c. Maximum Project Size 600 MB
10. Communications
    a. Ethernet 10/100 Mbps, auto-switching, auto-negotiating, auto-discovery, full/half duplex, TCP/IP, UDP/IP, CIP, DHCP, SSL, TLS, SSH, SFTP (SSH File Transfer Protocol), IEEE 802.1X, SNMP, IPv4 or IPv6, IEEE 802.3at compliant
    b. USB USB 2.0 host for room availability hallway sign [3,4]
    c. Bluetooth Crestron PinPoint proximity detection beacon [2,5]
11. Streaming Decoder
    a. Video Formats H.264 (MPEG-4 part 10 AVC), MJPEG
    b. Audio Formats AAC stereo
    c. Bitrates Up to 25 Mbps (20 Mbps maximum recommended)
    d. Streaming Input Resolutions Up to 1920x1080@30fps

e. Streaming Protocol RTSP

12. Streaming Encoder & Camera [2]
    a. Camera Resolution 5.0 MP
    b. Field of View 50° horizontal
    c. Video Format H.264 (MPEG-4 part 10 AVC)
    d. Streaming Output Resolution 1280x720
    e. Streaming Protocol RTSP, ONVIF discovery
13. Audio
    a. Features Built-in microphone and speakers, Rava SIP Intercom, multi-language voice recognition
    b. Audio Feedback Formats MP3
14. Connectors
    a. LAN PoE
        1) (1) 8-pin RJ45 connector, female, with 2 LED indicators;
        2) 10Base-T/100Base-TX Ethernet port;
        3) PoE+ PD port;
        4) Green and yellow LEDs indicate Ethernet port status
    b. USB
        1) (1) USB Type A connector, female;
        2) USB 2.0 host port;
        3) For optional room availability hallway sign
15. Power
    a. Power over Ethernet IEEE 802.3at Type 2 compliant PoE+ PD (Powered Device);
        1) Normally requests 15 Watts from an 802.3at Type 2 PSE with LLDP advanced power management;
        2) With room scheduling and USB enabled, requests 18 Watts from an 802.3at Type 2 PSE with LLDP;
        3) Requests 30 Watts (PoE+ Class 4) from an 802.3at Type 2 PSE without LLDP;
        4) Requests 15.4 Watts (PoE Class 0) from an 802.3af (or 802.3at Type 1) PSE;
        5) Note: Enabling the USB port requires use of an 802.3at Type 2 PoE+ PSE
16. Environmental
    a. Temperature
        1) 32° to 112° F (0° to 45° C)
    b. Humidity
        1) 10% to 90% RH (non-condensing)
    c. Heat Dissipation

1) 44 BTU/hr

17. Enclosure
    a. Construction
        1) Plastic, smooth black or white finish, edge-to-edge glass with black or white surround
    b. Mounting
        1) Surface mount over a 2 or 3-gang US electrical box, 2-gang European (DIN 49073) electrical box, or 2-gang UK (BS 4662) electrical box;
        2) Lectern mount over a 2-1/5" H x 3-3/4" W (56 mm H x 96 mm W) cutout;
        3) 1-3/8" (35 mm) minimum mounting depth;
        4) Additional wall mount, surface mount, rack mount, and tabletop options available separately

18. Dimensions
    a. Height 6.59 in (168 mm)
    b. Width 10.23 in (260 mm)
    c. Depth 1.52 in (39 mm)
    d. Dimensions do not include the mounting bracket

19. Weight
    a. 23.9 oz (675 g)

20. Compliance
    a. UL Listed for US & Canada, IC, CE, FCC Part 15 Class B digital device.

2.18 PASSIVE LOUDSPEAKERS

A. FULL RANGE TWO-WAY COAXIAL LOUDSPEAKER: REFERENCED PRODUCT FULCRUM ACOUSTIC FH1566

1. Performance Specifications
    a. Operating Mode
        1) Single-amplified w/ DSP
    b. Operating Range
        1) 54 Hz to 20 kHz
    c. Nominal Beamwidth (rotatable)
        1) 60° x 60°
    d. Transducers
        1) LF: 15″ neodymium magnet cone driver, 3.5″ voice coil
        2) HF: 4″ titanium diaphragm, neodymium compression driver
    e. Power Handling @ Nominal Impedance
        1) 80 V / 800 W @ 8 Ω
    f. Nominal Sensitivity @ Input Voltage (whole space)

1) 106 dB @ 2.83 V
g. Nominal Maximum SPL (peak / continuous)
1) 141 dB / 135 dB
h. Equalized Sensitivity @ Input Voltage
1) 103 dB @ 2.83 V
i. Equalized Maximum SPL (peak / continuous)
1) 138 dB / 132 dB
j. Recommended Power Amplifier
1) 800 W to 1600 W @ 8 Ω

2. Physical Specifications
a. Connections
1) (2) Neutrik NL4 Speakon
a. Pin 1+/-: Full Range
b. Pin 2+/-: NC
b. Mounting / Suspension Points
1) (12) M10 x 1.5 eye bolt angle points, (1) M10 x 1.5 pull back point
2) (2) M12 x 1.75 yoke points
c. Finish
1) Black painted enclosure w/ matte black grille, or
2) White painted enclosure w/ matte white grille

B. FULL RANGE TWO-WAY LOUDSPEAKER: REFERENCED PRODUCT FULCRUM ACOUSTIC CCX1226

1. Performance Specifications
a. Operating Mode
1) Single-amplified w/ DSP
b. Operating Range
1) 68 Hz to 18 kHz
c. Nominal Beamwidth
1) 120° x 60°
d. Transducers
1) HF/LF: Coaxial 3.0″ titanium diaphragm compression driver;
2) 12.0″ woofer, 3.0″ voice coil; single neodymium magnet
e. Power Handling @ Nominal Impedance
1) 57 V / 400 W @ 8 Ω
f. Nominal Sensitivity @ Input Voltage (whole space)
1) 103 dB @ 2.83 V
g. Nominal Maximum SPL (peak / continuous)
1) 135 dB / 130 dB
h. Equalized Sensitivity @ Input Voltage
1) 98 dB @ 2.83 V

i. Equalized Maximum SPL (peak / continuous)
1) 130 dB / 124 dB
j. Recommended Power Amplifier
1) 400 W to 800 W @ 8 Ω

2. Physical Specifications
a. Connections
1) (2) Neutrik NL4 Speakon
a. Pin 1+/-: Full Range
b. Pin 2+/-: NC
b. Mounting / Suspension Points
1) (12) M10 x 1.5 eye bolt angle points, (2) M10 x 1.5 yoke points
c. Finish
1) Black painted enclosure w/ matte black grille, or
2) White painted enclosure w/ matte white grille

C. SUB-BASS LOUDSPEAKER: REFERENCED PRODUCT FULCRUM ACOUSTIC CS118
1. Performance Specifications
a. Operating Mode
1) Single-amplified w/ DSP
b. Operating Range 2
1) 29 Hz to 137 Hz
c. Nominal Beamwidth
1) Subcardioid (10 dB rear rejection) within operating range
d. Transducers
1) LF: 18.0” woofer, 4.0” voice coil; ceramic magnet
e. Power Handling @ Nominal Impedance 3
1) 98 V / 1200 W @ 8 Ω
f. Nominal Sensitivity @ Input Voltage 4 (half / whole space)
1) 103 dB / 97 dB @ 2.83 V
g. Nominal Maximum Continuous SPL (half / whole space)
1) 140 dB / 134 dB peak
2) 134 dB / 128 dB continuous
h. Equalized Sensitivity @ Input Voltage 5 (half / whole space)
1) 100 dB / 94 dB @ 2.83 V
i. Equalized Maximum SPL 6 (half / whole space)
1) 136 dB / 130 dB peak
2) 130 dB / 124 dB continuous
j. Recommended Power Amplifier
1) 1200 W to 1800 W @ 8 Ω
2. Physical Specifications
a. Connections
1) (2) Neutrik NL4 Speakon

a. Pin 1+/-: LF
b. Pin 2+/-: NC

b. Mounting / Suspension Points
1) (16) M10 eye bolt angle points
2) (4) M12 yoke points

c. Finish
1) Black painted enclosure w/ matte black grille

2.19 POWERED LOUDSPEAKERS

A. POWERED FLOOR MONITOR: REFERENCED PRODUCT ELECTROVOICE PXM-12MP

1. Frequency response (-3 dB):
a. 64 Hz - 20 kHz

2. Frequency range (-10 dB):
a. 53 Hz - 20 kHz

3. Monitor Angle:
a. 55°

4. Maximum SPL:
a. 129 dB

5. Coverage (H x V):
a. 90˚ x 90˚

6. Amplifier Rating:
a. 700 W

7. LF Channel Rating:
a. 500 W

8. HF Channel Rating:
a. 200 W

9. Crossover frequency:
a. 1.6 kHz

10. Transducer:
a. CXCA2128-1NA 12″ / 1.75″ 2-way coaxial

11. Connectors:
a. 2x XLR/TRS combo input
b. 1x Stereo RCA input
c. 1x XLR THRU input
d. 1x XLR MIXOUT output

12. Enclosure:

a. 15 mm Plywood

13. Grille:
    a. Steel with black powder coat
14. Color:
    a. Black
15. Dimensions (H x W x D):mm (in)
    a. 334 mm x 409 mm x 484 mm (13.1 in x 16.1 in x 19.0 in)
16. Net weight:
    a. 13.5 kg (29.8 lb)
17. Shipping weight:
    a. 15.6 kg (34.3 lb)
18. Power consumption:
    a. 100 - 240 V AC, 50 - 60 Hz, 0.8 - 0.5 A

2.20 LOW IMPEDANCE STEREO AMPLIFIERS

A. NETWORK AMPLIFIER: REFERENCED PRODUCT ASHLY NXP8002

1. The unit shall be a 2 channel multi-mode amplifier capable of driving 2 Ohm loads at full power. The maximum rated output power shall be 800W per channel at Low Z, 70V, and 100V mode. There shall be an automatic but defeatable sleep mode consuming <1W, and instant standby mode controlled by contact closure or software. A switch mode power supply shall auto-detect 110 – 120VAC or 220 – 240VAC mains, and a Neutrik® powerCON shall be used for the AC cord. Each channel shall have selectable output mode of Low Z, 70V, or 100V, an 80Hz high-pass filter, input limiter, and input gain settings of 26dB, 32dB, 38dB, or 1.4V. Each channel shall have remote DC level control. Input connectors shall be Neutrik® XLR/TRS combo jack and Euroblock, while output connectors shall be Neutrik® speakON. The unit shall have a front panel power switch and level controls that can be disabled. LEDs shall indicate Protect, Sleep, Disabled, Com, and Bridge mode status, as well as Temperature, Output Current, Output Signal, and Clipping/Mute status per channel. The unit shall have Ethernet control with a real-time clock for event scheduling. The unit shall have serial data remote control, aux preamp outputs, preset control, fault condition logic outputs, optional network audio and AES3 digital audio capability with the addition of a 4-Channel DAC card. The amplifier shall have temperature dependent variable speed forced-air cooling. The unit shall weigh <22.2 lbs (10.1kg), measure 19”W x 3.5”H x 16.8”D (483mm x 89mm x 428mm), and mount in a standard 19” rack. There shall be a five year warranty for units purchased in the US. No other unit shall be acceptable unless all

specifications represented herein are met or exceeded and submitted in writing by an independent testing agent.

2.21 LOW IMPEDANCE MULTI-CHANNEL AMPLIFIERS

A. NETWORK AMPLIFIER: REFERENCED PRODUCT ASHLY NXP1.54

1. The unit shall be a 4 channel multi-mode amplifier capable of driving 2 Ohm loads at full power. The maximum rated output power shall be 1,500W per channel at Low Z and 70V modes, and 1,250W in 100V mode. There shall be an automatic but defeatable sleep mode consuming <1W, and instant standby mode controlled by contact closure or software. A switch mode power supply shall auto-detect 110 – 120VAC or 220 – 240VAC mains, and a Neutrik® powerCON shall be used for the AC cord. Each channel shall have selectable output mode of Low Z, 70V, or 100V, an 80Hz high-pass filter, input limiter, and input gain settings of 26dB, 32dB, 38dB, or 1.4V. Each channel shall have remote DC level control. Input connectors shall be Neutrik® XLR/TRS combo jack and Euroblock, while output connectors shall be Neutrik® speakON. The unit shall have a front panel power switch and level controls that can be disabled. LEDs shall indicate Protect, Sleep, Disabled, Com, and Bridge mode status, as well as Temperature, Output Current, Output Signal, and Clipping/Mute status per channel. The unit shall have Ethernet control with a real-time clock for event scheduling. The unit shall have serial data remote control, aux preamp outputs, preset control, fault condition logic outputs, optional network audio and AES3 digital audio capability with the addition of a 4-Channel DAC card. The amplifier shall have temperature dependent variable speed forced-air cooling. The unit shall weigh <28.7 lbs (13kg), measure 19”W x 3.5”H x 16.8”D (483mm x 89mm x 428mm), and mount in a standard 19” rack. There shall be a five year warranty for units purchased in the US. No other unit shall be acceptable unless all specifications represented herein are met or exceeded and submitted in writing by an independent testing agent.

2.22 INTERCOM SYSTEMS

A. INTERCOM POWER SUPPLY: REFERENCED PRODUCT CLEAR-COM PS-702

1. Program Line Input
   a. Maximum Level before Clipping: >= 20dBu
   b. Input Impedance: >= 5KΩ
2. Frequency Response
   a. Program Input - Party-line: 200 - 20KHz ± 3dB
3. Max Distortion
   a. Program Input - Party-line : <= 0.2%

4. Noise
    a. Program Mic Input - Party-line:< -70dBu
5. Max Gain
    a. Program Input - Party-line: >= -16dB
6. Min Gain
    a. Program Input - Party-line: <= -20dB
7. Mains Power
    a. Input Voltage Range: 100 - 240 VAC
    b. Input Frequency Range: 50 - 60 Hz
    c. Input Power : <= 60 VAC
    d. Output Voltage: 30 VDC ± 0.5V
    e. Output Current per Channel (Continuous): 1.2 A
    f. Output Current per Channel (Peak): 2 A (Do not exceed the 1.2A rating for more than 2 seconds per 1 minute period)
    g. Short Circuit Recovery Time (1st short): <= 0.5 sec
    h. Short Circuit Recovery Time: >= 20 shorts in 20sec) <= 20 sec
8. Station Capacity
    a. Up to 40 RS-701 beltpacks or 10 speaker stations or 12 headset stations distributed over both channels
9. Rear Panel Connectors
    a. Intercom: (8) XLR-3M (2 per channel)
    b. Program: (1) XLR-3F
    c. AC Power: IEC 320 connector
10. Rear Panel Controls
    a. (4) Termination On-Off switches
    b. (1) Volume control
11. Front Panel Controls & Indicators
    a. (4) Program switch
    b. (4) Send level controls
    c. (4) Overload LEDs
    d. (1) Power indicator LED
    e. (1) Power switch
12. Environmental
    a. 32˚ - 122˚F (0 - 50˚C)
13. Dimensions
    a. 19 in. W x 1.75 in. H x 7.5 in. D (483 mm x 44 mm x 190 mm)
14. Weight
    a. 6.16 lbs. (2.80 kg)

B. INTERCOM BELTPACK: REFERENCED PRODUCT CLEAR COM RS-701

1. General
   a. Amplifier Design: I.C. amplifiers, including solid-state digital switching and signaling circuits. Current-limited and shortcircuit protected.
   b. Signal to Noise: >75 dB
   c. Bridging Impedance: >15k
   d. Line Level: -14 dB, +5 dB max.
   e. Sidetone Adjust: >35 dB
   f. EMI and RFI rejection: >60 dB

2. Microphone Pre-Amplifier
   a. Headset Mic Impedance: 200 ohms
   b. Gain, mic to line: 41 dB (dynamic)
   c. Limiter Range: 26 dB
   d. Frequency Response: 200 Hz – 12 kHz contoured for intelligibility

3. Headphone Amplifier
   a. Load Impedance: 50 - 2,000 ohms
   b. Output Level: +17 dBv before clipping
   c. Distortion: <0.1% THD @ 1 kHz
   d. Gain, line to output: +34 dB
   e. Frequency Response: 100 Hz - 18 kHz, ±2dB

4. Connectors
   a. Intercom Line: (2) 3-pin XLR–M–F
   b. Headset: 4-pin XLR–M

5. Power Requirements
   a. RS-601 26mA quiescent
   b. 30mA average talk
   c. 50mA talk with signaling
   d. DC Voltage Range: 12-32 volts

6. Environmental
   a. Operating Temp. Range: 0°C - 70°C (32°F - 158° F)
   b. Humidity: 0 - 90% relative humidity

C. SINGLE MUFF INTERCOM HEADSET: REFERENCED PRODUCT CLEAR COM CC-300

1. Headphones
   a. Transducer type: neodymium magnet, copper- clad aluminium wire voice coil
   b. Nominal impedance 400 ohm single muff
   c. Frequency response 40 to 20 kHz
   d. Maximum continuous SPL: 102 dB at 1 kHz

2. Microphone

a. Transducer type: Dynamic
b. Polar pattern: Hyper-cardioid
c. Frequency response: 300 to 20 kHz
d. Front-to-back ratios: > 15 dB

D. INTERCOM CIRCUIT SELECTOR SWITCH: REFERENCED PRODUCT TELEX AUDIOCOM WP-2

1. The intercom channel selector plate shall be a stainless steel wall plate finished in non-glaring black which shall install in a standard, single-gang electrical box and which shall provide belt-pack access to an intercom system. It have a two-position rocker switch to access either of two intercom channels.

2.23 MICROPHONES AND ACCESSORIES:

A. UHF WIRELESS MICROPHONE SYSTEM: REFERENCED PRODUCT SENNHEISER EVOLUTION EW-D SERIES

1. UHF BODYPACK TRANSMITTER: SENNHEISER EW-D SK
a. The bodypack transmitter shall be for use with a companion receiver as part of a digital wireless RF transmission system.
b. The bodypack transmitter shall operate within ten UHF frequency ranges, with a switching bandwidth of up to 56 MHz: 470.2 – 526 MHz, 520 – 576 MHz, 552 – 607.8 MHz, 606.2 – 662 MHz, 630 – 662 MHz, 662 – 693.8 MHz, 823.2 – 831.8 MHz, 863.2 – 846.8 MHz, 925.2 – 937.3 MHz, 1785.2 – 1799.8 MHz; selectable frequencies shall be up to 2,240.
c. The audio frequency response shall be between 20 Hz and 20 kHz (-3 dB) @ 3 dBfs. Audio total harmonic distortion (THD) shall be ≤ -60 dB for 1 kHz @ -3 dBfs input level. Dynamic range shall be 134 dB.
d. A programmable mute switch shall be provided to mute or unmute the audio signal.
e. The bodypack transmitter's parameters shall be configurable in the associated receiver's menu and synchronized with the bodypack transmitter via Bluetooth Low Energy (BLE).
f. Power shall be supplied to the bodypack transmitter by two 1.5 V AA size batteries or by one Sennheiser BA 70 rechargeable battery pack. Operating time shall be typically 12 hours with a battery pack and up to 8 hours with AA batteries.
g. Occupied bandwidth shall be 200 kHz. Transmit power (radiated) shall be 10 mW ERP (1785.2 – 1799.8 MHz Range: 12 mW ERP).
h. The bodypack transmitter shall have a rugged metal housing; dimensions shall be approximately 63 x 80 x 20 mm (2.48" x 3.15" x 0.79") without antenna. Weight

i. without the batteries shall be approximately 120 grams (0.26 lbs). Operating temperature shall range from −10 °C to +55 °C (+14 °F to +131 °F).
j. The bodypack transmitter shall be compatible with microphones for every application: Sennheiser lavalier microphones ME 2, ME 4, MKE 1, MKE 2 Gold and MKE Essential Omni, Sennheiser headset microphones HS 2, HSP 2, HSP Essential Omni, ME 3 and SL Headmic 1.

2. UHF HANDHELD TRANSMITTER: SENNHEISER EW-D SKM-S
   a. The handheld transmitter shall be for use with a companion receiver as part of a digital wireless RF transmission system.
   b. The handheld transmitter shall operate within ten UHF frequency ranges, with a switching bandwidth of up to 56 MHz: 470.2 – 526 MHz, 520 – 576 MHz, 552 – 607.8 MHz, 606.2 – 662 MHz, 630 – 662 MHz, 662 – 693.8 MHz, 823.2 – 831.8 MHz, 863.2 – 846.8 MHz, 925.2 – 937.3 MHz, 1785.2 – 1799.8 MHz; selectable frequencies shall be up to 2,240.
   c. The audio frequency response shall be between 20 Hz and 20 kHz (-3 dB) @ 3 dBfs. Audio total harmonic distortion (THD) shall be ≤ -60 dB for 1 kHz @ -3 dBfs input level. Dynamic range shall be 134 dB.
   d. A programmable mute switch shall be provided to mute or unmute the audio signal.
   e. The handheld transmitter's parameters shall be configurable in the associated receiver's menu and synchronized with the handheld transmitter via Bluetooth Low Energy (BLE).
   f. Power shall be supplied to the handheld transmitter by two 1.5 V AA size batteries or by one Sennheiser BA 70 rechargeable battery pack. Operating time shall be typically 12 hours with a battery pack and up to 8 hours with AA batteries.
   g. Occupied bandwidth shall be 200 kHz. Transmit power (radiated) shall be 10 mW ERP (1785.2 – 1799.8 MHz Range: 12 mW ERP).
   h. The handheld transmitter shall have a rugged metal housing; dimensions shall be approximately 50 mm (1.97") in diameter and 268 mm (10.55") in length including a Sennheiser MMD 835 microphone module. Weight including MMD 835 microphone module shall be approximately
   i. 304 grams (0.67 lbs). Operating temperature shall range from −10 °C to +55 °C (+14 °F to +131 °F).
   j. A range of different microphone heads shall be available for the handheld transmitter.

3. UHF WIRELESS RECEIVER: SENNHEISER EW-D EM
   a. The stationary receiver with switching diversity technology shall be for use with a companion transmitter as part of a digital wireless RF transmission system.

b. The receiver shall operate within ten UHF frequency ranges, with a switching bandwidth of up to 56 MHz: 470.2 – 526 MHz, 520 – 576 MHz, 552 – 607.8 MHz, 606.2 – 662 MHz, 630 – 662 MHz, 662 – 693.8 MHz, 823.2 – 831.8 MHz, 863.2 – 846.8 MHz, 925.2 – 937.3 MHz, 1785.2 – 1799.8 MHz; selectable frequencies shall be up to 2,240.
c. The receiver shall feature Bluetooth® Low Energy (BLE) at a frequency range between 2402 and 2480 MHz for remote controlling the devices via a control App for iOS and Android.
d. The audio frequency response shall be between 20 Hz and 20 kHz (-3 dB) @ 3 dBfs. Audio total harmonic distortion (THD) shall be ≤ -60 dB for 1 kHz @ -3 dBfs input level. Dynamic range shall be 134 dB.
e. The receiver shall be menu-driven with a backlit LC display showing the current frequency, channel number, metering of RF level, metering of AF level, lock status, muting function, mute lsock status, antenna switching diversity, app connection, gain, audio output level, menu and battery status of the associated transmitter. An auto-lock feature shall be provided to prevent settings from being accidentally altered.
f. The receiver shall feature a balanced XLR-3M audio output with a maximum output of +18 dBu along with an unbalanced ¼" (6.3 mm) audio output with a maximum output of +12 dBu. Two BNC-type input sockets shall be provided for connecting the antennas.
g. The receiver shall operate on 12 V power supplied from the power supply unit or from a Sennheiser EW-D ASA antenna splitter. Power consumption shall be ≤ 300 mA. The receiver shall have a rugged metal housing; dimensions shall be approximately 212 x 44 x 189 mm (8.35" x 1.73" x 7.44"). Weight shall be approximately 1000 grams (2.2 lbs) without antennas and power supply. Operating temperature shall range from −10 °C to +55 °C (+14 °F to +131 °F).

B. ACTIVE WIRELESS ANTENNA SPLITTER: REFERENCED PRODUCT SENNHEISER EW-D ASA

1. Frequency ranges
   a. EW-D ASA (Q-R-S): 470 – 694 MHz
   b. EW-D ASA CN/ANZ (Q-R-S): 470 – 694 MHz
   c. EW-D ASA (T-U-V-W): 694 – 1075 MHz
   d. EW-D ASA (X-Y): 1350 – 1805 MHz
2. Antenna splitter
   a. 2 x 1:4 or 1 x 1:8, active
3. Gain
   a. in A – out A: 0 ± 1 dB
   b. in A – out A1 ... A4: 0 ± 1 dB
   c. in B – out B1 ... B4: 0 ± 1 dB

4. IIP3
   a. > 25 dBm
5. Impedance
   a. 50 Ω
6. Reflection loss
   a. 10 dB (all RF outputs)
7. Operating voltage
   a. DC +12 V from NT 12-35 CS power supply unit
8. Current consumption
   a. 210 mA
9. Total current consumption
   a. max. 3 A (with 4 EW-D EM and connected EW-D AB)
10. Supply for antenna boosters at ANT RF in A and ANT RF in B
    a. DC 12 V, 320 mA
11. Supply for receivers at A1 to A4
    a. DC 12 V, Typically 350 mA, max. 500 mA
12. Dimensions
    a. Approx. 212 x 168 x 43 mm
13. Weight
    a. Approx. 1100 g
14. Operating temperature range
    a. -10 °C - +55 °C (14 °F - 131 °F)
15. Storage temperature range
    a. -20 °C - +70 °C (-4 °F - 158Y °F)
16. Relative humidity
    a. 5 - 95 % (non-condensing)

C. OVER-EAR WIRELESS MIC ELEMENT: REFERENCED PRODUCT AV-JEFE AVL630

1. Element : Back Electret Condenser
2. Polar Pattern : Omnidirectional
3. Frequency : 50 Hz - 18,000 Hz
4. Sensitivity : - 60 dB +/- 3dB
5. Impedance : 1,500 Ohms +/- 30% (at 1 Khz)
6. Color: Beige-color
7. Dimension : f5.2 x 144mm
8. Capsule Diameter: 5mm
9. Operating Voltage : 1V - 10V DC

D. GENERAL PURPOSE HANDHELD SWITCHED VOCAL MICROPHONE: REFERENCED PRODUCT SHURE SM58
   1. Dynamic Element
   2. Frequency response: 50-15,000 Hz
   3. Type: Unidirectional (Cardioid)
   4. Sensitivity: -56dB
   5. Stand clip included

E. LARGE DIAPHRAGM VARIABLE PATTERN CONDENSER MICROPHONE REFERENCED PRODUCT ASTATIC M179
   1. The microphone shall be a dual diaphragm externally biased condenser microphone. The frequency response shall be 10Hz - 20KHz. The microphone shall have a continuously variable polar pattern.
   2. The sensitivity shall be -36dBV (16mV) @ 1Pa. The microphone shall have a professional 3 pin XLR type output connector. The microphone shall have a switch selectable 100Hz high pass filter with a 6dB per octave slope when enabled. The microphone shall have a switch selectable 20dB non-capacitive pad. The microphone will operate from standard 48V phantom power with a current consumption of 8mA.
   3. The dimensions of the microphone shall be 6 11/16" tall, 2" wide, and 15/16" high. The weight of the microphone shall be 17.8 oz (506 grams) not including the shockmount. The microphone will have a durable urethane painted finish. The microphone will supplied be with a shockmount.

F. OVERHEAD MICROPHONE: REFERENCED PRODUCT SENNHEISER ME36 WITH MZH 3015 GOOSENECK
   1. The microphone shall be a screw-on back-electret condenser, super-cardioid/lobar, mini-shotgun microphone and shall have a pressure gradient transducer/interference tube transducer. The microphone capsule shall mate with the Sennheiser MZH series of gooseneck mounts. The microphone shall accept phantom powering over the range from 12 to 48 volts DC. The response of the microphone shall be 40 Hz – 20 kHz. The microphone shall have a sensitivity of 18 mV/Pa. The electrical impedance of the microphone shall be 50 ohms. The microphone shall have an equivalent noise level of 23 dB(A).

2.24 BLUETOOTH AUDIO OVER CAT6 TRANSMITTER: REFERENCED PRODUCT RDL D-BT1A

A. Output: RDL Format-A (RJ45)

B. Format-A Input: RJ45 LOOP IN

C. Format-A Signal Pair Used: A, B, or C (summed mono mode, rear-panel switch-

selectable); B and C (stereo mode, pair A pass through)

D. Frequency Response: 20 Hz to 20 kHz (± 0.5 dB)

E. THD+N: < 0.1%

F. Noise below -20 dBFS: < -70 dB

G. Crosstalk (channel to channel): < 70 dB

H. Audio Operating Levels: -20 dBFS = +4 dBu (balanced), nominal

I. Ambient Operating Environment: 0° C to 40° C

J. Power Requirement: 24 Vdc @ 100 mA (through RJ45)

K. Dimensions: 1.73" (4.39 cm) W; 4.11" (10.44 cm) H; 1.62" (4.11 cm) D

2.25 AUDIO OVER CAT6 RECEIVER: REFERENCED PRODUCT RDL TX-TPR2A

A. Input:RDL TP Format-A

B. Input Connection: RJ45

C. Format-A Signal Pairs Used (2): B, C

D. Outputs (4): 150 Ω Balanced (2); 1 kΩ Unbalanced (2)

E. Output Connections: Detachable Terminal Block

F. Output Level: +4 dBu Bal., +22 dBu Max; -10 dBV Unbal., nominal

G. Frequency Response: 10 Hz to 30 kHz (+/- 0.1 dB)

H. THD+N: < 0.005%

I. Noise (below +4 dBu): < -90 dB

J. Crosstalk: < -90 dB (1 kHz); < -75 dB (20 Hz to 20 kHz)

K. Headroom: > 20 dB (above +4 dBu)

L. CMRR: > 60 dB (50 Hz to 150 Hz)

M. Indicator: Power LED

N. Power Connections (2): Power Jack; RJ45

O. Power Requirement: 24 Vdc @ 30 mA

P. Dimensions: 3.0" (7.6 cm) W; 1.6" (4.08 cm) H; 1.2" (3.05 cm) D

2.26 2X4 LINE LEVEL DISTRIBUTION AMPLIFIER: REFERENCED PRODUCT RADIO DESIGN LABS ADA4D

A. Inputs (2):

1. Stereo (A/left and B/right) on detachable terminal block

B. Input Impedance:

1. 20 kΩ balanced or 10 kΩ unbalanced

C. Input Level:

1. +4 dBu balanced (nominal), +25 dBu maximum; -10 dBV unbalanced

D. Input Gain Adjustments (2):

1. -5 dB to +15 dB (rel. +4 dBu balanced); -3 dB to +17 dB (rel. -10 dBV unbalanced)

E. Input Metering (2):

1. Dual-LED VU Meter for Input A and Input B

F. Mono mode:

1. Rear-panel switch-selectable (input A feeds all 8 outputs)

G. Outputs (8):

1. Stereo, A (4), B (4) on detachable terminal blocks

H. Output Impedance:

1. 150 Ω balanced; 75 Ω unbalanced

I. Output Level:

1. +4 dBu balanced (nominal), +24 dBu maximum; -10 dBV unbalanced

J. Output Level Adjustments (8):

1. -9 dB to +6 dB (rel. +4 dBu, balanced); -3 dB to + 12 dBu (rel. -10 dBV, unbalanced)

K. Frequency Response:

1. 10 Hz to 165 kHz (+/- 0.25 dB); 10 Hz to 35 kHz (+/- 0.01 dB)

L. THD+N:

1. < 0.0025% (20 Hz to 20 kHz)

M. Headroom:

1. > 20 dB (above +4 dBu input or output)

N. Noise:

1. < -92 dB (below +4 dBu output, 20 Hz to 20 kHz)

O. Crosstalk:

1. < -90 dB (20 Hz to 5 kHz); <-80 dB (5 kHz to 20 kHz)

P. CMRR:

1. > 90 dB (100 Hz)

Q. Ambient Operating Environment:

1. 0° C to 50° C

R. Power Requirement:

1. GROUND REFERENCED, 24 Vdc @ 82 mA (idle, nominal), 120 mA (max.)

S. Case dimensions:

1. 5.75" (14.6 cm)W x 1.65" (4.18 cm)H x 3.54" (9.0 cm)D; 3.9" (9.9 cm)D with connectors

2.27 1000VA UPS BACKUP: REFERENCED PRODUCT MID ATLANTIC UPX-1500R-2

A. Rackmount UPS shall operate on 120 VAC/60Hz current. Rackmount UPS shall have a nominal output of 120V. Rackmount UPS shall have a capacity of 1000 VA and 600 W (refer to chart). Rackmount UPS shall have 6 NEMA 5-15R receptacles on the rear of the unit. Rackmount UPS shall have a priority outlet bank consisting of 3 outlets dedicated to ensure maximum run time of critical components. Rackmount UPS shall have a non-critical outlet bank consisting of 3 outlets dedicated to load shedding. Rackmount UPS shall have a simulated sine wave output waveform. Rackmount UPS shall have an 8ms transfer time. Rackmount UPS shall be IP enabled when used with option IP Expansion card, model# UPS-IPCARD. Rackmount UPS shall include a 10’ 15A power cord with NEMA 5-15 plug. Rackmount UPS shall have surge suppression that utilizes a clean line-to-neutral design that does not pass noise contamination to ground. Rackmount UPS

shall allow for a 13 minute run time at half load and a 3 minute run time at full load. Rackmount UPS shall be RoHS EU Directive 2002/95/ EC & 2011/65/EU 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.

2.28 RACKS, FURNITURE, AND HARDWARE

A. SWING OUT WALL RACK: REFERENCED PRODUCT MID ATLANTIC AUDIO DWR SERIES

1. EIA compliant 19″ wall mount rack. Tool-Free Quick-MountTM system enables one-person installation. Center section and backpan shall be 16-gauge steel, phosphate pre-treated and finished in a black or granite gray textured powder coat (black finish is standard, suffix part # with GY to indicate a granite gray finish) . 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 rackspaces. Rack shall be constructed to swing open for component cabling access, center section shall pivot for either left or right opening. Backpan includes raised mounting embosses to mount power products and other accessories. Rack shall have 3/4″, 1″, 1-1/2″, 2″ and 3″ electrical knockouts, Decora R knockouts, and BNC knockouts for UHF/VHF antennas knockouts top and bottom. Large laser knockout on backpan shall have a 12-1/2″ x 12-1/2″ opening for cable-pass-through. Fan knockouts on top and bottom shall allow for installation of up to four 4-1/2" fans. Top, bottom and sides shall feature vertical vent pattern. Rack shall be UL Listed in the US and Canada.
2. PROVIDE WITH THE FOLLOWING OPTIONS
    a. Front doors shall be 16-gauge steel - vented.
    b. Vent Blockers used to promote active thermal management.

B. FLOOR STANDING METAL RACK: REFERENCED PRODUCT MID ATLANTIC AUDIO SLIM-5 SERIES

1. EIA compliant 19″ gangable ready-to-assemble equipment rack shall have a static load capacity of 1,000 lbs. and a UL Listed 400 lb. weight capacity. Slim 5 series rack shall be of ready-to-assemble construction. Rack top and bottom shall be constructed of 14-gauge steel; horizontal braces shall be 13-gauge steel. Top, bottom and braces shall be phosphate pre-treated and finished in black powder coat. Rack uprights shall be 11-gauge steel rackrail with tapped 10-32 mounting holes in universal EIA spacing with black e-coat finish and numbered rack spaces. Rack features eight 1/2″ or 3/4″ cable knockouts, four in top and four in base. Rack shall be UL listed in the US and Canada. Rack is warranted to be free from defects

in material or workmanship under normal use and conditions for the lifetime of the rack.

2. PROVIDE WITH THE FOLLOWING OPTIONS:
    a. Removable side panels
    b. Rear access pan shall be constructed of 18-gauge steel and come with keylock
    c. Adjustable Split Rackrail* (for rear equipment support) shall be constructed of 11-gauge steel and mount to accompanying 13-gauge steel brackets

C. RACK DRAWERS: REFERENCED PRODUCT MIDDLE ATLANTIC AUDIO D SERIES.

1. EIA compliant 19" rackmount drawer shall have a 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. 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.
2. 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.
3. 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.

D. VENT PANELS: REFERENCED PRODUCT MIDDLE ATLANTIC VT SERIES

1. EIA compliant 19" vent panels shall be constructed of 16-gauge perforated steel and shall have a black powdercoat finish. Vent panel shall be GREENGUARD Indoor Air Quality Certified for Children and Schools. Vent panel shall be RoHS EU Directive 2002/95/EC compliant. Vent panel shall be manufactured by an ISO 9001 and ISO 14001 registered company. Vent panel shall be warrantied to be free from defects in material or workmanship under normal use and conditions for the lifetime of the product.
2. Perforations
    a. Perforation pattern shall be: 5/32" dia. hole, with 3/16" staggered centers Open Area 64%

E. BLANK PANELS: REFERENCED PRODUCT MIDDLE ATLANTIC BL SERIES

1. Blank panels shall be constructed of 1/16" thick aluminum. Blank panels shall be RoHS EU Directive 2002/95/EC compliant. Blank panels shall be manufactured by an ISO 9001 and ISO 14001 registered company. Blank panels shall be warrantied

to be free from defects in material or workmanship under normal use and conditions for the lifetime of the panel.

2.29 RACK WORK LIGHT: REFERENCED PRODUCT SOUNDOLIER RWL-2

A. Portable lamp with wide light diffusion provides illumination of interior rack spaces. Supplied with a "non-mar" magnetic mount, 3-wire grounded AC outlet, on-off switch, high impact clear polycarbonate lens, two 10-Watt incandescent lamps (one for replacement) and six-foot power cord. Assembly is 18 and 22-gauge CRS. Standard finish is flat black epoxy.

2.30 VOICE-ACTIVATED RELAY: REFERENCED PRODUCT BOGEN COMMUNICATIONS VAR1

A. The unit shall be a voice-activated, DPDT style relay device that is activated upon detection of a signal at the microphone pre-amp or at either of the 70V, 25V or 600-ohm line level inputs.

B. The unit shall be capable of muting a sound system, activation of accessory equipment or activation of a zone-paging module.

C. The unit shall incorporate a selectable slide switch by which the user can select either the pre-amp input or the line inputs for sensing activation.

D. The VOX detect circuit shall include volume, sensitivity and delay controls.

E. The audio output shall be an isolated 600-ohm transformer.

F. The unit shall operate on DC power from an external power supply. Contractor is to provide the appropriate power supply for this unit and locate it in the rack near the voice-activated relay device.

G. The unit shall have the following system specifications:

1. Line Input:
    a. Impedance: 600 ohms
    b. Frequency Response: 100 Hz to 10 kHz
    c. 70V Input Impedance: 200k ohms
    d. Output Level: 400 m VRMS
    e. 25V Input Impedance: 75k ohms
    f. Output Level: 420 m VRMS
2. Mic Preamp:
    a. Gain: 62 dB
    b. Sensitivity: 750 micro volts, RMS for 1 VRMS out

c. Distortion: <2%
d. Frequency Response: 200 Hz to 10 kHz
e. Output Signal-to-Noise Ratio: 55 dB
f. VOX Sensitivity: 20 mV - 150 m VRMS @ 600 ohms Line input
g. Time Delay Range (approx.): 0.25 to 25 sec.
h. Relay Contact Rating: 2 amps/30 VDC, 0.5 amp/120 VAC

H. The voice-activated relay shall be set to mute the sound system (via the contact closures on the sound system processor) in the auditorium during an all-call or emergency page of the building. Contractor shall obtain the paging system feed (which the EC will run to the audio rack location) and shall wire this to the voice activated relay device.

2.31 43" LED DISPLAY: REFERENCED PRODUCT PANASONIC TH-43SQE2

A. DISPLAY PANEL

1. Screen Size (Diagonal)
   a. 43-inch class (1079.8 mm / 42.51 inch)
2. Panel type
   a. Backlight ADS / Direct-LED
3. Aspect ratio
   a. 16:9
4. Effective Display Area (W x H)
   a. 941.1 x 529.4 mm (37.05" x 20.84")
5. Resolution (H x V)
   a. 3840 x 2160
6. Brightness (Typ)
   a. 500 cd/m2
7. Contrast Ratio (Typ)
   a. 1200:1
8. Dynamic Contrast Ratio
   a. 50000:1
9. Max. Display Colors Approx.
   a. 1.07 Billion
10. Response Time (Typ)
    a. 8.0 ms (G to G)
11. Viewing Angle
    a. (Horizontal / Vertical) 178 ° / 178 ° (CR>10)

12. Panel Life Time
    a. (Typ) Approx. 50000 hours
13. Panel Surface Treatment
    a. Anti-glare type (Haze 25%)

B. CONNECTION TERMINAL

1. HDMI IN
   a. HDMI Type A Connector x 4 (HDCP2.2)
2. DisplayPort IN
   a. DisplayPort x 1 (HDCP2.2)
3. DIGITAL OUT
   a. HDMI Type A Connector x 1 (HDCP2.2)
4. SERIAL IN
   a. Stereo mini jack (Φ3.5 mm) x 1, RS-232C Compatible
5. IR IN
   a. Stereo mini jack (Φ3.5 mm) x 1
6. AUDIO OUT
   a. Stereo mini jack (Φ3.5 mm) x 1
   b. SPDIF x 1
7. LAN
   a. RJ45 x 1 compatible with PJLinkTM 10BASE-T/100BASE-TX
8. USB
   a. USB connector TYPE A x 1 : DC5 V / MAX 0.9 A, (USB 3.0 is supported)
   b. USB connector TYPE A x 1 : DC5 V / MAX 0.5 A, (USB 2.0 is supported)
   c. USB connector TYPE A x 1 : DC5 V / MAX 0.5 A, (USB 2.0 is supported) (Internal)
   d. USB connector TYPE C x 1 : DC5 V / MAX 3.0 A, (USB 3.0 is supported, DP Alt Mode)
9. microSD
   a. microSD / SDHC / SDXC / MAX 1TB
10. Wifi / Bluetooth® Built-in
    a. IEEE 802.11 a/b/g/n/ac Dual band Bluetooth® 5.1, HID / A2DP
11. SLOT
    a. Intel® SDM specification
    b. Corresponding size SDM-S / SDM-L, Supply power 50 W

C. AUDIO

1. Built in Speaker
    a. 16 W [8 W + 8 W]

D. ELECTRICAL

1. Power Supply
    a. AC110-240 V 50 Hz / 60 Hz 2.4 A-1.2 A
2. Power Consumption
    a. 110 W (Shipping Condition)
3. On Mode Average Power Consumption
    a. 105 W (Picture Mode: [Natural])
4. Power Off Condition
    a. 0 W
5. Stand-by Condition
    a. 0.5 W
6. Apparent power
    a. 233 VA
7. Energy efficiency class for Europe
    a. 1 Based on IEC 62087 Ed.2 measurement method

E. MECHANICAL

1. Dimension (W x H x D) Not including remote controller sensor
    a. 964 x 555 x 83 mm (37.92" x 21.85" x 3.26")
2. Weight
    a. 10.6 kg / 23.4 lbs
3. Cabinet Material
    a. Front: Metal, Side / Back: Plastic
4. Bezel Color
    a. Black
5. Bezel Width
    a. T/R/L 8.4 mm (0.33") B 12 mm (0.47")
6. Pitch for Wall-Hanging
    a. VESA Compliant 200 x 200 mm (7.9" x 7.9") (Installed by: M6 screws / Screw hole depth: 10 mm (0.39"), Allowable screw length 23 mm (0.91"))

F. INSTALLATION

1. Orientation
    a. Landscape / Portrait (clockwise rotation)

2. Tilting Angle
    a. Landscape / Portrait installation 45 degrees forward/backward

G. ENVIRONMENTAL

1. Operating Environment
    a. Temperature: 0 °C to 40 °C (32 °F to 104 °F) : 0 °C to 35 °C (32 °F to 95 °F)
    b. Humidity: 20% to 80% (No condensation)

H. STANDARD (CERTIFICATIONS)

1. SAFETY REGULATIONS
    a. UL 62368-1, CSA C22.2 No. 62368-1 EN62368-1
2. RADIATION REGULATIONS
    a. FCC 47 CFR Part 15 Subpart B, ICES-003
    b. EN55032, EN55035, EN61000-3-2, EN61000-3-3

I. WIRELESS LAN

1. Compliance standard IEEE 802.11 a/b/g/n/ac Dualband (Wireless LAN Standerd protocol)
2. Channel CH 1-13, CH 36-64, CH 100-140
3. Communication range Approx. 30 m (Depends on usage environment)

J. Bluetooth®

1. Supported version Bluetooth® 5.1
2. Profile HID / A2DP

2.32 4K30P PTZ CAMERA: REFERENCED PRODUCT PANASONIC AW-UE50

A. Imaging

1. Image Sensor
    a. 1/2.5"-Type MOS
2. Horizontal Resolution (TV Lines)
    a. 1500 TV Lines
3. Built-In ND Filter
    a. No
4. Image Stabilization
    a. Optical in Integrated Lens
5. Focus Control
    a. Autofocus
    b. Manual Focus

B. Exposure Control
   1. Shutter Type
      a. Electronic Rolling Shutter
   2. Shutter Speed
      a. 1/10000 to 1/25 Second
   3. Gain
      a. 0 to 36 dB (Native)
   4. Minimum Illumination
      a. 3 Lux
   5. White Balance
      a. 2000 to 15,000K

C. Lens
   1. Focal Length
      a. 4.1 to 98.9mm (35mm Equivalent: 25 to 600mm)
   2. Optical Zoom Ratio
      a. 24x
   3. Max Digital Zoom
      a. 36x (in 1080p)
   4. Field of View
      a. Horizontal: 74.1 to 3.3°
      b. Vertical: 46 to 1.9°
      c. Diagonal: 81.8 to 3.8°
   5. Maximum Aperture
      a. f/1.8 to 4
   6. Minimum Focus Distance
      a. Wide: 3.9" / 10.0 cm
      b. Telephoto: 47.2" / 120.0 cm

D. Video Capture
   1. External Recording Modes
      a. 4:2:2 10-Bit via HDMI
         1) 3840 x 2160 at 24.00/25/29.97 fps
         2) 1920 x 1080p at 23.98/24.00/25/29.97/50/59.94 fps
         3) 1920 x 1080i at 50/59.94 fps
         4) 1280 x 720 at 50/59.94 fps
      b. SDI/BNC

1) 1920 x 1080p at 23.98/24.00/25/29.97/50/59.94 fps
2) 1920 x 1080PsF at 23.98/25/29.97 fps
3) 1920 x 1080i at 50/59.94 fps
4) 1280 x 720 at 50/59.94 fps

c. RJ45 / USB
1) 1920 x 1080p at 25/29.97/50/59.94 fps
2) 1280 x 720 at 25/29.97/50/59.94 fps
3) 640 x 360 at 25/29.97/59.94 fps
4) 320 x 180p at 25/29.97/50/59.94 fps

2. Audio Recording
a. 2-Channel 16-Bit 48 kHz AAC LC Audio

3. Broadcast Output
a. NTSC/PAL

4. IP Streaming
a. H.264, H.265, MJPEG, NDI|HX, RTMP, RTMPS, RTP, RTSP, SRT, TCP, UDP
1) 1920 x 1080
2) 1280 x 720
3) 640 x 360
4) 320 x 180

E. Control

1. Move Speed
a. Pan: 0.08 to 180°/sec
b. Tilt: 0.08 to 180°/sec

2. Movement Range
a. Pan: 350° (-175 to 175°)
b. Tilt: 120° (-30 to 90°)

3. Tally Light
a. Yes

4. Supported Control Protocols
a. RS-422

F. Interface

1. Video I/O
a. 1x HDMI 1.4 Output
b. 1x BNC (3G-SDI) Output
c. 1x USB-C 3.0 / 3.1/3.2 Gen 1 Output

2. Audio I/O
a. 1x 1/8" / 3.5 mm TRS Stereo Mic/Line Input

3. Other I/O
    a. 1x RJ45 (LAN) Control Input
    b. 1x RJ45 (RS-422) Input

G. Power

1. PoE Support
    a. PoE+ 802.3at
2. Power I/O
    a. 1x Barrel (10.8 to 13.2VDC) Input
3. Power Consumption
    a. Power Supply: 10.8 to 13.2 VDC at 1.8 A
    b. PoE: 42 to 57 VDC at 0.6 A

H. Environmental

1. Operating Temperature
    a. 32 to 104°F / 0 to 40°C
2. Storage Temperature
    a. -4 to 122°F / -20 to 50°C
3. Operating Humidity
    a. 20 to 90%

I. General

1. OS Compatibility
    a. Windows 10 to 11 (32-/64-Bit)
    b. macOS 10.14 to 11.0.1
    c. iPadOS
2. Certifications
    a. FCC Part 15 Class A, ICES-003(A)
3. Sound Level
    a. NC25
4. Dimensions (W x H x D)
    a. 6.3 x 7.6 x 6.5" / 160 x 192.1 x 166 mm
5. Weight
    a. 4 lb / 1.8 kg

2.33 17,000 LUMEN WUXGA 3LCD LATER PROJECTOR: REFERENCED PRODUCT PANASONIC PT-MZ17KLBU

A. Projector type
    1. LCD projectors

B. DLP™ chip | Panel size (mm)
    1. 25.4 mm (1.0 in) diagonal (16:10 aspect ratio)

C. DLP™ chip | Panel size (inch)
    1. 25.4 mm (1.0 in) diagonal (16:10 aspect ratio)

D. DLP™ chip | Display method
    1. Transparent LCD panel (x 3, R/G/B)

E. DLP™ chip | Number of Pixels
    1. 2,304,000 (1920 x 1200) pixels x 3, total of 6,912,000 pixels

F. Light source
    1. Laser diodes

G. Light output
    1. 17,000 lm

H. Time until light output declines to 50 %
    1. 20,000 hours (NORMAL) / 24,000 hours (ECO)

I. Resolution
    1. 1920 x 1200 pixels

J. Screen size [diagonal] (mm)
    1. 1.78–25.4 m (70–1,000 in), 16:10 aspect ratio

K. Screen size [diagonal] (inch)
    1. 1.78–25.4 m (70–1,000 in), 16:10 aspect ratio

L. LENS
    1. Optional powered zoom lenses

M. Keystone correction range
    1. Vertical: ±40°, Horizontal: ±15°

N. Installation

1. Ceiling/floor, front/rear, free 360-degree installation

O. Terminals | SDI IN

1. BNC x 1: 3G/HD/SD-SDI input

P. Terminals | HDMI IN

1. HDMI 19-pin x 1 (Compatible with HDCP, Deep Color)

Q. Terminals | DVI-D IN

1. DVI-D 24-pin x 1 (DVI 1.0 compliant, compatible with HDCP, compatible with single link only)

R. Terminals | MULTI PROJECTOR SYNC IN

1. BNC x 1

S. Terminals | MULTI PROJECTOR SYNC OUT

1. BNC x 1

T. Terminals | SERIAL IN

1. D-sub 9-pin (female) x 1 for external control (RS-232C compliant)

U. Terminals | SERIAL OUT

1. D-sub 9-pin (male) x 1 for link control

V. Terminals | REMOTE 1 OUT

1. M3 stereo mini-jack x 1

W. Terminals | REMOTE 2 IN

1. D-sub 9-pin (female) x 1 for external control (parallel)

X. Terminals | LAN

1. RJ-45 x 1 for network connection, 10Base-T, 100Base-TX (Compatible with PJLink™ [Class 2], Art-Net)

Y. Terminals | DIGITAL LINK/LAN

1. RJ-45 x 1 for network and DIGITAL LINK connection (HDBaseT™ compliant), 100Base-TX (Compatible with PJLink™ [Class 2], Art-Net, HDCP, Deep Color)

Z. Power supply
    1. AC 100-240 V, 50/60 Hz

AA. Cabinet materials
    1. Molded plastic

BB. Operation noise
    1. 38 dB

CC. Dimensions (W x H x D) (inch)
    1. 650 x 185*3 x 440 mm (25 19/32″ x 7 9/32″ x 17 5/16″) (Without lens) (Not including protruding parts)

DD. Operating environment
    1. Operating temperature: 0–45 °C (32–113 °F); Operating humidity: 10–80 % (no condensation)

EE. Applicable software
    1. Logo Transfer Software, Multi Monitoring & Control Software, Early Warning Software, Geometry Manager Pro, Smart Projector Control for iOS/Android™

FF. Terminals | REMOTE 1 IN
    1. M3 x 1 for wired remote control

GG. Contrast Ratio
    1. 3,000,000:1 (Full On/Full Off)

HH. Terminals | USB
    1. USB Connector (Type A) x 1 (Output 5 V/2 A)

II. Center-to-corner zone ratio
    1. 90 %

JJ. Filter
    1. Included (Estimated maintenance time: approx. 20,000 hours)

KK. Terminal | RGB In
    1. D-sub HD 15-pin (female) x 1 (RGB/YPBPR/YCBCR)

LL. Weight

1. Approx. 22.3 kg (49.2 lbs)

2.34 MOTORIZED PROJECTION SCREEN: REFERENCED PRODUCT DA-LITE TENSIONED PROFESSIONAL ELECTROL

A. Tensioned System.

1. Screen Operation: Electrically operated, UL and ULC listed, retractable, heavy duty, with rigid metal roller and motor housed within the roller. Tab guide cable tensioning system to maintain even, lateral tension and hold viewing surface flat. Bottom end of fabric to be inserted into a custom aluminum slat bar with added weight to provide vertical tension on the screen surface.
   a. Motor: Single motor, UL and ULC certified, 3-wire permanently lubricated reversal-type, attached to header, with preset adjustable limit switches to automatically stop viewing surface in UP or DOWN position. Includes automatic thermal overload protection, integral gears, capacitor and electric brake to prevent coasting.
      1) Voltage, Frequency: 115 V, 60 Hz.
      2) Amperage: 2.4 amps.
      3) Limit Switches: Preset and adjustable to automatically stop viewing surface in UP or DOWN position.
      4) Housing: Inside metal roller.
2. Screen Mounting: counterweight pipe batten
3. Screen Case: Designed to receive mounting hardware and sized to suit projection screen.
   a. Material: Wood with double top member for rigidity.
   b. Case Finish:
      1) Prime painted black.
4. Screen Size:
   a. Indicated on Contract Drawings.
5. Acceptable Material: Da-Lite Screen Company, Inc., Tensioned Professional Electrol Projection Screen.
   a. Screen Material:
      1) Front projection, flame retardant, mildew-resistant seamless vinyl, black backed, with standard black borders, easily cleaned with mild soap and water solution.
      2) Gain: To SMPTE RP 94-2000, 1.1
   b. Format: HDTV - 1.78:1
   c. Acceptable Viewing Surface: Da-Lite Screen Company, Inc.:
      1) See contract drawings for exact screen surface

6. Optional Accessories:
    a. Screen Drop: See drawings for exact amount in black fabric.
    b. Single Motor Low Voltage Control (LVC): External.

2.35 INSTALLATION 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 - INSTALLED LINE LEVEL:

1. West Penn 293
    a. Construction
        1) Conductor Gauge: 22 AWG
        2) Strands: 7 x 26 tinned copper.
        3) Insulation: .008" Polypropylene
        4) Number of Conductors: 2
        5) Shield: Aluminum foil with 100% coverage
        6) Drain Wire: Stranded tinned copper.
        7) Jacket Material: PVC
        8) Jacket Thickness: 0.017" Nom
        9) Overall cable Diameter: 0.160" Nom
        10) Flame Rating: UL 1666 Riser Flame Test
    b. Electrical
        1) Temperature Rating: -20 C° to +60 C°
        2) Operating Voltage: 300V RMS
        3) Max Capacitance between conductors @ 1kHz: 40 pf/ft.
        4) Capacitance between Conductors to Shield @ 1kHz: 79 pF/ft
        5) DC Resistance per Conductor @ 20° C: 6.6 Ω/1M'
    c. Mechanical
        1) Min Bend Radius: 1.6"
        2) Max Pull Tension: 57.5 lbs.

B. WIRE - INSTALLED MULTIPAIR LINE LEVEL:

1. West Penn D440
    a. Construction
        1) Conductor Gauge: 18 AWG
        2) Strands: 7 x 26 tinned copper.
        3) Insulation: .006" Polyolefin
        4) Number of Conductors: 4 (2 Pair)
        5) Shield: Aluminum foil with 100% coverage
        6) Drain Wire: Stranded tinned copper.
        7) Jacket Material: PVC

8) Jacket Thickness: 0.025″ Nom
9) Overall cable Diameter: 0.268″ Nom
10) Flame Rating: UL 1685 Riser Flame Test

b. Electrical
1) Temperature Rating: -20 C° to +60 C°
2) Operating Voltage: 300V RMS
3) Max Capacitance between conductors @ 1kHz: 42 pf/ft.
4) Capacitance between Conductors to Shield @ 1kHz: 76 pF/ft
5) DC Resistance per Conductor @ 20° C: 6.6 Ω/1M′

c. Mechanical
1) Min Bend Radius: 2.7″
2) Max Pull Tension: 100 lbs.

2. West Penn D442
a. Construction
1) Conductor Gauge: 18 AWG
2) Strands: 7 x 26 tinned copper.
3) Insulation: .006″ Polyolefin
4) Number of Conductors: 8 (4 Pair)
5) Shield: Aluminum foil with 100% coverage
6) Drain Wire: Stranded tinned copper.
7) Jacket Material: PVC
8) Jacket Thickness: 0.025″ Nom
9) Overall cable Diameter: 0.268″ Nom
10) Flame Rating: UL 1685 Riser Flame Test

b. Electrical
1) Temperature Rating: -20 C° to +60 C°
2) Operating Voltage: 300V RMS
3) Max Capacitance between conductors @ 1kHz: 42 pf/ft.
4) Capacitance between Conductors to Shield @ 1kHz: 76 pF/ft
5) DC Resistance per Conductor @ 20° C: 6.6 Ω/1M′

c. Mechanical
1) Min Bend Radius: 2.7″
2) Max Pull Tension: 100 lbs.

C. WIRE - INSTALLED MICROPHONE LEVEL:

1. West Penn 291
a. Construction
1) Conductor Gauge: 22 AWG
2) Strands: 7 x 30 tinned copper.
3) Insulation: .007″ Polypropylene
4) Number of Conductors: 2

5) Shield: Aluminum foil with 100% coverage
6) Drain Wire: Stranded tinned copper.
7) Jacket Material: PVC
8) Jacket Thickness: 0.017" Nom
9) Overall cable Diameter: 0.127" Nom
10) Flame Rating: UL 1666 Riser Flame Test

b. Electrical
1) Temperature Rating: -20 C° to +60 C°
2) Operating Voltage: 300V RMS
3) Max Capacitance between conductors @ 1kHz: 34 pf/ft.
4) Capacitance between Conductors to Shield @ 1kHz: 67 pF/ft
5) DC Resistance per Conductor @ 20° C: 17 Ω/1M'

c. Mechanical
1) Min Bend Radius: 1.3"
2) Max Pull Tension: 23.7 lbs.

2. West Penn 293
a. Construction
1) Conductor Gauge: 22 AWG
2) Strands: 7 x 26 tinned copper.
3) Insulation: .008" Polypropylene
4) Number of Conductors: 2
5) Shield: Aluminum foil with 100% coverage
6) Drain Wire: Stranded tinned copper.
7) Jacket Material: PVC
8) Jacket Thickness: 0.017" Nom
9) Overall cable Diameter: 0.160" Nom
10) Flame Rating: UL 1666 Riser Flame Test

b. Electrical
1) Temperature Rating: -20 C° to +60 C°
2) Operating Voltage: 300V RMS
3) Max Capacitance between conductors @ 1kHz: 40 pf/ft.
4) Capacitance between Conductors to Shield @ 1kHz: 79 pF/ft
5) DC Resistance per Conductor @ 20° C: 6.6 Ω/1M'

c. Mechanical
1) Min Bend Radius: 1.6"
2) Max Pull Tension: 57.5 lbs.

3. Microphone level wiring will be run as follows: WP 291 CL3 - 22 AWG (or equal as referenced above) is to be used for runs ≤ 100 feet. WP 293 CL3 - 18 AWG (or equal as referenced above) is to be used for runs in excess of 100 feet.

D. WIRE - INSTALLED MULTIPAIR MICROPHONE LEVEL:

1. West Penn D430
    a. Construction
        1) Conductor Gauge: 22 AWG.
        2) Strands: 7 x 30 tinned copper.
        3) Insulation: .006" Polyolefin
        4) Number of Conductors: 4 (2 Pair)
        5) Shield: Aluminum foil with 100% coverage
        6) Drain Wire: Stranded tinned copper.
        7) Jacket Material: PVC
        8) Jacket Thickness: 0.025" Nom
        9) Overall cable Diameter: 0.235" Nom
        10) Flame Rating: UL 1685 Riser Flame Test
    b. Electrical
        1) Temperature Rating: -20 C° to +60 C°
        2) Operating Voltage: 300V RMS
        3) Max Capacitance between conductors @ 1kHz: 34 pf/ft.
        4) Capacitance between Conductors to Shield @ 1kHz: 67 pF/ft
        5) DC Resistance per Conductor @ 20° C: 17 Ω/1M'
    c. Mechanical
        1) Min Bend Radius: 2.4"
        2) Max Pull Tension: 55 lbs.
2. West Penn D439
    a. Construction
        1) Conductor Gauge: 22 AWG.
        2) Strands: 7 x 30 tinned copper.
        3) Insulation: .006" Polyolefin
        4) Number of Conductors: 8 (4 Pair)
        5) Shield: Aluminum foil with 100% coverage
        6) Drain Wire: Stranded tinned copper.
        7) Jacket Material: PVC
        8) Jacket Thickness: 0.025" Nom
        9) Overall cable Diameter: 0.28" Nom
        10) Flame Rating: UL 1685 Riser Flame Test
    b. Electrical
        1) Temperature Rating: -20° C to +60° C
        2) Operating Voltage: 300V RMS
        3) Max Capacitance between conductors @ 1kHz: 34 pf/ft.
        4) Capacitance between Conductors to Shield @ 1kHz: 67 pF/ft
        5) DC Resistance per Conductor @ 20° C: 17 Ω/1M'
    c. Mechanical
        1) Min Bend Radius: 2.5"
        2) Max Pull Tension: 80 lbs.

3. West Penn D432
    a. Construction
        1) Conductor Gauge: 22 AWG.
        2) Strands: 7 x 30 tinned copper.
        3) Insulation: .006" Polyolefin
        4) Number of Conductors: 12 (6 Pair)
        5) Shield: Aluminum foil with 100% coverage
        6) Drain Wire: Stranded tinned copper.
        7) Jacket Material: PVC
        8) Jacket Thickness: 0.025" Nom
        9) Overall cable Diameter: 0.332" Nom
        10) Flame Rating: UL 1685 Riser Flame Test
    b. Electrical
        1) Temperature Rating: -20° C to +60° C
        2) Operating Voltage: 300V RMS
        3) Max Capacitance between conductors @ 1kHz: 34 pf/ft.
        4) Capacitance between Conductors to Shield @ 1kHz: 67 pF/ft
        5) DC Resistance per Conductor @ 20° C: 17 Ω/1M'
    c. Mechanical
        1) Min Bend Radius: 3.0"
        2) Max Pull Tension: 126 lbs.

E. MICROPHONE CABLE PORTABLE: REFERENCED PRODUCT PRO CO M SERIES WITH 223 B CABLE

1. Conductor Gauge: 23 AWG. Strands: 60 x 32 bare copper. Nominal Lay length: 1.5". Insulation: .012" polypropylene. Shield: Braid Tinned copper - 96%. Capacitance between conductors: 19 pf/FT.

F. WIRELESS MICROPHONE ANTENNA CABLE: REFERENCED PRODUCT BELDEN 8240

1. Contruction:
    a. Conductor Gauge: 20 AWG Solid
    b. Insulation: .116" PE
    c. Jacket: PVC
    d. Shield: Tinned Copper Braid, 95" Coverage
    e. Overall Diameter: 0.193" Nom.
2. Electrical:
    a. Nominal Capacitance Between Conductor to Shield: 28.5 pf/ft
    b. Conductor DC Resistance: 10 Ohms/1000'
    c. Shield DCResistance: 4.1 Ohms/1000'
    d. Nominal Impedance: 52 Ohms
3. Mechanical

a. Minimum Bed Radius: 2″ installed
b. Max Pull Tension: 47 lbs.

G. WIRE – CAT5E NETWORK CABLE: REFERENCED PRODUCT WEST PENN 4245

1. Construction:
   a. Conductor Gauge: 24 AWG Solid
   b. Number of Conductors: 8 (4 Pair)
   c. Insulation: 0.008″ Thermoplastic
   d. Shield: None
   e. Drain: None
   f. Jacket Material: PVC
   g. Overall Diameter: 0.202″ Nom.
2. Electrical:
   a. Temperature Rating: -20° C to +60° C
   b. Operating Voltage: 300V RMS
   c. DC Resistance per Conductor @ 20° C: 9.38 Ω/100 m
   d. Mutual Capacitance: 14 pF/ft Nom
   e. Nominal Impedance: 100Ω +/- 15% (1-100 Mhz)
   f. Delay Skew: 45 ns/100m MAX
   g. Standards: TIA/EIA568-B.2
3. Mechanical
   a. Minimum Bed Radius: 4x Cable OD or 1″ min.
   b. Max Pull Tension: 25 lbs.

H. WIRE - INSTALLED SPEAKER LEVEL:

1. West Penn 227
   a. Contruction:
      1) Conductor Gauge: 2 - 12 AWG
      2) Strands: 19x25 bare copper
      3) Insulation: .010″ PVC
      4) Jacket: 0.015″ PVC
      5) Shield: none.
      6) Overall Diameter: 0.269″ Nom.
   b. Electrical:
      1) Max Capacitance Between Conductors: 33.5 pf/ft Nom
      2) DC Resistance per conductor: 1.7 Ohms/1000′
   c. Mechanical
      1) Minimum Bed Radius: 2.6″ installed
      2) Max Pull Tension: 152 lbs.
2. West Penn 226

a. Contruction:
   1) Conductor Gauge: 2 - 14 AWG
   2) Strands: 19x27 bare copper
   3) Insulation: .010" PVC
   4) Jacket: 0.015" PVC
   5) Shield: none.
   6) Overall Diameter: 0.234" Nom.
b. Electrical:
   1) Max Capacitance Between Conductors: 31 pf/ft Nom
   2) DC Resistance per conductor: 2.7 Ohms/1000'
c. Mechanical
   1) Minimum Bed Radius: 2.25" installed
   2) Max Pull Tension: 59 lbs.

3. West Penn 225
   a. Contruction:
      1) Conductor Gauge: 2 - 16 AWG
      2) Strands: 19x29 bare copper
      3) Insulation: .010" PVC
      4) Jacket: 0.015" PVC
      5) Shield: none.
      6) Overall Diameter: 0.189" Nom.
   b. Electrical:
      1) Max Capacitance Between Conductors: 33 pf/ft Nom
      2) DC Resistance per conductor: 4.4 Ohms/1000'
   c. Mechanical
      1) Minimum Bed Radius: 1.89" installed
      2) Max Pull Tension: 59 lbs.
      3)

I. WIRE - LOW IMPEDANCE SPEAKER LEVEL:

1. Whirlwind W12GA
   a. Conductor Gauge: 2 - 12 AWG
   b. Strands: 65x30 bare copper.
   c. Jacket: 0.33" PVC
   d. Insulation: .027" PVC
   e. Shield: none.

J. SERIAL CONTROL CABLE: REFERENCED PRODUCT EXTRON STP20-2

1. Construction:
   a. Conductor Gauge: 22 AWG 7x30 Stranded
   b. Insulation: Polypropylene

c. Outer Jacket: Grey PVC
d. Overall Diameter: 0.23" Nom.

2. Electrical:
a. Nominal Capacitance Between Conductor to Shield: 67 pf/ft
b. Nominal Capacitance Between Conductor to Conductor: 35 pf/ft
c. Nominal Impedance: 45 Ohms

3. Mechanical
a. Minimum Bed Radius: 2.3" installed

K. PORTABLE HDMI CABLE: REFERENCED PRODUCT EXTRON HDMI PRO SERIES

1. Performance/electrical
a. Standards High speed HDMI® cable
b. Data rates
1) 12 feet and shorter Supports 10.2 Gbps
2) 25 feet and longer Supports 4.95 Gbps
c. Color depth
1) 12 feet and shorter Supports 48 bit (16 bits per color)
2) 25 feet and longer Supports 24 bit (8 bits per color)
d. Vertical frequency
1) 12 feet and shorter Supports up to 120 Hz
2) 25 feet and longer Supports up to 60 Hz
e. Regulatory compliance
1) Safety UL CM
f. Temperature rating
1) Minimum: -25 °C
2) Maximum: 75 °C
g. Voltage 30 V
h. Pair impedance 100 ohms ±10 ohms
i. Attenuation
1) At 0.825 - 2.475 GHz: <21 dB per 12 m
2) At 2.475 - 4.125 GHz: <30 dB per 12 m
j. Skew
1) 12 feet and shorter
a. Intrapair ≤300 ps per 10 m
b. Interpair ≤2.4 ns per 10 m
2) 25 feet and longer
a. Intrapair ≤350 ps per 12 m
b. Interpair ≤2.42 ns per 12 m

2. General — physical characteristics
a. Connector type 1 male type A HDMI to 1 male type A HDMI
1) Contacts Gold plated

2) Material
   a. 12 feet and shorter
   b. Conductors: silver coated, tinned copper
   c. Drain wire: tinned copper
   d. Jacket: PVC
   e. 25 feet and longer Conductors: tinned copper
   f. Drain wire: tinned copper
   g. Jacket: PVC
3) Conductor guage
   a. 12 feet and shorter Conductors and drain wire: 24 AWG
   b. 25 feet and longer Conductors and drain wire: 22 AWG
4) Connector dimensions 2.46" L* x 0.80" W x 0.60" thick
5) 12 feet and shorter
   a. Cable outer diameter 0.41" (10.4 mm)
   b. Bend radius 4.10" (104.1 mm)
6) 25 feet and longer
   a. Cable outer diameter 0.47" (12.0 mm)
   b. Bend radius 4.50" (114.3 mm)

L. WIRE MULTICONDUCTOR SNAKE CABLE:

1. INSTALLATION MULTICORE SNAKE – REFERENCED PRODUCT WHIRLWIND W58PRFLX
   a. The Multiconductor cable will consist of from 4 - 58 pairs of individually shielded audio cable. Conductor Gauge: 24. Strands: 7 x 32 bare copper. Nominal Lay length: 0.93". Insulation: polyethylene. Shield: Foil wrap polyester 100%. Drain Wire: 24 gauge 7 strand tinned copper. Capacitance between conductors: 25 pF/ft. Capacitance between one conductor and other conductor tied to shield: 47 pf/FT. Black Outter Jacket
2. OUTDOOR MULTICORE SNAKE – REFERENCED PRODUCT WHIRLWIND W58PR
   a. The Multiconductor cable will consist of from 4 - 58 pairs of individually shielded audio cable. Conductor Gauge: 24. Strands: 7 x 32 bare copper. Nominal Lay length: 0.93". Insulation: polyethylene. Shield: Foil wrap polyester 100%. Drain Wire: 24 gauge 7 strand tinned copper. Capacitance between conductors: 25 pF/ft. Capacitance between one conductor and other conductor tied to shield: 47 pf/FT. Blue Outter Jacket
3. PORTABLE MULTICORE SNAKE – REFERENCED PRODUCT WHIRLWIND WITH CANARE MR202 SERIRES WIRE
   a. The Multiconductor cable will consist of from 4 - 58 pairs of individually shielded audio cable. Conductor Gauge: 24. Insulation: polyethylene. Shield: Foil wrap polyester 100%. Drain Wire: 25 gauge 7 strand tinned copper.

Capacitance between conductors: 23.2 pF/ft. Capacitance between one conductor and other conductor tied to shield: 43.3 pf/FT.

4. Multiconductor cable fan out end will be factory wired with colored and numbered heat shrink to identify the channel numbers. Length of cable is to be as required by site conditions.
5. Where multiconductor snake cable is indicated, the snake must have a common outer jacket. Individual pairs will not be accepted.

M. AV WIRING: CRESTRON DIGITAL MEDIA DM-CBL-8G

1. Construction
   a. Four twisted pair, polyester tape, drain, shield, braid, ripcord and overall jacket
2. Electrical & Performance
   a. Mutual Capacitance 17.1 pF / ft
   b. Velocity of Propagation 69%
   c. Propagation Delay Skew 45nS / 100 m
   d. DC Resistance 28.6 Ohms / 1000 ft maximum
   e. DC Resistance Unbalance of a Pair 5% maximum
   f. Capacitance Unbalance 330 pF / 100 m
   g. Characteristic Impedance 100 Ohms ±15% (1-250 MHz)
3. (4) Twisted Pairs
   a. Colors: Blue/white, orange/white, green/white, brown/white
   b. Conductors: 24 AWG x8 solid copper
   c. Insulation: 0.0055 inch thick HDPE
   d. Outer Diameter (per conductor): 0.040 inch (1.016 mm) maximum
   e. Drain : 26 AWG solid tin/copper
   f. Shield: Aluminum foil (100% coverage)
   g. Braid Tin/copper (40% nominal coverage)
4. Outer Jacket
   a. Color: Blue
   b. Material: PVC
   c. Thickness: 0.018 inch
   d. Outer Diameter: 0.244 ±0.008 inch (6.2 ±0.2 mm)
   e. Minimum Recommended Bend Radius: 2.75 inches
   f. Maximum Pull Tension: 25 lbs/ft
5. Rating
   a. NEC Article 800; UL Subject 444, Type CM; CSA Type CMG

N. WIRE – CAT6A NETWORK CABLE: REFERENCED PRODUCT WEST PENN 4246A

1. Construction:

a. Conductor Gauge: 24 AWG Solid
b. Number of Conductors: 8 (4 Pair)
c. Insulation: Polyolefin
d. Shield: None
e. Drain: None
f. Jacket Material: PVC
g. Overall Diameter: 0.309" Nom.

2. Electrical:
a. Temperature Rating: -20° C to +60° C
b. Operating Voltage: 300V RMS
c. DC Resistance per Conductor @ 20° C: 9.38 Ω/100 m
d. Mutual Capacitance: 13 pF/ft Nom
e. Nominal Impedance: 100Ω +/- 15% (1-1000 Mhz)
f. Delay Skew: 35 ns/100m MAX
g. Standards: TIA/EIA568-C.2

3. Mechanical
a. Minimum Bed Radius: 1.25" min.
b. Max Pull Tension: 35 lbs.

PART 3 - EXECUTION

3.1 GENERAL:

A. Contractor will adhere to all requirements of the general contract for this project as called for in the project manual.

B. Assess life safety implications of all installation methods and verify there is no compromise of life safety issues. All liability for rigging, fastening, wiring, and other installation methods will 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.

C. Any dangerous work areas marked or roped off in a manner that will inform all persons as to potential danger regardless of sensory handicaps.

D. Maintain M.S.D.S. for all materials used where applicable and submit same if requested upon completion.

E. Maintain integrity of all fire walls and doors during construction and upon completion.

F. Take all precautions necessary to guard against electromagnetic and electrostatic hum, RF noise, supply adequate ventilation, and install all equipment for the maximum safety of the operator.

G. The contractor will verify all on site dimensions prior to ordering or installation of critically dimensioned equipment and wiring. In a case of a 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.

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 specification will be the responsibility of the contractor at no additional cost to the owner.

I. Provide all racks, hardware, wire, conduit, raceways, and all other required parts to provide a complete system to the extent that such items are not provided by others. Provide rack shelves or kits for all equipment to be located in equipment racks that is not inherently rack mountable. Any shelf mounted equipment will be securely attached to the associated shelf.

J. All installation methods must be cosmetically acceptable to the owner. All equipment 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. Identify any equipment requiring licensing (wireless etc..) and initiate licensing procedures for all such equipment.

L. Coordinate all work with other on site trades in order to achieve a coordinated progress at all times.

3.2 WIRING AND RACKS:

A. CONNECTORS (The priority for use of connectors is as follows):

1. Wherever barrier strips or Phoenix connectors are available to connect equipment these are the preferable means for connection. Barrier connections are to be made utilizing insulated crimp connectors. Phoenix connectors may be utilized without crimp connectors if proper strain relief is provided to avoid fatigue to the connection.
2. Next in order of preference are XLR type connectors. Where no other means is available balanced 1/4" are to be used. Unbalanced 1/4" and RCA are to be use only if no other means of connection is possible. Use right angle jacks where

needed for space requirements. Banana jacks are not to be used on amplifier outputs.

3. All wiring (except AC power) entering or leaving the rack will be connected via terminal strips or direct connection to the equipment terminals or connectors. No in line connectors are acceptable. Appropriate connectors and controlled cycle crimping devices will be employed. No wire nuts may be used in any system wiring except AC power.

B. All AR (audio 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.

C. All wiring shall be neatly tie wrap bundled (or as indicated otherwise on contract drawings) with wires parallel and perpendicular to rack sides and backs and/or control booth walls or roll top desks (i.e. no random angle wiring). All wiring shall be dressed neatly from devices to input/output plates with excess cable hidden below the countertop and secured as described below.

D. All loose audio, control or power cables & wiring must be dressed neatly with tie wraps & eyes or ring runs & tucked up against underside of control booth countertop. All cabling shall be cut to length.

E. Provide a single 120 V AC 60 LED equivalent light source within each rack, located at the top of the rack as necessary to clear equipment mounted within the rack. Provide rough duty lamps and protective lamp cages for each lamp, as well a switch assembly within each rack.

F. No equipment or terminal strips will be mounted to the sides, doors, top or bottom of the racks. Tie down bars will be provided by the contractor for neat wiring in adherence with industry standard practice.

G. Wiring Standards - Plenum Rated Cable: Unless specifically noted on the drawings, all low voltage wiring is to be CL2/CL3 wiring.

H. No rack rails will be allowed for equipment mounting in the rear of the rack unless otherwise noted in this specification.

I. Separate wiring paths must be maintained within each rack for microphone level, line level, AC, and speaker level signals. No bundling of dissimilar signal types is allowed.

J. No undue stress may be placed on any connection by a lack of support of the wiring within the rack.

K. Any equipment having accessible controls that are not normally used during system operation will have it's 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.

L. Provide blank and/or vent panels as needed to complete each rack with no unfilled spaces, as per rack elevations or as required by alternates to equipment specified. No racks with unfilled panel spaces shall be allowed.

M. 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. 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).

N. ELECTRICAL & GROUNDING:

1. All equipment to have the availability of chassis ground lifts or to be mounted with ground lift isolation washers.
2. Grounding of shields and chassis shall adhere to industry standard practice, with shields terminated at one end only on signal cables. Terminate the open shield end with plastic tape or shrink on collars.
3. All electronics' ground will be terminated to a single point within the rack. Ground this point as well as the racks to an appropriate main service ground provided by others. No AC line cord safety grounds may be lifted in an attempt to cure hum or noise problems. All such problems will be rectified by accepted industry practice such as the use of transformer isolation, ground lift rack washers, etc...
4. 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. This service should be capable of powering all system equipment at 100% of rated power. Two U-ground outlets will be available for each 20 amp, single-phase circuit unless otherwise indicated or terminated into MPR style devices.
5. 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.
6. 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 industry standard practice.

7. Provide each rack with sufficient AC isolated ground distribution for all equipment with 2 spares per rack.

O. CONDUITS:

1. Use separate conduits for microphone level (below -20dBm), video and line level (up to +30dBm) speaker level (greater than +30 dBm), control circuits and power circuits. No sharing of signal types within conduits is permissible.
2. All conduits shall be concealed unless the owner has been notified in writing and accepts by written approval the location of the 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 by the installing contractor at no additional cost to the owner.

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. 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 & PRE-TEST

A. All equipment shall be turned on and before assembling into racks. 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, although the contractor should shop test each piece of equipment for signal flow integrity.

B. All sub assemblies and individual components (i.e. speakers etc.) shall be fully tested off

site before delivery for 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.

C. Cover and protect all equipment left or installed on site during construction.

D. 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. Permanently mark cables with an identifying label at each end, in a consistent logical manner. Submit to the consultant for approval a listing of intended nomenclature.

B. On metal panels and plates where possible engrave directly upon the plates and assemblies. Where disassembly of the equipment would be required to achieve engraving the use of adhesive or screw on engraved labels will suffice. Engravings will be paint filled for best contrast with black or white paint.

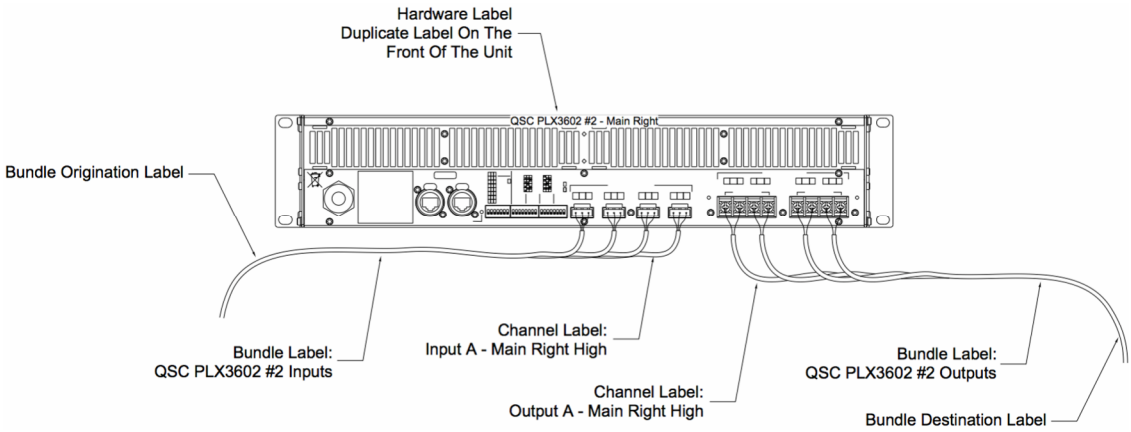
C. Do not use Dymo style labels or hand lettering. No cables will be labeled with masking tape, Gaffer tape, or other material subject to degradation. Such labeling may be done on a temporary basis during installation so long as all such labels are removed and their adhesive cleaned off when final labeling is applied. Self-laminating labels are preferable such as laser printed labels by Panduit.

D. Color-coding of the entire system will be logical and adhere to accepted industry standards.

E. Labeling must allow the owner and potential novice users to disconnect a piece of equipment or peripheral equipment and reconnect it without the need for drawings or assistance from the installing contractor. Labeling must be done in a manner that precludes errors in connecting. If multiple inputs of the same type (such as XLR, 1/4" etc....) are present in a location the labeling must be detailed.

1. All equipment shall be labeled on the back as to its function and where multiple units are present the unit number.

2. All input wiring shall be bundled, and all output wiring shall be bundled separately with the bundle labeled with the same nomenclature of the hardware. See example below:



3. Examples: Input 1 (XLR) plugged into an XYZ mixer should be labeled "INPUT 1 XYZ Mixer" if this mixer is located in a rack with other XLR input equipment. If this was a front of house mixer with only XLR inputs to the mixer then a snake labeling system of numbers only would be acceptable.
4. At the same mix positions, any 1/4" lines used for processing, sends, etc. would need to be labeled to match the nomenclature on the mixer and the associated line or piece of equipment due to multiple 1/4" jacks being present. A jack plugged into "AUX 1 OUT" should be labeled as such. If the other end plugs into "XYZ REVERB INPUT LEFT", it should be labeled as such.
5. Where network switches are being provided as part of the audio system, the contractor shall label all wiring destinations. Labels should describe network connection locations.
6. All punchdown block wiring shall be labeled on both the input and output. Input wiring shall be labeled with its origination and output wiring shall be labeled with its destination.

F. Labeling is subject to an extended warranty as noted in the "Warranty and Service" section within these specifications.

3.6 RIGGING:

A. The following minimum standards apply in addition to the standards referenced elsewhere in the specification. These guidelines do not negate the standards referenced elsewhere in the specification.

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 points plus a backup. Each point must be able to carry the entire rated load with a safety margin of at least ten (10) times the rated load. All methods must incorporate an independent safety backup with a safety margin of at least ten (10) times the rated maximum load as installed in case of failure of any rigging component.

D. Speakers:

1. All speakers that are to be suspended must have factory installed and rated rigging points. No loudspeaker may be modified in any way by the contractor for installation by suspension. Speaker hanging hardware for the speaker must be furnished by the manufacturer or an approved rigging hardware manufacturer.
2. Speakers to be installed on brackets or mounts must utilize factory supplied components. No field fabricated brackets are acceptable unless authorized in writing before installation.
3. Where Omnimount brackets are used for mounting, the contractor should use the manufacture provided mounting points for the approved Omnimount. If a speaker model does not have the points where necessary, the contractor will need to drill the enclosure with the proper hole spacing. The contractor will need to internally span every 2 mounting points with 1/4" angle. No T-nuts will be accepted as mounting points.
4. For speakers utilizing flytrack to obtain the aiming angles, a duplicate set of double-stud fittings in the fly track with wire rope to structural supports is required. Wire rope to be properly dressed and tied off every 12" with nylon zip-ties with all excess cut off. Provide a safety cable from a manufacture provided hang point directly to structural steel.
5. Speakers installed with a Polar Focus Z-Beam or approved equivalent are to incorporate a safety cable from the speaker directly to main steel. All support from the Z-Beam to the speaker will be as indicated on the drawings.
6. Speaker audio cables are to be dressed along the nearest support cable. Audio cables are to have no tension and are not to alter in any way the aiming angle of the speaker. Speaker cables to be properly dressed along support cables.

E. All speakers that are suspended with overhead rigging are to be supported by 3 separate points plus a safety back-up cable. The safety back-up cable must be directly attached to structural steel. The safety cable is to have little or no slack.

F. All hardware used for rigging of speakers or other audio equipment to be installed with a torque wrench set to the manufacture settings.

G. All rigging and related fastening methods must be treated as permanent. All threads must be treated with vibration compounds such as vibratite or loctite as per manufacturer's recommendations.

H. All rigging hardware must be load rated with the load rating or approval stamped on each piece of hardware.

I. No chain of any type will be acceptable for the hanging or backup support of any equipment unless specifically called out on the drawings.

J. No fabric or plastic devices of any type will be considered as acceptable methods of hanging of any equipment.

K. No stainless steel rope may be secured with threaded compression type fittings alone (Crosby Clamps). Compression type closures such as Nicopress must be utilized. All wire rope is to have strain relief thimbles installed. All Nicopress crimps to use copper sleeves.

L. 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.

M. Where shackles are used in the rigging of speakers or other audio equipment, the shackles are to be moused with industry standard mousing wire. Mousing wire to be neatly trimmed.

N. All rigging work is to be done by a rigging contractor unless the sound contractor can supply documentation of their personnel having appropriate training in rigging.

O. All rigging tools such as nicopress crimping tools must have been calibrated within 6 months of the date of installation.

P. Contractor to have a go/no go Nicopress gauge on site for testing of crimps. Every 6th crimp should be tested. If a crimp tests no-go, all crimps between the last passing test and the failure to be tested. Any crimps that fail are to be replaced.

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:

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

G. Provide 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 above ceilings and in walls, below slabs and elsewhere throughout building (this does not include control consoles, input stations, user interface devices, touchscreens, 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. PROCESSOR SET UP: Unless otherwise instructed within the following is the basic configuration for all processor systems:

1. Speaker Equalization: All speaker specific equalization to accomplish room preference curves, control speaker anomalies, provide high pass, low pass, or bandpass capabilities shall be accomplished on output DSP filter banks. Limiters shall be applied to prevent system overload. Verify required settings with speaker manufacturer data and amplifier voltage gains.
2. ADA system feeds - All ADA systems shall be fed with compression and auto level providing consistent gain of 0 dB +/-3dB.
3. Delay shall be applied where required to:
    a. Provide signal delay for delayed loudspeakers and ADA equipment.
    b. Provide signal delay to compensate for cluster packing frequency anomalies.
    c. Provide signal delay to integrate monitor system bleed with the main speaker systems.
    d. Provide feedback correction in monitor systems.
    e. Provide frequency shading and beam steering of low frequency systems.
4. Program inputs shall operate with no filters applied unless a preference curve is called for by the owner. All program inputs will include a compressor set to a threshold of 3dB below nominal operating level of the equipment connected. Set controls for soft knee compression, ratio of 6:1, attack time 30 Ms and release of .33 seconds unless conditions require different settings.
5. Program inputs shall incorporate gates set to eliminate background hiss of the equipment when program is not present. Set threshold and characteristics for a gradual fade out when program drops off. Low level program material must not allow gates to activate. Typically -55dB sensitivity.
6. Line level inputs from manual mixers shall have similar settings applied as is utilized with program inputs except with regard to compression. Limiting for system safety shall be utilized instead of gain control style compression. Set the threshold to 6 dB below system clipping with hard knee characteristics and minimum 10:1 ratio.

B. FOH Digital Console Set Up

1. Create base templates and libraries for the owner.

a. Create and overall template which the owner can create specific scene files for various uses. This base template should include all normally used inputs patched per owner preference. Verify the priority or wired and wireless inputs and set accordingly.
b. Verify repeated functions the owner identifies and set up channel patch, microphone types etc…… and create scenes for these uses.
c. Store microphone libraries by type with gain and EQ to allow the owner to import a microphone type on the fly to active channels.

C. AUDITORIUM SOUND SYSTEM

1. The audio system will be utilized for program playback and speech. Primary room equalization for the sound system will be done with the processor. The processor will also be used for notch filtering of overall room nodes and primary microphone feedback frequencies.
2. The audio system will be gain structured for the configurations typically used. The overall system will be capable of average levels of 90 dB and peak levels of 100 dB throughout the seating within the capabilities of the systems.
3. All gain structuring will be done according to accepted standards to provide a system with residual noise at a level below typical background noise with the HVAC on. No residual noise, hum, or buzz in the system above this level will be acceptable.
4. Equalization will be performed to provide high intelligibility and good music reproduction as follows:
   a. The main system equalization will target an averaged room response of 80 - 8000 Hz +/-2dB. Test source for initial tuning will be broad band pink noise applied to the music inputs.
5. System configuration
   a. GENERAL MICROPHONE SETUP - The intent of this section is to ensure repeatable results under specific uses of this space. In order to get consistent results the same microphones will need to be set up in a similar fashion every time a particular preset is engaged. The specific mic types and locations will change from preset to preset. This will require making a chart listing specific mic types and stand locations for each preset. This chart is to remain near or on the panel housing the preset controls AT ALL TIMES. The specific mic types and stand locations will be determined upon system installation and setup by the sound contractor and the owner or owner's representative, and they should be determined with an actual performance group in place.
   b. GENERAL PROCESSOR SETUP - The contractor shall program all processors with any factory tuning parameters for the speakers.
6. Automixer Setup:

a. Set transmitter sensitivities for handheld and bodypack wireless mics so that the automixer input levels are the same at their indicated working distances. The working distance for the handheld mic shall be 6" and the working distance for the over-ear microphone for use with the bodypack wireless shall be 2". Engage all feedback eliminator filters on all mic inputs. Gain structure hard-wired mic inputs for a 6" working distance. Route all inputs to the main, monitor, and ADA matrix outputs. Engage automixing functions on mic inputs only. Set input compressors and output limiters as indicated in the processor setup section. Contractor to instruct the owner about proper use of electronic instruments with a direct box at the hardwired automixer inputs.

7. TOUCHSCREEN SETUP:
   a. Each touchpanel screen shall incorporate a standard "Home Screen" that uses the owner's logo as the background behind all button/preset display overlays. Actual logo to be used is TBD by the owner. Contractor is to obtain appropriate file from owner. Size logo on screen as directed by owner.
   b. Each touchpanel screen shall incorporate a "Home" button or object on every screen (or physical button on unit – if screen is so equipped) that will take the user to the home screen whenever this button is activated.
   c. Each touchpanel screen shall incorporate a "Back" button or object on every screen, except the Home screen, (or physical button on unit – if screen is so equipped) that will take the user back to the previous page/screen whenever this button is activated.
   d. Each touchpanel screen shall incorporate a "Sound System Processor Presets Screen" which will allow the user to choose one of the various preprogrammed system presets from the sound system processor (i.e. Automated Lecture, Manual Theater, etc.). Selection of any particular system preset will tell the sound system processor which system preset to make active, and that particular preset will become highlighted and active.
   e. Each touchpanel screen shall incorporate a "Media Plate Screen" which will allow the user to choose one of the various media plates within the job (i.e. DM Plate, etc.). Selection of any particular media plate will tell the Crestron control devices which source plate has been selected for media input and that particular media plate will become highlighted and active.
   f. Each touchpanel screen shall incorporate a "Plate Menu Screen" which will allow the user to choose one of the various video input connectors located on that particular media plate as the input source (i.e. VGA, S-Video or Composite Video, etc.). Selection of any particular video source input connector icon will tell the Crestron control devices and projector which input source has been selected for media input and that particular video input icon will become highlighted and active.

g. Each touchpanel screen shall incorporate a "Projector & Screen Control". This screen shall have buttons for turning the projector on and off and a status windows that shows off or on. There shall be buttons for the projection screen for up, down, and stop.
h. All touchpanel buttons shall be programmed so that, when a button or preset is selected, the active icon highlights or changes color and becomes visually distinguished from all other buttons/presets on the page in order to easily identify and indicate which button or preset has been activated and is currently active.
i. Contractor shall program a lighting page that will recall the basic presets on all of the entry wall stations.
j. Touchpanel stations with no physical, external buttons on the unit itself shall program iconic display buttons for all on screen navigation. Fixed touchpanel stations with physical, external buttons can be programmed so that the unit's physical buttons activate on screen commands; however, two of the buttons should be dedicated to "Home" and "Back" functions regardless of the page displayed.
k. Contractor is to submit all screen layouts (jpeg screen shots are acceptable) to the consultant for final approval prior to loading all software.
l. Contractor is responsible for all touchpanel and control system programming and final touchpanel screen looks, layouts and icons and for interfacing each piece of controlled equipment with the Crestron control system. Contractor is to verify that all controlled equipment can "talk to" and be controlled by the Creston control unit(s) and the touchpanel displays.

8. CONTROL SYSTEM PRESETS:
   a. Preset 1 - Automated - Crestron CP3 programmed to recall the Automated preset from the sound system processors. Crestron touchpanel stations to be programmed so that the graphic for this preset is set to a different color that the rest.
   b. Preset 2 - Manual Configuration - Crestron CP3 programmed to recall the Manual Configuration preset from the sound system processors. Crestron touchpanel stations to be programmed so that the graphic for this preset is set to a different color that the rest.

9. SOUND SYSTEM PROCESSOR PRESETS:
   a. Preset 1 - Automated – Automixer main and monitor inputs active along with the AV inputs with all others muted. All processor outputs active. Volume controls for automix inputs available on the portable fader remote.
   b. Preset 2 - Manual Configuration - Console main left/right, hearing assistance feed, and monitor inputs on the processor active with all others muted. All outputs on the processor active.

10. DIGITAL CONSOLE SETUP

a. Channel Setup
   1) Channel Gain Structure – contractor shall program the gain structure for each mic type provided. Gain structure shall be set so that the fader has full range to unity.
   2) Channel EQ – Contractor shall program the channel EQ for each provided mic type. EQ shall be contoured for typical uses of the mic type.
   3) Channel Dynamics – Contractor shall program each mic type and line input type with compression and gating. Gating thresholds shall be set for -55 dB. Compressors shall be set with soft knee compression, ratio of 5:1, attack time 30 ms and release of .33 seconds.
   4) Channel Routing – Contractor shall program channel routings to each monitor bus as well as main left right outputs.

b. Monitor Setup
   1) Contractor shall program each output with a 1/3 octave graphic eq's and set delay as required. Set all stage monitor busses to post fader.

c. Main Left/Right Setup
   1) Contractor shall program each output with a 1/3 octave graphic eq.

d. Create base templates and libraries for the owner.
   1) Create and overall template which the owner can create specific scene files for various uses. This base template should include all normally used inputs patched per owner preference. Verify the priority or wired and wireless inputs and set accordingly.
   2) Verify repeated functions the owner identifies and set up channel patch, microphone types etc…… and create scenes for these uses.

D. TEST EQUIPMENT: (All test equipment will remain the property of the contractor.)

1. Loudspeaker phase checker.
2. Digital Multimeter - May be included with AC voltmeter.
3. SMAART other DUAL FFT Analyzer with calibrated microphones.
4. All cables, adaptors, etc. required for test procedures enumerated.
5. Two walkie-talkies.
6. Laptop PC loaded with all DSP control software loaded. A cable or wireless access point of at least 100' to interface to the DSP's must be onsite during acceptance tests.

3.11 INITIAL POST COMPLETION TESTS & SET UP:

A. Parasitic oscillation and RF pickup: Verify that the system is free from RF pickup and oscillation with no input as well as normal operating levels.

B. Loudspeaker phasing: Check each loudspeaker with a phase measuring device for proper

polarity.

C. Proceed to equalize all systems to conform to the specified initial performance criteria.

D. Uniformity: Measure each speaker system on axis within direct field coverage. Equalize to +- 3dB 150 Hz – 8000 Hz using impulse sweeps. Where delay or down fill elements are included perform direct field measurements of each area with all systems operating.

E. Distortion, rattles, and buzzes: With high quality digital program material set the equalized systems for average levels of 90 dB check for unusual distortions or rattles. Also apply a constant sine wave sweep from 80 Hz - 8000 Hz at a level providing average levels of 86 dB measured at standing ear height. Walk through all systems and check for unusual distortions or rattles. Correct any problems. If the problem is outside of the system, bring the source to the attention of the owner. (ceiling tiles etc….)

F. Gain Control Settings: Adjust controls for optimum signal to noise of the all systems relative to the performance requirements of this specification.

G. After initial tests have been made, proceed to equalize the system for feedback control as per normal practice.

H. Verify all systems inputs, outputs, equipment and functions.

3.12 CONSOLE PATCHING

A. Verify all stage boxes and other patchable devices are synchronized and patched to access inputs as needed for the system configuration.

3.13 WARRANTY AND SERVICE:

A. The contractor guarantees all equipment, materials, and workmanship to be free from defects for a period of one year from the date of 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. 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.

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 at no charge to the owner.

E. Provide all service at the owners location regardless of any manufacturer warranty terms regarding carry in service.

F. 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.

3.14 OWNER INSTRUCTION:

A. The contractor shall provide a training program for the owner 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 audio and AV systems and related equipment. This training time shall not exceed (24) hours. No training block shall be less than four hours in duration. This time is in addition to training times noted below. Final Adjustment visit hours are not included in the training hours, they are additional. See Section 3.24.D.3 below.

B. The contractor shall provide additional software training for the owner of (4) hours specifically and exclusively for wireless mic frequency coordination, etc.

C. All owner instruction and programming services shall be provided by the contractor as part of this contract & shall be scheduled and performed within twelve months of the final system turnover date to the owner. Any unused training hours that do not get utilized during that twelve month period shall be considered forfeit.

1. The turnover date is defined as the date of completion of all open punch list items and final acceptance by the owner.
2. Attendees/trainees shall be as designated by the owner and may consist of multiple groups requiring separate training sessions on the same topics (all sessions must fit into the training times as allotted above).

D. All owner instruction training hours are exclusive of travel time. Training time hours will begin to elapse at the prearranged hour agreed upon by both the owner and the contractor.

E. It is understood that, if there are multiple spaces/locations (e.g., high school auditorium, middle school gym, elementary school cafetorium, etc.), the training sessions noted shall be required independently at each facility.

3.15 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.

3.16 QUALIFICATIONS OF TRAINERS

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

3.17 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 owner personnel do not the contractor must notify the owner that a four hour segment has been used up.

C. If a scheduled session lasts less than four hour it will still expend four hours of allotted training.

3.18 EXAMPLE TRAINING SCHEDULE:

Typical Training Hour Breakdown	Hours	Typical Content
System overview and basic Training	4	Full Walk around, system layout, power sources etc. And an overview of operation. Set up and operation of automixer with and without stage monitors. Adjusting remote controls.
Console Template Creation and Microphone Tunings for library. Tuning stage monitors for specific mike setups and saving files. I pad remote access set up	4	This session can be the same day as system overview if schedule allows. Understanding the file systems and Library Systems and assist the owner in obtaining good mike EQ for type uses.
Compressors, gates, automixer	4	Training users on how these are applied to create consistent in mixes.
Special Effects	4	

Assistance with setting up first Event	4	Show files, presets, global EQ techniques, etc.
On site for first show as tech support	4	
On site for Second show as tech support	4	
Follow Up Higher Level Training	4	
	32	Total Allotted hours vary on each project, this is just an example.

3.19 INITIAL TRAINING

A. Walk through the facility and familiarize the owner with where primary equipment is and what it does. This should include a walk to the power panels feeding the systems and show what breakers operate various power feeds.

B. Train on primary control surfaces (Consoles, touchscreens etc….) for the most commonly used functions.

C. Train on how to EQ Microphones, use Gates and compressors, put together scenes, presets, shows etc….

D. Train on how to perform patch and routing changes

E. Train on creating and saving libraries for specific microphone types

F. Train on patching and use of effects and insertable graphic eq’s

G. Train on saving and restoring consoles and other software programmed devices.

H. It is recommended that most training be hands on with the owner’s personnel operating the equipment.

3.20 FOLLOW UP SESSIONS

A. Often this will be used for in rehearsal or show sessions where the contractor is an assistant to the operates during actual use.

B. Some operators may want to schedule session on higher level functions.

C. Sessions may also be used to change configurations for the owner. Often once as system is used or a while changes are requested for default presets and controls.

D. Provide training only at the request of the owners authorized representative (s). Track all training hours and provide copies to the owner of who attended and what general topics were covered.

3.21 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, provide portable lighting if needed.

B. Provide Simple explanations of what each piece of equipment does, what would occur if it was 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.

E. This training will be converted by the contractor to a DVD.

F. Edit and title into chapters based on general content.

3.22 DEVICE SPECIFIC TRAINING

A. Device specific training should be recorded by the contractor independent of the initial training session. This recording can be done in the contractors shop, at the site without the owner, or other locations as appropriate.

B. This second DVD video is to provide two levels of information:

1. Basics - A walk around of the site should be video recorded that shows the owner where primary equipemnt is located, and what screens and indicator lights look like when everything is working properly.
2. This should include a walk to the power panels feeding the systems and show what breakers operate various power feeds.
3. Record a quick start 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 scene file
    c. How to unmute microphones
    d. Basics of console navigation
        1) Select
        2) Toggle Screens

3) EQ Screens

e. How to shut down the console without saving

C. A second level for anyone who need to do the following:

1. Use gates and compressors to automate channels
2. How to use internal spectrum analyzers to assist with EQ
3. EQ functions – filter types, bandwidth etc.....
4. How to load libraries on the fly
5. Perform digital patching - Access remote stage boxes.

D. Edit the DVD into chapters for an end user to quickly find what they need.

E. Also provide to the owner links to factory training video series for higher end functions.

F. Provide both training videos in DVD and USB stick formats

G. On the USB include a PDF document with active links to factory training videos an sites

H. In subsequent sessions of training with the owners personnel higher level functions may be covered. Some owners will not require this some will. The contractor is not required to video record subsequent sessions. The owner can record in audio or video any session they want using their own equipment.

3.23 SIGNAGE:

A. A sign shall be posted in an accessible location (typically on the rack(s) or in the control booth) providing the name, address and phone number of the primary system contractor, manufacturer and supplier (if not already listed) of the system equipment.

3.24 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 of the following conditions must be met before scheduling an acceptance tests:

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.
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. Test equipment as enumerated above must be set up and operational. A technician familiar with the equipment must be on hand.
2. Tools must be on hand to remove connector plates and provide for other possible inspections.
3. All racks must be open and all security covers removed.
4. Documentation for all wiring must be completed in at least a neat draft form and on site. This must include as built nomenclature and wiring schedules.
5. The control software must be programmed and all equalization completed for the presets and scenarios as indicated.
6. The control laptop computer must be located in the middle of the seating area for the room to be tested. The technician who performed the programming must be on hand for the testing and acceptance.
7. Any return trips to correct any of the above conditions will be wholly billed to the contractor and deducted from the contractor's remaining balances with the owner at the same rate.
8. Changes to the tuning accommodate subjective assessments will be done during acceptance. These adjustments will incur no costs to the contractor.

D. CONDITIONS OF ACCEPTANCE:

1. 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:
   a. All specified equipment is installed and the system is operating in an acceptable manner from a functional standpoint.
2. 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.
3. Final adjustments for the sound system presets will likely need to be changed in the days following completion. This will require the participation of the contractor

at several events over as much as forty-five (45) days after system acceptance. These adjustments will be made at no additional charge and upon reasonable notice by the owner. These visits will not exceed a total of (8) eight manhours on site (including any travel time).

4. 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).
5. 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.
    c. The contractor must verify these conditions can be maintained during testing.

E. AUDIO – TYPICALLY TAKES 4-8 HOURS:

1. Required Attendance – Personnel from the sound contractor equipped with test equipment as required within specifications. All test equipment set up and ready for use.
2. All room finishes complete. The sound systems may not be tested until carpeting, chairs, acoustical panels, stage curtains, etc. are all installed.
3. System Status:
    a. All labeling complete
    b. Front of equipment faces
    c. Rear of equipment panels
    d. Cabling & cable dress
    e. Plates installed with all trim rings present
    f. Snakes and output cabling
4. All security covers removed, but on site ready for reinstallation after tests.
5. All systems must be fully wired and gain structured – free from buzzes, hum and noise.
6. The system must be equalized as required within specifications. Additional tuning will be done during acceptance, but primary equalization should be done prior to acceptance.
7. All microphone inputs and line level outputs tested for continuity and operation.
8. All intercoms tested on all circuits and able to be verified.
9. Hearing assistance system tested and ready to be verified.

10. Recording systems set up and calibrated for expected gain.
11. All wireless systems must be coordinated for frequencies with no interference in the locality they are installed. Units should not unsquelch or exhibit any noise issues even if all transmitters are not in use.
12. All wireless must be walk tested for dropouts and set up for drop out free performance and frequency coordinated.
13. Automixer must be set up and operational with appropriate gain structure for each input type. All aux sends routed and gain structured for monitor feeds and ADA.
14. All auxiliary gear and record systems tested.
15. HVAC system operational and able to be controlled if needed.
16. Interface at the booth location to all DSP and digital consoles with software and laptop must be set up and operating. A programmer from the sound contractor must be on site fully versed in all DSP and console operations and programming. Adjusting the system from the rack or backstage is not acceptable. Speakers shall be grouped by function in the processor for ease of changes.
17. Speakers shall all be wired properly, in phase and aimed and steered as per the contract documents.
18. Processors must be programmed with all factory parameters for each loudspeaker type. This includes stage monitors.
19. Each speaker and each section of biamp/triamp speakers needs to be able to be fully controlled during testing, as well as all processor setting. If this requires additional personnel at the amp racks with walkie-talkies or cell phones these persons need to be available.
20. Audio control console must be set up with the proper cards installed and all addressing, programming and patching fully complete.
21. The ADA system must be fully functioning with levels set, source selection and a quality signal present at each receiver and throughout the room.
22. All green room feeds shall be present, tested and without hums, buzzes, ground bars, etc.
23. Verification in the form of signed documents that all portable equipment has been delivered to the owner per specs and drawings. Portable equipment must be available for visual inspection as well.

F. VIDEO & PROJECTION SYSTEMS – TYPICALLY TAKES 1-2 HOURS:

1. Projectors properly adjusted for contrast, color and resolution input by input.
2. Control system programmed to allow all operational modes.
3. Source material set up for viewing:
    a. DVD – HDMI or analog as required by design.
    b. Demo DVD for viewing if system is DVD equipped.
    c. Excel spreadsheet
    d. Test patterns – Grayscale – SMPTE Bars, Luma Ramp.
    e. HDMI test generator if the system is HDMI compatible.

4. Any other specific software such as Final Cut Pro, etc. must be configured with appropriate surround sound assignments.

G. CONTROL SYSTEMS – TYPICALLY TAKES 1-2 HOURS:

1. All control system equipment installed and fully functioning.
2. All control system software programming complete.
3. All touchscreen controls fully programmed and functional (i.e. all buttons, pages, commands, etc. must work and execute intended tasks).
4. All touchscreens must mirror each other and all pages update to both screens as to current selection status, etc.

3.25 CLOSEOUT DOCUMENTATION

A. All closeout documentation including training videos must provide the owner with usable training. 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
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 sites audio and AV system 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 there is no sound .
   2) Power up power down of console
   3) Changing between auto and manual modes
   4) A key stroke guide on how to get to menus to check routing, access effects etc….
   5) Constructing and editing scenes
   6) file saves, file loads.
   7) A short list of the required software reset procedures for all audio system related subsystems.
c. Emergency contact number(s) and procedures to follow in the event of a catastrophic system failure.
d. Maintenance procedures and recommended schedules required for equipment installed that requires regular scheduled maintenance.
e. A DVD (or set of DVD's, depending on requirements listed Under Training Sections above)

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

SECTION 192000 THEATRICAL LIGHTING, RELAY & RIGGING SYSTEMS

PART 1 - GENERAL

1.1 PROJECT INFORMATION:

A. Owner: Newburgh Free Academy North Campus
301 Robinson Ave
Newburgh, NY 12550

B. Architect: CSArch
19 Front Street
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 theatrical contractor, 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 new/removals related work or adjacent/mounting surfaces, etc. that might become damaged, have holes cut into them, receive anchorages, left with holes, etc. due to removals work, become inadvertently over sprayed/painted or become dirty during construction and the installation of the indicated devices will be protected/patched by the contractor (this includes patching to match existing & painting/repainting all affected walls, ceilings, misc. surfaces, boxes, devices, etc.). All responsibility for protection & patching work shall be by the contractor. The contractor shall provide final cleaning and/or repair of all equipment,

patching/painting related surfaces, etc. related to or in their scope to like new (and to match adjacencies) 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:

AFF	Above finished floor (finished walkable floor/platform surface referenced)

At Height/Working At Height	Working in any place or location and at a height AFF where a person could fall and potentially injure themselves; there is no minimum or upper limit to this height.
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.
Diagrammatic	A diagram, paragraph, note or drawing serving to explain general intents and requirements (not necessarily an exact representation).
Devices	Any piece of gear, equipment, indicated component and any misc. related items required to implement and install a fully functioning system.
Equal or Equivalent	Equally acceptable as determined by Owner's Representative.
ETR	Existing to remain.
Extend	To increase the length(s) of any indicated conduit/wiring, etc. 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/repainting of holes, marks and damage/damaged surfaces left from removals or new installations work. Consult project manual for additional requirements.
Provide	Procure all required materials, labor, coordination and equipment and locate, install, connect and test 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.
Shall	Indicates that the contractor must perform work and provide devices as indicated. This is a mandatory, obligatory, contractual requirement and is not optional in any way.
VIF (Verify in Field)	Verify in field (VIF) is understood to require the contractor to verify and obtain specific dimensions, locations, interconnections,

	configurations and other related details regarding the existing site conditions. It acknowledges that certain limitations may exist in the preliminary site surveys and existing documentation due to inaccessibility or unintended inaccuracies and explicitly transfers the responsibility to verify these items to the executing contractor. It requires the construction team to physically confirm these items on-site before fabricating components or proceeding with installation.

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 as closely to those indicated dimensions as is possible, unless alternate instructions have been given to the contractor in writing by the consultant (or unless building conditions dictate that dimensions be altered). Any altered installation dimensions must be cleared, in writing, by the consultant prior to installation.

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 and must be stamped per following sections. Provide all work and equipment required for a professional, workman-like installation.

1.5 SECTION INCLUDES BUT IS NOT LIMITED TO:

A. Lighting Systems:
   1. Removals – May include storage and reinstallation of some items. See entire drawings set for all related removals work.
   2. Provision of Theatrical lighting system and related work scope as indicated on drawings including controls for lighting fixtures.
   3. Wiring, setup, focus and commissioning.
   4. Training and closeout documents.

B. Rigging Systems:
   1. Removals – May include storage and reinstallation of some items. See entire drawings set for all related removals work.
   2. Provision of stage and house rigging systems and related work scope as indicted on drawings.
   3. Set up and commissioning.
   4. Wiring, setup, etc. for motorized rigging.
   5. 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 in these written specifications.

1.8 GENERAL REQUIREMENTS:

A. ITEMS TO BE PROVIDED BY OTHERS:
   1. Structural steel (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/lighting system related work on this project must be certified (those performing rigging and/or low voltage terminations, system commissioning, programing, 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 and arena rigger 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 rigging & 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 and rigging system shop drawings with all contractors 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 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".

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.

E. It is understood throughout this document that any referenced standards are intended to refer to the most current version of said standard (even if an older version of the standard is referenced).

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. Full-sized physical samples/mockups must contain all matching equivalent product equipment (fixture, driver, power supply, housing, connectorizations, cross-sectional area, connection types/locations, etc.). Physical samples/mockups that feature some alternate variant from what is being proposed as an equivalent will not be considered at all. Physical samples/mockups may be required for every different variant of said equipment. Full-sized equivalent physical samples/mockups must be delivered to the owner, architect and consultant (as directed in the submittal review process) for full evaluation and testing and cannot adversely affect the overall construction schedule (products that adversely affect the overall construction schedule shall not be considered at all). 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. Final acceptance of equivalent or "or equal" products shall be as indicated below. Along with the above required submissions for equivalent or "or equal" products, the contractor shall submit paperwork detailing the shipment dates/timelines of those products, as this will weigh heavily into the acceptance or rejection of those products as well as their technical aspects.

C. If proposing equivalents that affect the system design as is indicated on the contract drawings, the bidder must submit additional flow charts, detail drawings, manufacturer supporting data and any other drawings necessary to show the 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 may have varying power requirements, physical dimensions, differing minimum clearances, etc.

E. The risk of whether or not bid equivalents or "or equal" submissions will be accepted is borne solely by the contractor. See section 2.1 "Performance Requirements" and further statements below for more information.

F. No equivalents will be considered after award of the contract unless specifically provided in the Contract Documents.

G. The final judgment as to the equality or equivalency of any product submitted as an "or equal" will be solely that of the consultant, architect, construction manager and owner. The contractor shall abide by these decisions.

H. Equivalents must meet or exceed the specified product's performance characteristics. No product shall be considered equivalent to the specified product if it has lesser performance characteristics in any critical area.

I. All costs for any changes required by other trades to implement the contractor provided "or equal" equivalents will be borne by the contractor.

J. All costs for providing the specified products (or any required rush shipping, etc.) due to the rejection of contractor intended "or equal" products (that have been determined by the consultant, architect, construction manager and owner to not be equivalent) will be borne by the contractor.

1.15 SUBMITTALS:

A. Equipment: The contractor must, after bid award but before ordering any equipment or starting any installation work, submit to the consultant, architect & owner for approval a list of all equipment to be furnished showing types, models,

quantities and manufacturer. Attach manufacturer data 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 a copy of the drill drive winch and curtain draw machine manufacturer's written verification ("certificate of compliance") that all hoists and related controls are fully compliant with the latest version of the ANSI motorized rigging standard.

G. 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 certifications.
   4. Current manufacturer certifications.

H. 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.). The stamp must be legible, unaltered and bearing the written date of the PE review.

I. Submit material schedules, shop drawings, bills of materials, lighting & rigging system data/cut sheets and any applicable fire rating data or MSDS sheets for all

lighting & rigging system components and curtains for approval by the architect, consultant and owner prior to any fabrication or installation as follows:

1. Technical Drawings - Lighting:
    a. The full set of submitted drawings and data sheets must be presented in a professional manner.
    b. 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.
    c. 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.
    d. Drawings of proposed mounting methods for all equipment.
    e. Samples of proposed marking systems for wire and equipment labeling.
    f. Rack layouts, panel layouts and proposed labeling.
    g. Schedule for submission of drawings for fabrication and site work.
    h. PE stamped shop drawings for the intended rigging supports for all fixtures being suspended in non-standard ways (i.e. fixtures being suspended from Unistrut channels, angle iron, box steel, misc. metal, etc. and that are not mounted into drop/hard ceilings or from typical pendant style mounts).

2. Technical Drawings - Rigging:
    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.

h. Submission of this package by the contractor is proof that the contractor has reviewed the entire system design, all site conditions and that he understands the intents of the overall system, installation and related system architecture and that concurs that the designed system will actually function as laid out on the contract documents.

* 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.

J. Quality Assurance - Lighting

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.

K. Quality Assurance - Rigging

1. The Basis of design for the drill drive and related counterweight rigging system equipment shall be manufactured by Thern Stage Equipment. 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.

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 and applicable building rigging steel, wooden glu-lam beams & purlins, floor loading, system uplift on structure, seismic requirements, etc. Submission of this package by the contractor is proof that the contractor and his PE have reviewed the entire system design, understands the intents and concurs that the designed system will actually function as laid out in the contract documents and that all related building components will sufficiently withstand the forces imposed upon them by the intended rigging systems equipment.

1.16 GENERAL SYSTEM DESCRIPTION:

A. Theatrical Lighting System:
   1. Architectural Lighting Controls
   2. Performance Lighting consoles
   3. Relay panels
   4. Integrally dimmed LED lighting
   5. Emergency Lighting Interfaces
   6. Hang and focus of luminaires
   7. Commissioning, Training and closeout documentation

B. Theatrical Rigging System:
   1. Drill drive rigging system (and related counterweight system components)
   2. Dead hung rigging system
   3. Motorized Curtain Draw machine and related controls
   4. Curtains (stage and/or window/door curtains)
   5. Tormentor welded lighting pipe assemblies

6. Rigid/batten cove system
7. Misc. required Unistrut, misc. metal, supports, hardware, etc.
8. Safety signage

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. Relay rack substitutions require proof that the substituted product meets all performance requirements including but not limited to:

a. Product warranty period
b. Physical rack size
c. Relay density
d. dB noise output of rack
e. Rack noise frequency response curve
f. 0-10 Volt control capabilities
g. DMX routing and control capabilities
h. Relay rack's acoustic output and tonality
i. No field modifying the rack itself by the contractor in order to meet spec.
j. No operational capabilities limitations in order to meet spec.

2. 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
3. DMX/0-10V Data Emergency Bypass device substitutions require proof that the substituted product meets all performance requirements including but not limited to:
   a. Physical device size
   b. Device installation options (rack mount, DIN rail mount, etc.)
   c. Physical quantity of inputs, outputs, sourcing & sinking
   d. Physical quantity of emergency, UL924, contact, panic or other inputs
   e. Output modes (DMX, 0-10V, 0-15V, 0-2.5V, 0-5V, etc.)
   f. Current rating per channel
   g. Snapshot ability of a DMX "look" into the device's non-volatile memory
   h. Signal isolation and fault protection limits
   i. Quantity of DMX universe control

j. Protocol conversion and compatibility with alternate control schemes (sACN, DMX, RDM, 0-10V, DALI, etc.)
k. DIP switches, programming buttons & configuration limitations
l. Panic controls interface
m. UL924 controls interface
n. UL924 capabilities
o. No operational capabilities limitations in order to meet spec.
p. Required (or not required) device backbox quantities & sizes
q. Emergency control system topology
r. Device quantity, lack of need for additional power/control conduits, wiring, etc.
s. LED indicator light for device emergency status, etc.
t. Form factor
u. No required, additional or "buried" accessories or devices in order to obtain system performance requirements.

4. 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
5. 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.

6. Lighting 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 fixture size
   c. Form factor
   d. Light output pattern
   e. Light output intensity in FC distribution
   f. Wattage of lamps
   g. Expected and average lamp life
   h. Ability of fixtures to fit/hang in intended locations and with all physical limitations of surrounding structure.
   i. Ability of theatrical fixtures to side-hang on tormentor or Shakespeare pipe assemblies.
   j. Ability of theatrical style fixtures to be oriented "base up" for houselighting applications.
7. 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 (physical size, weight, etc.)
   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. Fixture cooling methodologies – convection cooled, fan cooled, overall fan noise in dB, tonality of fan noise and any frequency spectrum spikes in the overall response curve, etc.
bb. Programmatic usage of the space as well as the specific room acoustic character, overall HVAC noise and tonality, etc. will also have an effect on any particular fixture's suitability for use in a space and are evaluated on a case-by-case basis.

8. Outlet box substitutions require proof that the substituted product meets all performance requirements including but not limited to:
   a. Physical outlet box size
   b. Outlet box bracket type, style, customization extents and required frequency of suspension locations.
   c. Form factor
   d. Load rating of outlet box brackets
9. Connector strip substitutions require proof that the substituted product meets all performance requirements including but not limited to:

a. Physical connector strip size
b. Connector strip bracket type, style, size and required frequency of suspension locations.
c. Form factor
d. Load rating of connector strip brackets

10. Drill drive clew winch 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 unit).
    d. Overhead support steel requirements.
    e. Attachment method.
    f. Unit hoisting capacity.
    g. Ability of unit to route liftlines out of various points along case, including out both ends of case, without the need for additional blocks, structure, muling of liftlines, etc.
    h. dB noise output of hoist.
    i. Hoist noise frequency response curve.
    j. Availability of sound suppression housing/shroud to minimize unit noise.
    k. Quantity of available liftlines and liftline gauge/wire diameter.
    l. Control interface size, power requirements and ergonomic layout.
    m. Motor control or motor starter cabinet size & power/control requirements.
    n. Control wiring requirements.
    o. Wireway interface size, location & interface.
    p. Cable management assembly options, size and interface.
    q. Load sensing or overload/underload protection interface.
    r. User interface panel capabilities, functionality and ergonomics.
    s. Pendant or wireless remote capabilities, physical size and operational considerations and ergonomics.
    t. Programmable preset positions available.
    u. Hoist ascent/descent of associated loads configuration (i.e. self-climbing, wall mounting option, overhead mounting option, etc.)
    v. Availability of finishes (powder coating, etc.)
    w. Self-contained.
    x. UL or other appropriate agency listings and ratings.
11. 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 – curtains to be inherently flame resistant as described in detailed curtain fabric descriptions below
    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
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

12. Motorized curtain draw machine 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 unit).
    d. Overhead support requirements.
    e. Machine pull capacity and torque ratings.
    f. Machine duty cycle limitations.
    g. dB noise output of machine.
    h. Control interface size, power requirements and ergonomic layout.
    i. Motor control or motor starter cabinet size & power/control requirements.
    j. Control wiring requirements.
    k. Limit switch stops and capabilities.
    l. Interconnectivity with and control by third-party control system.
    m. Programmable preset positions available.
13. 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. Sheave materials available.
    f. Custom pieces available if need arises.
    g. Sheave counts available.
    h. Idler assemblies.
    i. Critical spacing, line handling or physical size characteristics that may impact installation intents.
    j. Load ratings and WLL capacities.
    k. Safety factors.

l. Sheave diameters.
m. Attachment methods.
n. Welding requirements.
o. Physical construction.
p. Rated and expected life duty cycles.
q. Part traceability.
r. Appropriateness or approval for overhead lifting use.

14. 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. All individual parts and overall assemblies shall additionally conform to the requirements listed below in the “Standards” section of these written specifications.

G. No contractor-manufactured products shall be acceptable in place of referenced items except for those items enumerated in this specification as "custom.”

H. 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.

I. 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.

J. Specification details are provided only for the features required for current and intended future uses of the products.

K. 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 (as well as those referred to below) apply to the stage/house rigging hardware only and not to the building or related structure from which the rigging components are supported/suspended or from which they are accessed.
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 manual counterweight rigging system components used with the drill drive clew winch system shall conform (as a minimum) to the standards set forth in ANSI E1.4-1 – 2022 (Entertainment Technology - Manual Counterweight Rigging Systems) or the current version of the most recent standard revision.

D. All dead hung rigging system components shall conform (as a minimum) to the standards set forth in ANSI E1.4-2 – 2021 (Entertainment Technology – Statically Suspended Rigging Systems) or the current version of the most recent standard revision.

E. 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.

F. 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.

G. 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.

H. 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.

I. 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. BRIDLES:

1. Bridle components, attachments, fittings, terminations and connections shall comply with all related and relevant requirements listed in this section. Bridles shall not be spliced to lift lines.
2. Resultant load angles created by bridle assemblies shall not exceed 60-degrees (30-degrees from vertical) based upon the specific loading conditions of the application.
3. Bridle connections at the batten shall be fixed in place in a manner that prevents slipping along the batten; however, the drilling of pipe battens and fixing bridle connection points (clamps) in place with bolts is not recommended due to potential derating. All bridle point connections with the pipe batten should be accomplished with a full pipe clamp or similar mechanical device properly installed as per the manufacturer's recommendations and guidelines.

4. All bridled lines shall connect at the bridle point via a weldless ring or weldless pear-shaped link designed for bridle applications. All weldless rings or pear-shaped links shall be quenched & tempered alloy or forged carbon steel, shall be proof tested with certification certificate and meet the performance requirements of Federal Specification RRC-271D, Type VI (except for those provisions required of the contractor).

C. 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.

D. 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.

E. 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.

F. 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.

G. 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.

H. 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^{th} link or similar).
6. Trim chains shall be Peerless black theatrical chain or equal.

I. OVERHEAD LIFTING CHAINS:

1. Any overhead lifting chain must be a Grade 80 or Grade 100 (or higher) alloy chain approved for overhead lifting (with the exception of the Grade 63 trim chains which meet the OSHA requirements).
2. All overhead lifting chain or chain assemblies or related components must meet the OSHA 1910.184(e)(5) and the ASME B30.9 standards.
3. All overhead lifting chain or chain assemblies and related individual components that are visible shall be flat black, unless otherwise noted on the contract documents (excepting those portions that are buried within ceilings, etc. that cannot be seen from the audience areas of the facility).
4. Any individual component manufactured for overhead lifting quality standards, if it is used as part of a lifting assembly, then the entire assembly must be tested and tagged before use.
5. Chain assemblies shall not use horizontal angles of less than 30°.
6. The overhead lifting assembly shall be rated for not more than the WLL of the weakest component in that assembly (that component with the lowest WLL).
7. Side loading of any overhead lifting chain is not permitted.
8. Any sharp edges which may contact any portion of an overhead lifting chain or assembly must be dulled and/or properly wrapped/padded in order to protect the chain and related components. Failure to do so will result in the installing contractor having to provide all new components and installation labor at his own cost.

9. If the overhead lifting chain or any related assembly components have been exposed to high temperatures, water or corrosive materials, then any affected components shall be removed from service per OSHA and ASME standards and replaced by the contractor (up until the time of the official turnover of the space to the owner).

J. SHEAVES:

1. Sheaves shall be of the following materials, as specified:
   a. ASTM A-48 Class 30 grey iron castings
   b. Nylatron or Polyamide Nylon (PA6-G)
   c. Steel (only as specifically noted or indicated)
2. Groove depths shall be sufficient to encompass fully the cables and ropes. Grooves shall have sloped sides (8-degree minimum) and conform to rope and cable manufacturers' standards for groove shape and tolerance.
3. Sheaves shall be supported by bearings and a machined steel shaft, which shall be keyed to one side plate to prevent rotation. Proper adjustment of the bearing shall be accomplished by means of a fine thread, self-locking nut on the opposite end of the shaft. Each sheave shall run plumb and true without rubbing its side plates when rotated.

K. LOCKING RAILS:

1. The locking rail shall be constructed from structural steel shapes and shall consist of a top railing and its supports. The rail top shall be drilled to receive the rope locks on the required centers. The rail shall be designed to accept either the anticipated loads imposed by the counterweight sets, or 23 kg (50 pounds) per rope lock plus concentrated loads of 227 kg (500 pounds) at the midpoint between each locking rail upright, whichever is greater. It shall also be designed to absorb a horizontal load as dictated by system design and applicable codes.

2. The locking rail assembly itself shall be attached to the building structure using weldments, bolts or anchors specifically sized and designed for the loads, mounting surfaces and conditions present in the field or shall be welded to appropriate substrates (if they exist). Any weldments indicated on the drawings or otherwise required must be provided by the contractor or by a qualified sub-contractor. Any weldments needed shall be specified by the manufacturer(s) and shall meet or exceed minimum industry standards and those standard practices set forth within related contract weldment specifications. No weldments noted shall be negotiable or optional. See structural and TR series drawings as well as structural specifications for more information on mounting details, attachment methods and requirements, embedment depths, etc. The preferred method of attachment is to weld the locking rail stanchions to existing steel channel (flush mounted in floor). If this does not exist, then locking rail shall be attached with epoxy anchor bolt method. See project structural engineer for embedment depth, exact type of anchor, drilling procedures, etc. as well as manufacturer's recommendations for expected loading imposed. All welding shall be performed by the installing rigging contractor or qualified sub-contractor, as per current AWS (or other required) standards. Manufacturer shall specify weld.
3. Any customizations of locking rails shall be performed and provided by a manufacturer. Customized locking rails must be engineered by a manufacturer, delivered to the jobsite and installed to be a single functioning unit. The contractor shall not be allowed to augment, alter or modify a locking rail in order to meet maximum loading forces or any other parameters.

L. 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.

M. 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.

N. 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 $1/10^{th}$ 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.

O. 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)	¼″	½
	5/16″	¾
	3/8″	1
	7/16″	1.5
	½″	2
	5/8″	3.25

	¾″	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)	¼″	.23
(referenced product forged, HG-227)	5/16″	.36
	3/8″	.54
	½″	1
	5/8″	1.59
	¾″	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 THEATRICAL LIGHTING CONSOLE: REFERENCED PRODUCT ETC ELEMENT 2

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 Element 2 as manufactured by Electronic Theatre Controls, Inc., or equal.
2. The system shall provide control of either 1,024 or 6,144 outputs on a maximum of 32,768 control channels, which may be any number from 1 to 99,999. Output shall be distributed over a 10/100 MB Ethernet network using Net3/ACN, ETCNet2, Avab and/or Artnet (multi-cast) protocols. The user shall be able to control the application of protocols at an individual address level.
3. The system shall support full bi-directional RDM communication with compatible devices via Net3 DMX/RDM Gateways. RDM communication shall adhere to ANSII standard E1.20-2006 Entertainment Technology – RDM – Remote Device Management Over DMX512 Networks. Supported RDM features shall include:
   a. Discovery and Identification of RDM capable devices
   b. Setting of start addresses, operating modes and additional settings as exposed by connected devices and controllable via RDM
   c. Viewing of Sensor data as provided by connected devices
   d. Error reporting as provided by connected device
4. A maximum of 10,000 cues, 1000 groups, 1000 presets, 4 x 1000 palettes (Intensity, Focus, Color and Beam), 99,999 macros, 1000 effects, 1000 curves, 1000 Color Paths and 1000 snapshots may be contained in non-volatile electronic memory and stored to an onboard solid-state hard drive or to any USB storage device.
5. Channels shall respond to cue information by last instruction with discrete rate control provided for all cues. The console may be placed in Tracking or Cue Only mode by the user as a system default and overridden on individual record actions as required. HTP/LTP intensity flags, block, proportional, intensity master or manual master fade control. Priority and Background Priority may be placed on the cue list. It shall also be possible for a cue list to contribute to playback background states or to withhold such contributions.

6. A Master Playback fader pair shall be provided. The fader pair may execute crossfades or all-fades, with IFCB cue level timing,
7. The console shall provide 40 pageable faders that may be operate in either LTP channel or fader mode. Virtual fader control for playbacks is also provided.
8. A high-resolution level wheel shall be provided to control intensity for selected channels and scrolling within selected displays. A high-resolution rate wheel, which may also be used for fader paging shall be provided.
9. Virtual moving light controls shall provide mouse/touch-based tools for all parameters. The tools shall display the current value for each parameter and provide controls for adjusting each parameter.
10. Control and programming features for automated fixtures shall also include: a standard library of fixture profiles, the ability to copy and edit existing profiles and create new profiles, patch displays including channel and output addressing, 16-bit fade resolution, color characterization allowing color in up to six different color spaces.
11. System information, including playback status, live output and blind values for all record targets shall be displayed on a maximum of two external high resolution monitors, which may also be multi-touch touch-screens. Every display shall support three user-definable workspaces. Each of these workspaces shall provide individually configured frames, with size/scaling controls. Any Windows 7 compatible display may be used.
12. A context sensitive on-line Help feature shall explain and provide an example of the operation of each feature of the system. This help system shall be integrated into the on-board user manual via hyperlinks. Optional dynamic prompts are also provided.
13. A fully integrated Virtual Media Server feature shall allow user to map images and animations to a rig array. 40 such maps may be created, each with 12 layers. System that rely on external hardware or software for this functionality shall not be acceptable.
14. User-definable, interactive displays may be created. These displays, which can be used in live and blind operating modes, allow graphical layout of channels, desk buttons and programming tools. Standard symbols are provided, and the user may import their own symbols or graphics. Each symbol may be individually defined with data feedback characteristics. Non-interactive status information, such as a mirror of other user's command lines, may also be included in the display. A graphical browser is provided for fast selection of these views. Multiple zoom factors and placements may be stored and recalled for each display.
15. A detachable alphanumeric keyboard shall be optional. The keyboard shall allow labeling of all show content. An integrated virtual alphanumeric keyboard shall be provided.
16. Console software upgrades shall be made by the user via flash drive. It shall be possible to install software updates in all consoles, processor units and remotes from one device over the network.

17. The console operating software shall be loaded into program execution memory from the internal hard drive when the console is powered. In the event of an uncontrolled shutdown, the console shall return to its last output state when power is restored. Devices requiring a UPS to provide such protections shall not be acceptable.
18. Integrated dimmer monitoring features shall be provided to allow indication of dimming system status, error states and dimmer load monitoring. Adjustment of dimmer configuration from the console shall also be supported. Communications with the dimming system shall utilize ANSI E1.17 2006 - Entertainment Technology - Architecture for Control Networks.
19. Integrated RDM device features shall be provided. The console shall discover and patch RDM devices. The console shall monitor RDM devices to allow indication of RDM device online/offline status error states. The console shall be capable of changing settings of RDM devices such as the DMX start address. Communications with the RDM devices shall utilize ANSI E1.20 2006 – Remote Device Management.
20. Network configuration tools shall be provided from within the desk.
21. Show data may be created and modified on a personal computer, using either Windows 7 or higher or a Macintosh platform running OS 10.11 or later via a free offline editing application. The program shall run natively on Apple operating systems. Applications requiring PC emulation programs shall not be acceptable.
22. A PC, using either Windows 7 (or higher), or a Macintosh running OS 10.11 (or later) using the offline software application shall be able to connect to a control system via the network and view or modify current show data in an independent display environment, using an ETCnomad key. When connected without the key, the computer shall operate in Mirror Mode, with the device to be mirrored selectable by the user.
23. Synchronized backup shall be provided via another full console on the network, an ETCnomad/Puck, or by use of a remote processor unit. The backup device shall maintain synchronized playback with the master and shall take over control of the lighting system upon loss of communication with the master.
24. A maximum of 99 users may access and interact with show data simultaneously. Each user shall have an individual workspace. User identification may be assigned to more than one control device, allowing users to work in tandem, or allowing a designer/ALD to mirror the current display format, mode and command line of the associated programmer. Partitioned control allows discrete control of channel/parameter groupings by user. Partitioned control may be easily enabled and disabled with no need to merge show data from multiple users.
25. The system shall support up to 32 individual simultaneous Time Code inputs or Event lists using Show Control Gateways.
26. Systems that do not provide the above capabilities shall not be acceptable.

B. Controls and Playback

1. Manual Control and Programming Section

a. The console keyboard shall be grouped by function. Major groupings shall be record target functions, numeric keys, level assignment functions, display navigation functions and controls, as well as non-intensity parameter controls.
b. The command keypad shall be fully interactive with direct selects and other virtual controls, which provide "one touch" selection of channels, groups, palettes, presets, effects, snapshots and macros.
c. Non-intensity parameters may be set numerically via an extensible keypad. This control shall be fully interactive with the moving light controls. The controls shall also access available modes for each parameter type, min and max values for each parameter as applicable, as well as home position on a parameter basis.
d. Only those parameters available for control in the active lighting system shall be displayed for control. Displays shall condense or lowlight parameters not available to selected channels.
e. Lamp controls provide direct access to luminaire functions such as striking and dousing arc lamps and calibrating entire fixtures or individual mechanisms of fixtures, as provided by the luminaire manufacturer. User access to these features is normalized across all manufacturers for ease of use. Use of a "control channel" for accessing these functions shall not be required and systems requiring use of control channels for these functions shall not be acceptable.
f. Fan functions shall be provided both via command line operation and through encoder controls.
g. Highlight shall be supported, with user definable highlight values. Lowlight conditions may be defined for selected, but not specified channels. Rem Dim commands, at specific levels by channel, may be optionally and automatically called with the highlight command.
h. Advanced color control functions provide color mixing in any of six different color spaces. Gel matches are provided via gel picker or by command line control. Tinting tools allow adjusting the color mix irrespective of the native mixing system. Spectrum tools support adjusting the output of additive color systems with more than three emitter types, allowing the X/Y coordinate to be held while adjusting the recipe that achieves that mix. Color Path tools allow the user to control the live fade of fixtures through the color space.
i. The Virtual Media Server function shall allow the user to create layouts of devices, identified as pixel maps. Media content (images, movies, text and procedurally generated effects) may then be applied, manipulated and stored. Stock content is provided and the user may import his own imagery and animations.
j. Macros may be set to run as default. Default macros called manually hall post to the command line, but executed via cue lists shall run in the background. The user may override this behavior by defining the macro to always execute

in the foreground or background, regardless of the recall method. Startup, Shutdown and Disconnect macros may also be defined.

2. Playback Section
   a. The playback faders shall consist of a 100mm Master Fader pair with associated control buttons as well as 40 45mm faders which may be placed in channel or playback mode.
   b. Virtual fader controls are also available for playbacks.
   c. It shall be possible to instantaneously halt an active cue, back to the previous cue, manually override the intensity fade or manually override the entire fade.
   d. It shall be possible for a cue list to contribute to the background state or for the contents to be withheld from such. Priority and background priority states may be established.

3. Channel/Playback Faders
   a. Up to 999 proportional, fully overlapping additive or inhibitive submasters may be defined. Submasters shall have colored LEDs to indicate submaster status. Each submaster may have fade up, dwell and down fade times. Submasters may be set to priority and background priority status.
   b. Submasters may be set to HTP or LTP intensity. Non-intensity parameters on submasters shall be LTP only.
   c. Exclusive mode for a submaster shall prohibit the live contribution of that submaster from storing to cues or other submasters. Shield mode prohibits access of associated channels from any other playback or manual control operations.
   d. A submaster potentiometer may be defined as proportional, master only or intensity master. When set as an intensity master, a mark and unmark feature is supplied.
   e. The submaster blind buffer shall be linked directly to live playback.
   f. It shall be possible to set submaster values directly from the command line.
   g. Submasters may be set to fade to background or to minimum value when the fader is returned toward zero.
   h. Submaster values may contribute to the background state or withheld from such.
   i. Presets and IFCB palettes may be mapped to playbacks, either individually or in user defined groupings.
   j. Channel mode shall allow the user access to the first 120 channels, operating in LTP logic. Faders that are not currently set to the same level as the corresponding channel must be matched to that level before gaining control. Physical channels may be cleared without impacting output using Sneak.

4. Grand Master Faders
   a. The location of the Grand Master shall be user definable. The grand master shall have associated blackout and blackout enable buttons.

b. Blackout shall send all associated intensity outputs to zero. Non-intensity outputs shall not be affected. It shall be possible to exclude channels from Blackout and Grand Master control.

C. Display Controls

1. Format shall change the view of selected displays.
2. It shall be possible for the user to choose which parameter categories or parameters (s)he wishes to display.
3. Flexichannel modes shall change which channels are viewed in selected displays, as follows:
   a. No modes
   b. Masters only/cells only
   c. Use Partitions
4. Flexichannel states shall change which channels are viewed in selected displays, modified by the modes, as follows:
   a. All channels
   b. Patched channels
   c. Show channels
   d. Active/Moved channels
   e. Selected channels
   f. Manual Channels
   g. View channels (user identified list)
   h. Channels with discrete timing
5. Expand shall extend the selected view sequentially across connected displays, vertically or horizontally.
6. [Time] depressed shall display discrete timing data. [Data] suppressed shall display absolute values of referenced data. These functions may be latched.
7. Displays may also be toggled to show stored data currently manually overridden, the source of the current parameter data, output level, patch assignment, part structure and referenced marking data.
8. Playback status displays are provided with a variety of different formats. Indications are provided per cue for live moves (lights fading from zero and also moving non-intensity parameters) and dark moves (inactive lights which have stored non-intensity parameter moves).
9. Display content including which of the workspaces is in focus on any of the external monitors and what views are docked in those workspaces may be instantly recalled using snapshots.

D. Operating Modes

1. Live Mode

a. Channel lists may be constructed using the +, -, and Thru keys as well as the direct selects. Channel selection and deselection is fully interactive, regardless of the method used.
b. Levels may also be set with the keypad, level wheel and non-intensity encoders. "Selected" channels shall be those last addressed and under keypad control. Controls are provided for single button access to the last selected channel list, all channels with manual levels and all active channels.
c. Channels may be set at a user defined default level using the Level key. +% and -% keys adjust channels quickly by user definable values.
d. Channels and/or channel parameters may be captured. Capture mode shall allow the user to selectively capture channel data at specific levels. Captured data shall be indicated on the Live display.
e. Sneak shall be used to restore specified channels to background states, default values, or to send them to specified values, in user specified times.
f. Selected channels may be set at a level or held to current values while all other channels are set to zero using Rem Dim. Toggling Rem Dim shall restore all unselected channels to original levels. The Rem Dim level shall be user definable via the command line or with a default setup value.
g. Channels may be recorded into groups for fast recall of commonly used channels. 1000 groups shall be available. Groups shall store selection order. The Offset function supports rapid creation of ordered groups, including reverse and random order.
h. Parameter settings may be stored to Intensity, Focus, Color and Beam Palettes and to Presets. All referenced data may be stored to whole numbers or to up to 99 decimal places between each whole number.
i. The following conditions may be placed on a channel or channel parameter to be included with a cue record action.
    1) Discrete fade time and/or delay
    2) Block flag
    3) IFCB Filters, which may be set at a parameter level.
    4) Release and Restore
j. Cues may be recorded in any order. Up to 99 decimal cues may be inserted between any two whole number cues. Each cue may contain a maximum of twenty parts.
k. It shall be possible to record cues and cue parts with the following information:
    1) Any collection of channel data, as determined by the use of "Record", "Record Only" or selective store commands, combined with parameter filters.
    2) Cue Level timing and delays for Intensity Up, Intensity Down, Focus, Color and Beam.
    3) Follow or hang time
    4) Link instruction

5) Loop value
6) Block, Preheat, and/or Mark Flag
7) Curve
8) Label and note
9) Execute list to trigger other activity

l. Non-intensity channel parameters may be preset to an upcoming position using Automark. Automark shall set any stored parameter transitions in the cue just prior to intensity becoming active. Automark may be disabled on a cue or cue part basis, enabling a "live" move. .

m. Any channel parameter may be stored with an effect instruction. These effects may contain relative offsets from current value, or absolute instructions. Effects may be progressive action or on/off states. Entry and exit behaviors shall modify the channel parameters activity when beginning and ending the effect.

n. Update may be used to selectively add modified parameter data quickly to that parameter's current source. Update may be specified to modify referenced data content or break the link to that content. A dialogue informs the user of the content that will be updated. A trace command may be used to modify the data to the original source of its move instruction. It shall be possible to update inactive record targets.

o. Recall From quickly pulls specified data from record targets or other channels into the current view.

p. Copy To quickly copies selected data to specified channels or other record targets.

q. Address and channel check functions shall be provided.

r. Channel parameters may be "parked" at levels. Those levels are not added to any live record operations, nor may they be changed until the parked element is "unparked". Scaled park provides real time proportional adjustment of stored intensity values. Address Park shall also be provided.

s. About shall provide detailed status of selected channels or specified record targets. This shall include current source, current value, discrete timing, parked value, marked to and for indications. Background levels and current DMX output are also displayed. Channel usage indicates submaster and cue information and also provide a "dark moves" report on a per channel basis.

t. 1000 snapshots may be stored which instantly recall specified front panel and display configurations.

u. Live data may be displayed in a summary view or detailed table orientation.

v. Query shall allow selection of channels by their current or possible state. Keywords and fixture types shall allow quick access to fixtures.

w. User definable home positions, on a per channel basis, may be defined.

x. Channel level offset commands provide channel ordering and sub-grouping functions.

y. Undo shall be used to sequentially step back through manual operations or to undo record and delete actions. It shall be possible to undo multiple commands in one action.

2. Blind
   a. The Blind display allows viewing and modification of all record targets without affecting stage levels.
   b. Record target data may be displayed in a summary view, a detailed table orientation or a spreadsheet view, which allows quick data comparisons, move and replace functions.
   c. Changes to blind data shall be automatically stored. Range selection of both record targets and channels shall be supported.

3. Patch Display
   a. Patch shall be used to display and modify the system control channels with their associated library data.
   b. Each channel may be provided with a proportional patch level, curve, label, swap and invert functions, as well as keywords to service Query.
   c. Offset functions in patch shall allow selection of channel ranges and shall allow the user to establish a "custom" footprint for any device output.
   d. Custom color wheels, color scrolls and gobo wheels shall be defined in patch. These devices shall be created with a simple table and graphical user interface supported by images of major manufacturers.
   e. RDM discovery and device monitoring shall be supported.
   f. Copy to and Move functions shall be supported in patch.

4. Setup/Browser
   a. Setup shall access system, user and device configurations.
   b. It shall be possible to partially import Eos show files. Users shall be able to select as much or as little of the show file as required, with renumber tools.
   c. It shall be possible to import ASCII and Lightwright data files. It shall be possible to export as ASCII or .csv.
   d. Setup shall also access show data storage, import, export, print to .pdf and clear functions, as well as show data utilities.
   e. The system shall support programming and playback of real time clock events, including cue, submaster and macro execution at specific times of specified days or at a time based on astronomical events.
   f. A control screen shall be provided for network configuration, selecting date/time, software update controls, selecting functional language and/or keyboard for labeling option, as well as other system level tools.
   g. Available languages for prompts, advisories and help messages shall include English, Bulgarian, German, Spanish, French, Italian, Japanese, Korean, Russian, Chinese, simplified and Chinese, traditional.

h. Supported keyboards shall include American, United Kingdom, French, German, Italian, Korean, Norwegian, Russian, Slovakian, Turkish, Swiss, Swedish, Finnish and Bulgarian.

E. Dimmer Monitoring and Configuration

1. The lighting control system shall provide communication with an ETC Sensor+, Sensor3 or FDX dimming system for remote monitoring and configuration of show specific functions from within the software application.
2. Circuit level configuration and monitoring functions shall include but not be limited to:
   a. Control mode (dimmable, switched, latch-lock, always on, off or fluorescent).
   b. Curves
   c. Control threshold
   d. Min and Max Scale Voltage
   e. Preheat
   f. Scale load
3. Rack status messages shall include but not be limited to:
   a. State of UL924 panic closure
   b. DMX port error/failure
   c. Network error/failure
   d. A, B, C Phase below 90 or above 139 volts and headroom warning
   e. Ambient temperatures out of range
4. Circuit status shall include but not be limited to:
   a. Module type and location
   b. Output level
   c. Control Source
   d. Overtemp
5. Advanced circuit feedback shall include but not be limited to:
   a. Load higher or lower than recorded value
   b. DC detected on output
   c. SCR failed on/off
   d. Breaker trip
   e. Module has been removed
   f. Load failure
   g. Shutdown due to Overtemp

F. Interface Options

1. The console shall support a variety of local interfaces.
   a. AC input
   b. USB (five ports for items such as alpha-numeric keyboard, mouse, touch screens, USB Flash drive)

c. Ethernet (two ports)
d. Two Display Port output connectors, supporting Windows 7 compliant monitors as 1280x1024 resolution minimum. Touchscreen/multi-touch support of any/all of these monitors is provided.
e. Contact Closure trigger via D-Sub connector
f. 4 DMX/RDM ports
g. Alternative Contact Closure trigger through Gateway
h. OSC Transmit/Receive
i. MIDI In/Out, MSC and MIDI Notes through Gateway
j. SMPTE Timecode through Gateway

G. Accessories

1. ETCPad (ETC Portable Access Device)
2. iRFR and iRFR Preview (applications for iPhone, iPod Touch and iPad units)
3. aRFR (application for Android devices)
4. Net3 Remote Video Interface
5. Gateways
   a. Net3/ETCNet 2 to DMX/RDM Gateways (one to four ports)
   b. MIDI/SMPTE Gateway
   c. I/O Gateway with 12 analog inputs, 12 SPDT contact outputs, RS-232 interface

H. Synchronized Backup

1. An optional Backup system shall consist of one of the following combinations of devices:
   a. Two networked Consoles.
   b. One Console with one Remote Processor Unit (RPU)
   c. One (or more) Consoles with two Remote Processor Units (RPUs)
   d. ETCnomad/Puck

I. Physical

1. All operator controls and console electronics for a standard system shall be housed in a single desktop console, not to exceed 35” wide, 15” deep, 4.5” high, weighing 16 pounds. Console power shall be 90 – 240V AC at 50 or 60Hz, supplied via a detachable locking power cord.

2.5 LIGHTING CONSOLE WIDESCREEN TOUCHSCREEN DISPLAY: REFERENCED PRODUCT DELL S2240T 21.5" FULL HD 16:9 BLACK MULTITOUCH LED TOUCHSCREEN MONITOR

A. Display:
   1. Viewable image size (diagonal): 54.6 cm (21.5 inches)
   2. Horizontal/Vertical: 476.64 mm (18.77 inches); 268.11 mm (10.56 inches)
   3. Maximum resolution: 1920 x 1080 at 60 Hz

4. Aspect ratio: 16:9
5. Pixel pitch: 0.248 x 0.248 mm
6. Brightness (typical): 250 cd/m^2
7. Color gamut (typical): 84%
8. Color depth: 16.7 million colors
9. Contrast ratio (typical): 3,000:1
10. Dynamic contrast ratio (max): 8 million:1
11. Viewing angle (typical): (178° vertical / 178° horizontal)
12. Response time (typical): 12 ms with overdrive
13. Panel type: VA
14. Panel Backlight: LED
15. Tilt: Up to 60°
16. Flat Panel Mount Interface: VESA Mount 100mm x 100mm (Wall Mount sold separately)

B. Touch specifications:
1. Touch technology: Projected capacitive system
2. Sensor stack thickness: 1.1 mm
3. Cover glass thickness: 1.1 +/- 0.2 mm
4. Touch method: Fingers and thin gloves
5. Touch point: 10 touch-points
6. Response time: 25 ms
7. Supporting OS: Windows 8 Certified

C. Connectivity:
1. Connectors (S2240T):
a. DVI-D (HDCP)
b. HDMI
c. VGA
d. USB 2.0 upstream port (for touch enablement)
e. Audio line-out

D. Security: Security lock slot

E. Physical:
1. Dimensions:
a. Height (extended): 370.8 mm (14.60 inches); Width: 522.5 mm (20.57 inches); Depth: 205.7 mm (8.10 inches)
2. Weight:
a. Weight with packaging: 6.9 kg (15.20 lbs)
b. Weight without packaging: 5.80 kg (12.78 lb)
c. Weight of monitor only (without stand): 3.4 kg (7.49 lb)

F. Service and warranty: 1 year limited hardware warranty and advanced exchange service.

G. Power:
1. AC input voltage/frequency/Current (typical): 100 VAC to 240 VAC / 50 Hz or 60 Hz + 3 Hz / 1.2 A (typical)
2. Power consumption (normal operation, typical): 20 W
3. Power consumption (active off mode): <0.5W

2.6 WALL MOUNTED RELAY PANEL AND LOAD CENTER: REFERENCED PRODUCT ETC UNISON ECHO RELAY PANEL

A. General

1. The wall mount relay panel shall be the Echo Relay Panel as manufactured by ETC, Inc., or equal
2. Relay Panels shall be UL508, UL67, and UL924 Listed, and shall be so labeled when delivered
3. Relay Panels shall consist of a main enclosure with 30 pole breaker subpanel, relay/dimmer sub panel, integral control electronics, and a low voltage subpanel for data terminations and provision for accessory cards
   a. Up to two accessory cards shall be supported per relay panel

B. Mechanical

1. The panel shall be constructed of 16-gauge steel. All panel components shall be properly treated and finished in fine-textured, scratch resistant paint
2. Relay panels shall be available in 120 and 277 Volt AC configurations
   a. 120V enclosures shall be 67.5″ high by 14.36″ wide and 4″ deep with a weight not more than 80 pounds
   b. 277V enclosures shall be 67.5″ high by 20″ wide and 6″ deep with a weight not more than 130 pounds
3. The panel shall be capable of being mounted on the surface of a wall or recessed mounted
   1) 120VAC panels shall support mounting between standard wall stud framing (16-inch on center spacing)
4. Choice of panel covers shall be available for surface or recess mount applications. This outer panel shall ship complete with a locking door to limit access to electronics and breakers, breakers
   a. Optional center-pin reject security screws shall be available for all accessible screws
   b. Recess mount doors shall extend 1″ beyond all panel edges to hide wall cut-out
5. The unit shall provide interior cover over breaker panel to allow access only to class 2 wiring and prevent direct access to class 1 line voltage components
6. The Relay panel shall support up to twenty-four 20-amp single pole circuits made up of relays or 300W phase-adaptive dimmers

a. Two and three-pole relay circuits shall be supported at decreased density where each pole constitutes one of the available single-pole circuits. Mixing of circuits in any combination shall be supported
b. Panels that do not support an integral dimmer module shall not be acceptable

7. Relays shall include integral switches for manual control while power is unavailable to the panel such that critical lighting can be set to an on state, without the need for power to the panel
8. Relay output lugs shall accept 6-14AWG copper wire
9. Breaker subpanel may include up to twenty-nine 20-amp single pole, up to fourteen 20 amp double pole, or nine three pole breakers as required in any combination up to capacity
10. Control wiring for DMX, station bus, and Emergency input terminations shall land on removable headers for contractor installation.

C. User Interface

1. The user interface shall contain a graphical display with button pad to include 0-9 number entry, up, down back arrow navigation and enter
2. Test shortcut button shall be available for local activation of preset, sequence and set level overrides
3. The user interface shall have a power status LED indicator (Blue), a DMX status LED indicator (Green), a network status LED indicator (Green) and an LED indicator (red) for errors
4. Interface shall allow the backlight to timeout and shall provide user editable options to shut off backlight completely as well as adjust screen contrast
5. Ethernet interface shall default to automatic IP through link local and DHCP. Upon receiving IP address, the address of the Network Interface Card (NIC) shall display in the about menu. Static address and settings shall also be possible
6. The control interface shall support a USB memory stick interface for uploads of configurations and software updates

D. Functional

1. Panel setup shall be user programmable. The control interface shall provide the following relay setup features (per circuit):
   a. Type (1 pole, 2 pole, or 3 pole)
   b. Name
   c. Circuit Number
   d. DMX address
   e. sACN address
   f. Space Number
   g. Circuit Modes
      1) Normal (priority and HTP based activation and dimming)

2) Latch-lock
3) Fluorescent
4) DALI

h. On threshold level
i. Off threshold level
j. Include in UL924 emergency activation
k. Allow Manual

2. Relay panels shall support discrete addressing of each relay. Panels that are restricted to use of start address with sequential addressing and cannot assign each 0-10V output control to any internal relay shall not be acceptable
3. The panel shall be capable of switching all relays on or off at once, or in a user-selectable delay per relay using a period of 0.1 to 60 seconds, in 0.1 second increments
4. An Ethernet connection shall provide advanced control of relays over streaming ACN (sACN) and transmit status, control override, and measured energy usage per branch circuit via an internal Web UI or central monitoring interface
   a. Control electronics shall report the following information per branch circuit.
      1) Breaker state (On/Off)
      2) Breaker state (Open/Closed)
      3) Current draw (In Amps)
      4) Voltage
      5) Energy usage
   b. Panels that do not report this information shall not be acceptable.
5. Built-in Control shall include:
   a. Ability to record up to 16 presets in each space from the control panel, connected control stations, or timed events
   b. Presets shall be programmable by recording current levels (as set by DMX or connected control stations), by entering levels on the control panel directly, manually selecting relay state on each relay or a combination of these methods. From the control panel, stations, or timed events it shall be possible to record values for up to 16 zones per space
   c. Up to 8 spaces in a single rack for total of up to 16 spaces shall be supported per system or system subnet
   d. Indication of an active preset shall be visible on the control panel display
   e. One 16-step sequence per space for power up and power down routines
   f. The panel shall have a UL924-listed contact input for use in Emergency Lighting systems. The panel shall respond to the

contact input by setting included relays to “on”, while setting non-emergency relays “off”. Each relay can be selected for activation upon contact input

g. Upon Data loss the system shall provide options to hold last look infinitely or hold for a configured time period set by the installing technician then fade/switch to the input of the next available priority

h. Control electronics shall respond directly to control stations for zone, preset, and sequence control. Systems that require secondary control systems for this functionality are not acceptable

i. After power loss, electronics shall be capable of holding the system in its previous state until new level data (DMX, architectural presets, sequences and zones, or local overrides) is received to make each relay change state

6. The control of lighting and associated systems via real time and Astronomical clock controls

a. The relay panel shall allow the activation of presets, sequence, and zone programming of up to 50 time clock events via a built in real and astronomical timeclock

b. System time events shall be programmable via the control panel.

1) Time clock events shall be assigned to system day types. Standard day types include: everyday, weekday, weekend, Sunday, Monday, Tuesday, Wednesday, Thursday, Friday and Saturday

2) Time clock events shall be activated based on sunrise, sunset, time of day or periodic event

3) System shall automatically compensate for regions using a fully configurable daylight saving time

4) Presets shall be assigned to events at the time clock

c. The time clock shall support event override

1) It shall be possible to override the timed event schedule form the face panel of the time clock

d. The time clock shall support timed event hold

1) It shall be possible to hold a timed event from the face panel of the processor

2) Timed event hold shall meet California Title 24 requirements

7. The panel shall receive ESTA DMX512-A control protocol. Addressing shall be set via the user interface button keypad with any relay being patched to any DMX control address

a. 2,500V of optical isolation shall be provided between the DMX512 inputs and the control electronics as well as between control and power components

b. The relays shall respond to control changes (DMX or Stations) in less than 25 milliseconds. DMX512 update speed shall be 40Hz
c. Setting changes shall be able to be made across all, some, or just one selected relay in a single action from the face panel
d. DMX data loss shall allow for levels/relays to be held for ever or for a specified time before switching to a lower priority source
e. Initial Panel setup
    1) The relay panel shall automatically detect the type of relay or dimmer installed in each location without need for manual configuration of the physical arrangement.
    2) Quick rack setup shall be available to apply address settings across all circuits for rack number, DMX Start Address, sACN universe, and sACN start address.
    3) Emergency Setup Menu shall provide optional delays when emergency is activated or deactivated, and option to turn off non-emergency circuits shall be available. Record function shall allow circuits that are turned on to be added to the emergency setting

E. Electrical

1. Relay Panels shall be available to support power input from:
    a. 120/208V three phase 4-wire plus ground
    b. 120/240V single phase 3-wire plus ground
    c. 277/480V, 230/400V and 240/415V three phase. 4-wire plus ground
2. Conduit Entry:
    a. Feeders:
        1) Top or top-side (upper 6" of either side)
        2) Bottom or bottom-side 6" of either side
        3) Feeders shall enter through the top or bottom according to the orientation of the enclosure
        4) Feeder entry shall be nearest to the location of the feeder lugs or main breaker
    b. Load:
        1) Load wiring shall enter through the top or bottom of the enclosure
        2) Load wiring shall enter through the top/bottom surface nearest to the breaker sub panel
        3) Load wiring may also enter through left and/or right side provided a low voltage chase is not required through the same area. If class 2 chase is required, a field installable barrier panel shall be provided upon request. When installed, the left or right side of the panel, where the barrier has been installed, shall not permit load wiring

c. Low Voltage:
   1) Top or top-side (upper 6" of either side)
   2) Bottom or bottom-side (bottom 6" of either side)
   3) For low voltage conduit entry at the relay end of the cabinet, conduits shall be located at the outer 3" of the top/bottom panel
   4) Field installed low voltage channel shall be provided separately for installation on the left or right side of the panel to allow class 2 wiring to traverse the panel from top to bottom or bottom to top

3. All relays shall be mechanically latching
4. The relay shall be capable of switching 20A at up to 300V
5. The relay panel shall support a maximum feed size of 200 Amps
6. Relay panels shall support main circuit breaker options:
   a. Main breaker options shall be optional and available for purchase upon request
   b. Main breakers shall be field installable
   c. Main breakers shall be available in 100 and 200 Amps for 120V systems and 150 Amps for 277V systems
   d. Series rated SCCR ratings apply as follows with appropriate main breaker:
      1) 22,000A at 120/240V
      2) 10,000A at 100A; 120/208V
      3) 10,000A, 22,000 or 42,000 at 200A; 120/208V
      4) 14,000A at 150A and 200A; 277V/480V
      5) 65,000A at 200A; 277V/480V
   e. Main breakers shall allow the following range of wire sizes:
      1) 1AWG-300kcmil at 120/240V
      2) 3/0 to 300kcmil at 120/208V
      3) 6AWG-300kcmil at 277V/480V

F. Relay

1. Each relay shall have a manual override switch with on/off status indication
2. Relays shall be rated for use with:
   a. 16A Electronic Ballast loads @ 120, 240 and 277V
   b. 20A Tungsten loads at 120, 240, and 277V
   c. 20A 277V Ballast (HID)
   d. Motor loads with ratings of 20 FLA @ 120V, 17 FLA @ 240V, and 14 FLA @ 277V 100,000A symmetrical SCCR
3. Isolation shall be 4000V RMS
4. Relays shall be latching state
5. Rated Life:
   a. 1,000,000 mechanical activations

b. 100,000 cycles at full resistive load
c. 30,000 cycles full motor, inductive, tungsten, and electronic (LED)
d. Decreasing loading shall increase the rated life of the relay inversely proportional the square of the load

6. Relays shall support reporting of current usage with an accuracy of five percent of the connected load

G. Phase Adaptive Dimmer

1. The phase adaptive dimmer module shall be fully rated for loads up to 300W
2. By default, phase adaptive dimmers shall automatically detect the required dimming mode based on connected loads and lock the mode in at power-up
3. The phase adaptive dimmer shall support tungsten/incandescent, 2-wire fluorescent, line-drive LED, electronic transformer and magnetic transformer loads
   a. Magnetic transformer loads shall be supported at 120V up to 300W when the connected transformers are loaded to their rated current capacity
4. Dimmers that do not support magnetic loads shall not be acceptable
5. The panel shall support a maximum phase dimming load of 7,200W f populated fully with (24) 300W dimmer modules. Panels that do not support phase dimmers and relays combined in a single panel shall not be accepted

H. Relay Panel Accessories

1. A low voltage 0-10V dimming option shall provide up to 24 0-10v control outputs that are linked to relay circuits within the panel. Each output shall support up to 400mA of current sink per output
2. A contact input option shall provide 24 dry contact inputs to be linked for direct or group relay control, to activate a preset, or to activate a sequence. Controller software shall allow for normally open maintained, normally closed maintained, or momentary toggle
3. A DALI control option shall provide 24 control loops of broadcast DALI control, with each loop controlling up to 64 DALI devices
4. A RideThru option shall provide short-term power backup of control electronics by automatically engaging when power is lost, and recharging when normal power is present
5. A tamperproof hardware kit shall be available that provides center reject Torx head screws to prevent access to panel interior by unqualified individuals.
6. Provide with a custom wiring harness in order to interface with the Sensor Battery backup system as required.

I. Main Breaker options shall be available as specified in Section E.6 Thermal

1. The panel shall be convection cooled. Panels that require the use of cooling fans shall not be acceptable
2. The panel shall operate safely in an environment having an ambient temperature between 32ºF (0ºC) and 104ºF (40C), and humidity between 5-95% non-condensing.

2.7 TOUCHSCREEN CONTROL STATIONS: REFERENCED PRODUCT ETC UNISON ECHOTOUCH CONTROLLER MK2

A. General

1. The Touchscreen protocols station shall provide control of up to 512 networked addresses or up to 512 local DMX addresses on a maximum of eighty (80) control zones. Addresses may be distributed using DMX512-A or via sACN or Art-Net Ethernet-based lighting
2. The Touchscreen station shall operate using graphic buttons, faders and other images on at least 7 user programmable control pages
3. Touchscreen stations shall support default and fully graphical control pages
4. The Touchscreen shall integrate with ETC Unison Echo Controls

B. Mechanical

1. Touchscreen stations shall consist of a seven-inch, backlit liquid crystal display (LCD) with a minimum resolution of 800 by 400 pixels with a capacitive multi-touch interface
2. Touchscreen bezels shall be constructed of cast aluminum finished in a fine texture powder coat.
    a. Touchscreen shall be available in four standard colors
        1) Cream (RAL 9001)
        2) Gray (RAL 7001)
        3) Black (RAL 9004)
        4) Signal White (RAL 9003)
    b. The bezel shall have no visible means of attachment
3. Touchscreen stations shall support surface, flush and rack mounting options
    a. Flush-mount to industry standard 3-gang back box
    b. Surface back box dimensions shall be 7.35 in/187 mm wide x 4.88 in/124 mm high x 3.5 in/89 mm deep and available from the manufacturer
    c. Rack mounting options shall fit in standard 19″ racks an shall be no taller than 3 EIA rack units

C. Electrical

1. The Touchscreen shall have an RJ45 Ethernet port for connection to a lighting system and for Power over Ethernet (PoE)

2. The Touchscreen shall have an EchoConnect connection terminals
    a. Control wiring utilizing 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)
    b. Control wiring shall be topology free. It may be point-to-point, bus, loop, home run or any combination of these. Control products that require daisy-chain wiring shall not be acceptable
3. The Touchscreen shall use (2) #16 AWG stranded wires for 24 VDC operating power when not utilizing Power over Ethernet (PoE)
4. The Touchscreen shall have typical power draw of 400mA
5. The Touchscreen shall have a USB type A connector for firmware maintenance
6. The Touchscreen shall be cULus Listed and CE Compliant
7. The Touchscreen shall be FCC Compliant

D. 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), conforming to TIA-568A/B, and shall be installed by a qualified network installer
3. Switches shall comply with power-over-Ethernet IEEE802.3af, unless a separate in-line power supply is provided

E. Functional

1. System
    a. A maximum of 64 presets shall be contained in non-volatile electronic memory
    b. A maximum of 4 internal sequences. Sequences shall record user-selected zone levels
    c. The Touchscreen shall be equipped with an on-board help system
    d. The Touchscreen software upgrades shall be made by the user via USB drive. Changing internal components shall not be required
    e. The Touchscreen shall provide a USB port allowing show data to be saved for archival or transfer to other consoles or a personal computer
    f. Systems that do not provide the above capabilities shall not be acceptable
2. Patching
    a. The Touchscreen 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 Touchscreen shall support patching, address setting, and mode changes using Remote Device Management (RDM) on the local DMX/RDM port

3. Playback control
   a. Customizable zone display using Zone Map. It shall be possible to rearrange the graphical representations for control channels to closely mimic the positions of fixtures in the installation
   b. Seven users customizable interactive pages
   c. Color and white pickers
   d. Touch-based parameter controls with reference-based palettes
   e. Virtual level wheel
4. Layout and configuration
   a. It shall be possible to view and modify the layout of the users pages
   b. It shall be possible to add, remove or edit the following items:
      1) Preset Buttons
      2) Off Buttons
      3) Sequence Buttons
      4) Zone and space modifier buttons
      5) Space combine buttons
      6) Zone Fader
   c. There shall be three options for inactivity
      1) Dim screen to level
      2) Turn screen off
      3) Display user chosen inactivity image
   d. It shall be possible to have multiple configurations stored within an LCD Station
5. TimeClock
   a. The Touchscreen shall have a built-in astronomical and real time event engine allowing the activation of presets and sequences
      1) The system shall support 80 events.
      2) The system shall support astronomical, real-time and manual control events in up to 16 control spaces.
   b. Timed events shall be programmable via the Touchscreen.
      1) TimeClock events shall be assigned to system day types. Standard day types include: everyday, weekday, weekend and day of the week.
      2) TimeClock events shall be activated based on sunrise, sunset, time of day, open and closed events and a configurable state-based engine.
      3) The TimeClock shall automatically compensate for regions using configurable daylight-savings time.
      4) Presets shall support assignment to events via the TimeClock user interface.

c. Timed events shall resume automatically after power loss
d. The Touchscreen shall support timed event hold
1) Timed event hold shall meet California Title 24 requirements

2.8 ARCHITECTURAL DIGITAL INTERFACE STATIONS: REFERENCED PRODUCT ETC ECHO SYSTEM EXPANSION MODULE

PRODUCT DATA SHEET 0 - A. System Expansion Module

1.1 1. General

A. a. The system expansion modules shall be the Echo Expansion Bridge (EEB) by ETC, Inc., or equal

B. b. The Expansion Bridge shall allow for the following features:

1. 1) Connection of a third party wireless access point to allow for wireless (Wi-Fi) connection of the EchoAccess Mobile App to the Echo Control System
2. 2) Combination of up to four Echo segments to create a larger integrated Echo system
3. 3) Communication with a Unison Paradigm Architectural Control Processor to allow for control interaction and indication of the comprehensive control system

1.2 2. Mechanical

A. a. The Echo Expansion Bridge shall be DIN-rail mounted on DIN43880 and EN60715 (35/7.5) compatible rail

B. b. The Bridge shall be constructed of injection-molded, black ABS plastic that fully encloses all electrical components

C. c. The Bridge shall have a backlit display for identification, status reporting and configuration

D. d. The Bridge shall have buttons for up, down, back and enter for use with the backlit display

E. e. The Bridge shall have a hard reset button accessible on the front panel

F. f. The Bridge shall have LED indicators:

1. 1) Power Status - Blue
2. 2) Network Status - Green

1.3 3. Electrical

A. a. The Expansion Bridge shall have an RJ45 Ethernet port for connection to a network that supports additional lighting control products

B. b.The Bridge shall have four EchoConnect connection terminals

1. 1) Control wiring utilizing 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. 2) Control wiring shall be topology free. It may be point-to-point, bus, loop, home run or any combination of these. Control products that require daisy-chain wiring shall not be acceptable.

- c. The station shall use (2) #16 AWG stranded wires for 24vDC operating power when not utilizing Power over Ethernet (PoE).
- d.The Bridge shall support a MicroSD card for firmware maintenance
- e.The Bridge shall be UL/ cUL LISTED and CE marked
- f. The Bridge shall be FCC Compliant

- 4. Network
  - a.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
  - b.All network cabling shall be Category 5 (or better), conforming to TIA-568A/B, and shall be installed by a qualified network installer
  - c. Switches shall comply with power-over-Ethernet IEEE802.3af, unless a separate in-line power supply is provided

- 5. Environmental
  - a.The ambient operating temperature shall be 0° to 50°C (32° to 122°F)
  - b.The operating humidity shall be 5% to 95% non-condensing

- 6. Functional
  - a.Connection to EchoAccess Mobile Application
    - 1) The Expansion Bridge shall facilitate communication from an Echo control system to a wireless access point
    - 2) The EchoAccess Mobile Application shall connect to the wireless access point and send control and configuration commands to the Expansion Bridge for communication to all connected Echo Products
  - b.Creation of larger Echo control systems
    - 1) The Expansion Bridge shall allow up to four Echo control segments to be merged together

- 2) Each Echo segment must contain an EchoConnect Station Power Supply
- 3) The following system maximums shall be supported per bridge:
  - a) Sixty four (64) Stations, Sensors and Control Interfaces
  - b) Sixty four (64) Power Control and Output Products
  - c) Sixteen (16) Control Spaces
  - d) Sixteen (16) Control Zones per Space
- c. Connection to a Unison Paradigm Architectural Control Processor (P-ACP)
  - 1) The Expansion Bridge shall communicate to a Paradigm Architectural Control Processor using an Ethernet Network
  - 2) Up to sixteen (16) Bridges shall be able to connect to a single (P-ACP)
  - 3) Up to 128 Bridges shall be able to connect to a single Paradigm Projects
  - 4) Paradigm systems shall be able to control and indicate status of the following Echo control properties
    - a) Echo Zones
    - b) Echo Presets
    - c) Echo Space Combine
    - d) Echo Space Lockout

2.9 ARCHITECTURAL BUTTON, FADER & INTERFACE STATIONS: REFERENCED PRODUCT ETC ECHO INSPIRE 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 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.

a) Presets shall have a discrete fade time, programmable from zero to 1,000 hours with a resolution of one millisecond.
b) 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.
a) Macro and sequence steps shall provide user selectable steps, and allow the application of conditional logic.
b) 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.
a) 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.
b) 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 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.
         a) Presets shall have a discrete fade time, programmable from zero to 1,000 hours with a resolution of one millisecond.
         b) 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.
         a) Macro and sequence steps shall provide user selectable steps, and allow the application of conditional logic.
         b) 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.
         a) 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.
         b) 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.
      a) Presets shall have a discrete fade time, programmable from zero to 1,000 hours with a resolution of one millisecond.
      b) 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.
      a) Macro and sequence steps shall provide user selectable steps, and allow the application of conditional logic.
      b) 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.
      a) 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.
      b) 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:
         a) Normally-Open 2-pole contact closure outputs: 1A@30Vdc & .5A@120V.

2.10 ARCHITECTURAL CONTROLS, INTERFACES & STATIONS: REFERENCED PRODUCT ETC ECHO SYSTEM

A. Distributed Power Controllers:

1. Standards Compliance: cULus Listed, Rated for plenum use. Supports Demand Response via EchoConnect. Conforms to UL 508 and UL 2043.
2. Features:
    a. Zones: Single or dual.
    b. Phase Dimming: Forward or reverse.
    c. 20 A fully-rated relay for use with general purpose, tungsten, fluorescent and LED loads
    d. Fully isolated 0- 10 V dimming for direct connection to dimming ballasts and LED drivers
    e. 24 VDC for occupancy sensor power.
    f. Accepts contact closure trigger for occupancy/photo status.
    g. Plug and Play: ready to go out of the box, no software or external programming required.
    h. Supports Unison Echo control stations and responsive controls.
    i. Supports EchoConnect, a two-wire topology-free system to provide station connectivity.
3. Functional:
    a. Provides control of one or two control zones, including relay, 0-10V, or line dimmed.
    b. Plug and Play: ready to go out of the box, no software or external programming required.
    c. Interacts with Unison Echo control stations and responsive controls.
    d. 24 VDC occupancy sensor power and contact input.
    e. Occupancy-sensor status may be shared to the entire Echo Control System.
4. Mechanical:
    a. Constructed of injection-molded ABS plastic.
    b. Button interface and LED indicator per zone for configuration.
    c. Rotary dials for selection of space and zone number.
    d. Half-inch conduit knockout mounted.
    e. MicroSD for field software upgrades.
5. Electrical:
    a. 120- 277 V, 60 Hz power input.
    b. Normally Open (NO) 20 A fully-rated relay.
    c. 120 V or 277 VAC, 50/60 Hz power input.
    d. Phase-adaptive dimming variant, default reverse phase, auto-switches to forward phase depending on load type.
    e. Forward phase dimming variant for Magnetic loads dims in forward phase only

f. 600W load capacity.
g. 0- 10 VDC ballast control (sink) rated for 100 mA maximum, fully isolated from ground.
h. 24 VDC power output rated for 50 mA maximum.
i. Dry contact input for Sensor status.
j. EchoConnect Class 2 control network.

1) Topology-free wiring using Belden 8471 or equivalent and one No. 18 ESD drain wire.
2) Wiring may be bus, loop, homerun, or any combination of these.

6. Operational Room Temperature: 14 to 113 degrees F (Minus 10 to 45 degrees C).
7. Relative Humidity, Non-Condensing: 5 to 95 percent.
8. Accessories: Model E4VB. 4 inch Box with voltage barrier.
9. Presets Supported: 16.

B. Product: Unison Echo Architectural Control Processor. Works with Unison DRds to provide flexibility of a modular power-control rack to any installation. Supports control stations, DMX input, and Ethernet.

1. Model E-ACP Echo Architectural Control Processor.
2. Standards Compliance: cULus Listed. CE compliant.
3. Features:
   a. For use with any EchoConnect-enabled station, sensor, or power controller.
   b. Snapshot: Connect a DMX input or set levels locally and then save to a Preset with the touch of a button.
   c. Plug and Play: No software or external programming required.
   d. Secure-It User Access: Multiple levels of secure user access at the interface.
   e. EchoConnect: Two-wire, topology-free system.
   f. Presets: 64 and 16 spaces.
4. Mechanical:
   a. Designed for use in Unison DRd enclosures.
   b. Microprocessor-based, solid-state technology to provide multi-scene lighting.
   c. Fully-contained plug-in assembly with no discrete wire connections.
   d. Front-panel user interface with backlit LCD.
   e. Support for Secure Digital (SD) and Universal Serial Bus (USB) media on the front panel.
5. Control Zone Capacity: 512.
   a. One physical DMX port for data input.
   b. One DMX thru port for DMX data through to other devices.
   c. sACN data input for level control. Four universes and six simultaneous sources.

6. Configuration Data: Stored in non-volatile flash memory.
    a. Load to and from removable media (SD and USB).
7. Local User Interface: Access to Dimming setup and status.
    a. Control for channels, presets, and sequence.
8. Stations and Sensors:
    a. Connects to Echo Processors via topology-free EchoConnect control network.
    b. Supports 16 Echo control products, including stations and sensors.
    c. Supports 15 Echo output products, including distributed relays and dimmers.
9. Operation:
    a. Support for 16-bit DMX attributes.
    b. Activate/Deactivate presets.
    c. Preset fade up, fade down, and hold times up to 60 minutes and 59 seconds.
10. Electrical:
    a. No discrete wiring connections required.
    b. One ESTA DMX512A input and thru port.
    c. Supports ANSI E1.31; streaming CAN.
    d. System configuration and programming information stored in non-volatile flash memory.
11. Operating Temperature Range: 32 to 104 degrees F (0 to 40 degrees C).
    a. Relative Humidity, Non-Condensing: 10 to 90 percent. non-condensing.

C. Interfaces:

1. Product: Unison Echo Expansion Bridge.
    a. Model: EEB Echo Expansion Bridge.
    b. Combines four Echo segments to create larger Echo control systems.
    c. Integrate Echo control systems into Unison Paradigm Systems allowing for Paradigm control and status indication.
    d. Allows for connection to EchoAccess Mobile App via a wireless access point.
2. Product: Unison Echo BACnet Interface.
    a. Model: EBI Echo BACnet Interface.
    b. Reports real-time Echo system status to BACnet system.
    c. Reporting of all Echo control points are supported.
    d. Integrates Echo lighting system into building-wide monitoring and management systems.
    e. Accepts standard BACnet control commands.
3. Product: Unison Echo Integration Interface.
    a. Model: EII Echo Integration Interface.

b. Reports real-time Echo system status to the third-party system.
c. Accepts predefined UDP commands.
d. Compatible with all Echo products.
e. Definable subscription addresses for security.

4. Product: Unison Echo Contact Interfaces.
   a. Available with 4 inputs, Demand Response, or 4-outputs.
   b. Input and Demand Response interface support wet or dry contacts.
   c. Inputs a support momentary or maintained closures (per input).
   d. Demand Response supports maintained closures.
   e. Outputs provides triggers for third-party systems.
   f. Outputs support normally open or normally closed operation per output.
   g. Programmable through EchoAccess mobile app.
   h. DIN rail mounted for simple installation.
5. Product: Unison Echo DMX Scene Controller.
   a. Model: EDMXC Echo DMX Scene Controller.
   b. DMX input for snapshot capture of lighting scenes.
   c. 32 presets of 512 DMX addresses.
   d. Sequence playback of presets.
   e. Echo control of 16 patched DMX Zones.
   f. Works with EchoAccess and Inspire Four-Button with Fader Station for live control of intensity, hue and saturation or color temperature of Echo zones.
   g. Basic and custom-use modes.
   h. Configurable Power On Behavior, DMX Loss Action, and DMX Active Action.
   i. Demand Response integration.
6. Product: Unison Echo-Echoflex Interface.
   a. Model: EEI Echo-Echoflex Interface.
   b. Four Echoflex product inputs to trigger Echo Presets.
   c. Four Echo zone outputs to control Echoflex power products.
   d. Onboard configuration and testing tools.
   e. Input and output status indicators.
7. Product: Unison Echo EchoAccess Interface.
   a. Model: EACC EchoAccess Interface.
   b. Communication from EchoAccess mobile app to devices on EchoConnect system bus via Bluetooth Smart.
   c. Mobile app available for Android and iOS.
   d. Preset, zone and color control for Echo products.
   e. Advanced feature configuration of Echo products.
8. Standards Compliance: UL and cUL Listed. CE Compliant.
   a. California Title 24 compliant.
   b. RoHS compliance.

c. WEEE.

9. Functional: Unison Echo Expansion Bridge.
   a. Combines four Echo Control Segments to create a single larger Echo control system with the following maximums:

1) 4 Power Supplies. As needed based on system size.
2) 64 Control Products: Stations, Sensors, and Interfaces.
3) 64 Output Products: Zone Controllers, Panel Power Products, DMX Scene Controller, EEI.
4) Zones per space: 16.
5) Spaces per bridge: 16.

   b. Connects to a wireless access point to allow the EchoAccess Mobile App to connect to the Echo system via Wi-Fi.
   c. Allows Paradigm systems to control and display status of the following:

1) Echo Presets.
2) Echo Zones.
3) Echo Space Combine.
4) Echo Space Lockout.

   d. Paradigm supports a maximum of 16 Expansion Bridges per Paradigm Control Processor and a maximum of 128 Bridges per Paradigm Project.

10. Functional: Unison Echo BACnet Interface:
    a. Integrates with any BACnet IP system.
    b. Uses default BACnet commands.
    c. Reports the status of the following to a BACnet system:

1) Zones, Presets, Space Occupancy, Space Lockout, Timed Event Hold, and Demand Response.

    d. Allows a BACnet system to control the following:

1) Zones, Presets, Space Lockout, Timed Event Hold, and Demand Response.

11. Functional: Unison Echo Integration Interface.
    a. Integrates with any system that supports User Datagram Protocol (UDP) strings
    b. Reports the status of the following to an external system: Zones, Presets, and Sequences.
    c. Allows an External System to Control the Following: Zones, Presets, and Sequences.
12. Functional: Unison Echo Contact Interfaces.
    a. Integrates with all Echo System products.
    b. Input Interface provides four contacts in to trigger Echo presets, zones, space combine, etc.
    c. One input per contact input interface can be used to trigger space occupancy.

d. Demand Response Interface provides trigger of Demand Response in Echo Spaces, one space per input.
e. Output Interface opens and closes relays based on zone, preset, occupancy, or other control status.

13. Functional: Unison Echo DMX Scene Controller.
    a. Direct control or Recall prerecorded scenes for playback using DMX.
    b. DMX input for snapshot recording up to 32 presets.
    c. DMX output for up to 512 addresses.
    d. Sequence playback of presets.
    e. Use any Unison Echo station for preset or sequence playback.
    f. Supports DMX pass-through for real-time output of incoming level when recording snapshots.
    g. Meets USITT DMX-512A specifications.
    h. EchoAccess configurable Power On Behavior, DMX Loss Action, and DMX Active Action.
    i. Demand Response integration options.
14. Functional: Unison Echo EchoAccess Interface.
    a. Remote control of preset activation/deactivation, record, raise, lower, zone on/off control and room combine.
    b. Control of Zone Intensity, Color, Tint, and Color Temperature.
    c. Configuration of all Echo Control and Output Products.
    d. Configurable security levels for both connection and configuration.
15. Functional: Unison Echo-Echoflex Interface.
    a. Receives wireless trigger from Echoflex system and translates it into an Echo preset trigger.
    b. Receives zone level from Echo system and translates it into a wireless Echoflex command.
    c. Compatible with Echo stations, sensors, interfaces, and power controllers.
    d. Compatible with Echoflex station, sensors, and a power controllers.
16. Mechanical:
    a. Din-rail mounting complies with DIN43880 (35/7.5 rail).
    b. Flush-mount in industry standard backbox, RACO 690 or equivalent Constructed of injection-molded, ABS plastic.
    c. Intuitive four-button interface and onboard display for identification, status, and configuration.
    d. Four integrated contact input terminals or four integrated contact output terminals.
    e. Toggle switch for Basic and Custom and Config Mode.
    f. Contact Status and power indicators:

1) Green status indicator.
2) Blue power indicator.

    g. One integrated DMX-input and one integrated DMX-output port.

h. Toggle switches for DMX-Termination and Config Mode.
i. DMX-In, DMX-Out and power indicators.

1) Blue power indicator.
2) Bi-color DMX activity indicator.

j. Gangable for custom applications.
k. Enclosed electronics assembly and faceplate included.
l. Power and Bluetooth activity indicators.

1) Blue power status indicator.
2) Amber Bluetooth activity indicator.

m. Buttons and LED indicators for wireless inputs and wired output configuration and status.

17. Electrical:
    a. MicroSD card slot for firmware maintenance.
    b. Connects to two-wire EchoConnect control networks through low-voltage Class 2 wiring.

1) Topology-Free Wiring: Belden 8471 and No. 14 ESD drain wire.
2) Two No. 16 AWG wires for 24 VDC auxiliary power when required.

c. Supports PoE or 24VDC.
d. Compliant with IEEE 802.3i for 10BASE-T, 802.3u for 100BASE-TX and 802.3af for Power over Ethernet.
e. Supports 24 VDC.
f. 902 MHz wireless radio.
g. 80 ft (24 m) open-air transmission range.

18. Operational Room Temperature: 32 to 122 degrees F (0 to 50 degrees C).
19. Relative Humidity Non-Condensing: 5 to 95 percent.
20. Contact and Demand Response Inputs:
    a. Four pairs of terminal connectors support In and V-Out per input.
    b. Wet or dry contact closure per input.
    c. Momentary or Maintained input supported per contact.
    d. Each input supports up to 2000 feet of 18 AWG wire; 1000 ft to a switch, 1000 ft back to device, when device is fed with 24 VDC input.
21. Contact Outputs:
    a. Four sets of terminal connectors for relay outputs.
    b. LED status indicator per input indicates current output state.
22. DMX Ports:
    a. Eight-position removable pluggable connectors for in and out ports.

1) Connectors designed for use with Belden 9729.
2) Optional headers available for use with Belden 1583A.

b. Input is fully optically isolated from controller electronics.
c. Withstands fault voltages up to 250 VAC.
d. Integrated DMX termination.

23. EchoAccess Configuration Option:

a. DMX Output Refresh Rate.
b. Preset Timings.
c. Definable Power On, DMX Loss, and DMX Active behavior.

D. Time Clock:

1. Product: Unison Echo TimeClock.
   a. Model E-ATC: Echo TimeClock Station.
2. Functional:
   a. Home screen displays time, date, and any active tasks.
   b. Ability to hold current preset for timed-event override (up to two hours).
   c. Supports up to 16 presets.
   d. Supports every day, weekday, weekends, and day of week recurrence.
   e. Supports Time-of-day, sunrise with offset, and sunset with offset events.
   f. Supports 50 events.
   g. Supports up to 16 control spaces.
3. Mechanical:
   a. Mounts in flush-mount, industry-standard, two-gang backboxes.
   b. Surface-mount backboxes available from ETC.
   c. High-contrast, backlit graphical LCD.
   d. Six-button menu-navigation keypad.
   e. Locking cover available.
   f. Fully enclosed electronics assembly.
4. Electrical:
   a. Connects via EchoConnect control network. Low-voltage Class 2 wiring.

1) Topology-free and polarity-independent wiring over Belden 8471 and one No. 14 ESD drain wire.
2) Wiring: Bus, loop, homerun, or any combination of these.
   b. Control Wiring per System: Up to 1640 ft (500 m).

E. Stations:

1. Product: Unison Echo Keyswitch Station. Enables security for stations within an Echo Space. While lockout station is active all stations are disabled to prevent unwanted control activation.
   a. Model EPSKS: Echo Key switch Station.
2. Standards Compliance: cULus Listed. CE Certified.
3. Functional:
   a. Button and Fader Functions: preset activation/ deactivation, record, raise, lower, zone on/off control and room combine.
   b. Blue button illumination for active status.

c. Amber or no button illumination for inactive status.
d. Fader halo-illumination displays actual output level.
e. Zone or preset control from any station with real-time user toggle.

4. Functional:
   a. Rotary switch assigns space to be locked out.
   b. Activating lockout causes the system to ignore all button actuations within the assigned space.
5. Functional:
   a. Button functions: preset activation/ deactivation, record, raise, lower, zone on/off control and room combine.
6. Mechanical:
   a. Enclosed electronics assembly and faceplate included.
   b. No visible means of attachment.
   c. Flush-mount in industry-standard backbox, RACO 690 or equivalent.
   d. Surface-mount backboxes available from manufacturer.
   e. Constructed of injection-molded, ABS plastic.
   f. Cantilevered switch arrays with removable button caps.
   g. User configurable legends on each button or use standard legends that come with each station. Field configurable without the use of tools.
   h. Integral LED response indicator for each button with indication of active(blue) and inactive(amber or off) state.
   i. Integral red LED indicator shows lockout state.
   j. Indelibly marked legends in a contrasting color.
   k. Integral LED response-indicator for each button configurable per station in 16 standard colors.
7. Electrical:
   a. Connect via EchoConnect control network. Low-voltage Class 2 wiring.
   b. Topology-free wiring over Belden 8471 and one No. 14 ESD drain wire.

1) Control Wiring: 1640 ft (500 m).
   c. Belden 1583A or equivalent Ethernet control wire when used with Cat5 termination accessories.

1) Control Wiring: 1000 ft (300 m)using CAT5.
   d. Wiring: Bus, loop, homerun, or any combination of these.
   e. Station Terminations: Removable connectors.
8. Operating Temperature Range: 32-122 degrees F (0-50 degrees C).
9. Relevant Humidity Non-Condensing: 5-95 percent maximum.

F. Power Modules:

1. Convert Input Power into Class II Low-Voltage Power with data line. Energize control stations, zone controllers, time clock, and devices for multi-scene lighting control.
2. Electrical:
    a. Utilize line-voltage power supplied by contractor, terminated inside dimming enclosure, or power supply.
    b. EchoConnect Communications with Remote Devices: Control stations, zone controllers, time clock stations and other devices.
    c. EchoConnect Network: Low-voltage Class II twisted pair wiring, type Belden 8471 (unshielded) or Belden 8719 (shielded). And one No 14 AWG drain wire for system not using grounded metal conduit.

1) Topology Free Network: Bus, loop, home run, star, or any combination.
2) Control Bus Wiring: Permit total wire runs of 1640 ft (500 m)
3) Wiring Between Stations: Not to exceed 1313 ft (400 m).
4) CAT5 Wiring: For systems not requiring topology free infrastructure or EchoConnect bus lengths not more than 1000 ft (305 m).

3. Capacity: Power for up to 16 control stations, zone controllers, time clock stations and other devices, and/or provide 24 V Auxiliary Power to devices that require it.

G. Touchscreen Control Stations to be Unison Echo EchoTouch Controller Mk2. Controls 512 DMX addresses on up to 80 control zones.

1. Standards Compliance: cULus Listed and CE Compliant. FCC Compliant.
2. Operation: Graphic buttons, faders, and images on at least 7 user programmable default and fully graphical control pages.
3. Touchscreen: Integrated with ETC Unison Echo Controls.
    a. Seven-inch, backlit liquid crystal display. Resolution: 800 by 400 pixels minimum, with capacitive multi-touch interface.
    b. Bezels: Cast aluminum. Finish: Fine texture powder coat.

1) Four colors: Cream, Gray, Black, or Signal White.
2) No visible means of attachment.
    c. Supports Surface, Flush and Rack Mounting.

1) Flush-mount: To industry standard 3 gang back box.
2) Surface Back Box Dimensions (WxHxD): 7.35 x 4.88 x 3.5 inches 187 x 124 x 3.5 89 mm) available from Manufacturer.
3) Rack Mounting: Fit in standard 19 inch (483 mm) racks, no taller than 3 EIA rack units.

4. Electrical:
    a. RJ45 Ethernet Port: Connection to lighting system and Power over Ethernet.
    b. Control Wiring: EchoConnect Connection terminals.

1) Low-voltage, Class II unshielded twisted pair, type Belden 8471 and one No. 14 ESD drain wire; when not installed in grounded metal conduit.

2) Topology free. Point-to-point, bus, loop, home run or any combination.

c. Power Input, Non-PoE: Two, No. 16 AWG stranded wires for 24 VDC.

d. Typical Power Draw: 400 mA.

e. Firmware Maintenance: USB type A connector.

f. Network:

1) Network Cabling: Category 5 or better. Conform to TIA-568A/B. Installed by qualified network installers.

g. Functional System:

1) Presets: 64. Contained in non-volatile electronic memory.

2) Internal sequences: 4. Record user-selected zone levels.

3) Touchscreen: Equipped with on-board help system.

4) Software upgrades: Via USB drive only.

5) USB Port: Show data to be saved for archival or transfer to other consoles or a personal computer.

h. Patching: Facilities for dimmers and multi-parameter devices via built in library of fixture definitions.

1) Fixture Library: Updated via software based updates. Create custom fixture definitions using offline application.

2) Touchscreen: Support patching, address setting, and mode changes using Remote Device Management (RDM) on local DMX/RDM port.

i. Playback Control: Customizable zone display. Rearrange graphical representations for control channels to mimic fixture positions in installation.

1) Seven user customizable interactive pages.

2) Color and white pickers.

3) Touch-based parameter controls with reference-based palettes.

4) Virtual level wheel.

j. Layout and Configuration: View and modify layout of user pages.

1) Add, remove, or edit the following items: Preset buttons. Off buttons. Sequence buttons. Zone and space modifier buttons. Space combine buttons. Zone fader.

2) Three Options for Inactivity: Dim screen to level. Turn screen off. Display user chosen inactivity image.

3) Multiple Configurations: May be stored within an LCD Station.

5. Time Clock: Touchscreen built-in astronomical and real time event engine allowing presets and sequences activation.

a. Support 80 Events: Astronomical, real-time, and manual control events in 16 control spaces.

b. Timed Events: Programmable via Touchscreen.

1) Assigned to day types.

a. Day Types: everyday, weekday, weekend, and day of week.

2) Activation: Based on sunrise, sunset, time of day, opened and closed events and configurable state based engine.

3) Compensate for regions using daylight saving time.

4) Assignment to events via time clock user interface.
5) Resumes automatically after power loss.

c. Support timed event hold. Timed Event Hold: Meet CA Title 24 requirements.

6. External Control: Control of lighting system through built-in UDP integration.

a. Supports full control of lighting system using UDP strings.

1) Security settings to limit incoming control strings to subscribers-only.

b. Supports up to two subscribers for receiving status messages.
c. Control and status integrations from 3rd party systems include:

1) Zones.
2) Channels.
3) Presets.
4) Spaces.
5) Sequences.
6) Lockout.

2.11 EMERGENCY LIGHTING TRANSFER SWITCH: REFERENCED PRODUCT ETC BRANCH CIRCUIT EMERGENCY LIGHTING TRANSFER SWITCH (BCELTS)

A. General

1. The Branch Circuit Emergency Lighting Transfer Switch (BCELTS) shall be the SC1008 as manufactured by ETC, Inc., or equal
2. The BCELTS shall provide automatic transfer of a single branch circuit from normal to emergency power source, when normal power fails
3. The BCELTS shall transfer a lighting load branch circuit from a dimmer/ relay or secondary control output to a second power source in the event of a loss of power to the primary power source, a normal system failure, or activation of a fire alarm
4. The system shall be listed under ANSI / UL1008 Transfer Switch Equipment and comply with ANSI / NFPA 110 Standard for Emergency and Standby Power Systems, and ANSI / NFPA 70 (NEC), including Article 700, 701 and 702 safety standards. Emergency transfer systems that do not comply with the below stated NEC articles and sections shall not be permitted
   a. Satisfies requirements of the National Electrical Code (NFPA 70):
   b. Article 700 – Emergency Systems
   c. Article 701 – Legally Required Standby Systems
   d. Article 702 – Optional Standby Systems
   e. Section 518.3(C) – Assembly Occupancies
   f. Section 520.7 – Theatres and Similar Locations
   g. Section 540.11(C) – Motion Picture Projection Rooms
5. The BCELTS shall transfer a single circuit at 120V or 277V up to 20 Amperes in capacity

B. Transfer Switch

1. The BCELTS shall be a UL1008 transfer switch listed for Emergency Systems (NEC Articles 700 and 701; UL CCN WPWR)
    a. Transfer switches not listed under UL1008 shall not be acceptable
    b. Transfer switches listed under UL1008 for Optional Standby (NEC Article 702; UL CCN WPXT) applications only shall not be acceptable
    c. Automatic Load Control Relays (ALCR) listed under UL924 shall not be acceptable
2. The switch shall be positively latched and unaffected by voltage variations or momentary outages so that constant contact pressure is maintained and temperature rise at the contacts is minimized
3. The switch shall be electrically interlocked to ensure only one position, either Normal or Emergency, is engaged at any time
4. The switch shall be break-before-make to ensure that normal and emergency sources are never interconnected within the unit
5. Built-in fuses shall provide 10,000 Ampere Short Circuit Current Rating (SCCR) on the connected emergency circuit
6. Switch contacts shall withstand transfer without welding, with 180º phase displacement between normal and emergency power sources if both sources are energized
7. Transfer switch contacts shall be rated for mixed loads, including electric discharge lamps and tungsten filament lamps
8. Transfer switch shall be rated for a minimum of 6,000 cycles at full tungsten load

C. Control Circuitry

1. The control circuitry shall direct the operation of the transfer switch
2. A field-configurable normally closed (NC) or normally open (NO) dry contact closure input shall be provided
    a. Up to (10) BCELTS devices may be connected to a single remote loop
3. The BCELTS shall support transfer of a 0-10V or DALI controlled circuit
    a. Upon activation of emergency transfer the BCELTS shall break the 0-10V or DALI control circuit, driving connected 0-10V circuits to full output and DALI circuits to their default level.

D. Operation

1. Transfer to alternate emergency supply will occur when normal supply sense voltage drops below 80V when used at 120V or 277V

E. Enclosure

1. The BCELTS shall be mounted in a NEMA 1 interior type enclosure finished in fine- textured epoxy paint

2. The enclosure shall be 8.5”H x 10.5”W x 2.75”D
3. The system shall be provided with an approved overlay mounted on the front of the enclosure, stating, “BRANCH CIRCUIT EMERGENCY LIGHTING TRANSFER SWITCH”
4. The enclosure shall be provided with an approved label indicating that the system is UL1008 LISTED for Emergency Systems

2.12 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.

2.13 GRID IRON JUNCTION BOXES: REFERENCED PRODUCT ETC GRID IRON JUNCTION BOXES

A. 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.

2.14 PURE SINE WAVE UNINTERRUPTIBLE POWER SUPPLY WITH SURGE SUPPRESSION AND POWER FILTRATION: REFERENCED PRODUCT MIDDLE ATLANTIC NEXSYS SERIES UPX-2000R-2 RACKMOUNT UNITERRUPTABLE POWER SUPPLY

A. GENERAL

1. Provide the specific model of backup UPS as listed on the contract documents (or most recent iteration or replacement model) *and* as is needed based upon the plugged equipment power requirements.
2. Provide expanded run time battery pack as indicated.

B. Specifications

1. Rackmount Uninterruptible Power Supply (UPS) shall be Middle Atlantic Products model # UPX- __ R-2 or UPX- RLNK-__-__ (refer to chart). UPS shall be line interactive with AVR. Unit shall measure 19.00" W x 3.50" H x __.00"
D (refer to chart for depth) and occupy 2 rack spaces. UPS shall have a rear mounting range of 20" to 36". UPS shall have slim rail mounting allowing mounting with a pair of middle rack rail. Unit shall operate on 120 VAC/60Hz current with a Power Factor of 0.9. Unit shall have a nominal output of 120V with optional selection for 110V or 127V. 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 all outlets controlled via 2 banks for selection of non-critical load shedding, or individual outlet control, depending on model. Unit shall be IP enabled, depending on model (RLNK models), or when used with optional RackLinkTM Network card, model# UPX-RLNK-CARD. Rackmount UPS shall include an IEC-C13 detachable 6' (1.83m) SignalSAFETM power cord with NEMA __ (refer to chart) plug. UPS shall have all mode surge suppression and overload protection.

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 4 additional hot swappable batteries. Rackmount UPS shall utilize Middle Atlantic NEXSYS Power Management 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 tested to UL 1778 and CAN CSA-C22.2 standards in US and Canada. Rackmount UPS shall be FCC Class A certified and complies with Canadian ICES-003. Rackmount UPS shall be EnergyStar 2.0 certified.

C. Expanded Battery Pack:

1. Rackmount expandable run time battery pack shall be Middle Atlantic Products model# UPX-EXPANRUN-__-__ (refer
to chart). UPX-EXPANRUN-10-15 shall be suitable for use with UPX-1_00R-2 and UPX-RLNK-1_00R-_ (refer to chart). UPX-EXPANRUN-20 shall be suitable for use with UPX-2000R-2 and UPX-RLNK-2000R-_UPS-2200R. UPS-EBPR shall measure 19.00" W x 3.50" H x __" D (refer to chart for depth) and occupy 2 rack spaces. UPS-EBPR shall require __" useable depth (refer to chart). 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 expandable run time battery pack 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 expandable run time battery pack shall be tested to UL 1778 and CAN CSA-C22.2 standards for US and Canada. Rackmount UPS shall be FCC Class A certified and complies with Canadian ICES-003.

D. Features:

1. Pure Sine Wave technology with Automatic Voltage Regulation to improve the quality of power provided to the A/V system
2. 8 outlets
    a. Bank Controlled option with (2) 4 outlet banks
    b. Individually Controlled options for all 8 outlets via RackLinkTM
3. All NEXSYS UPSs have a Pure Sine Wave output and AVR (automatic voltage regulation) providing the cleanest power to your connected equipment, especially the most sensitive equipment
4. Everything is assembled and connected right from the factory saving you time during your installations
    a. Rack ears are pre-installed with the "4-Post" mounting brackets ready to be rack mounted even if you have a 3rd pair of rackrail
    b. The battery is already connected so just plug it in

5. The NEXSYS Power Management Software on your PC allows you to customize and configure various settings and notifications
6. The NEXSYS UPSs are RackLink compatible for remote monitoring and management and some are compatible right out of the box! Look for RLNK in the part number. Use the RackLink Discovery Tool on your on PC, Apple or Android devices and connect directly to the UPS
7. Set reminders or notifications for things like battery replacement, etc. via email or on the UPS
8. Front panel LCD screen shows UPS Device Name, Model Number, Serial Number
9. Hot swappable battery from the front access panel for easy service without disrupting the system
10. The IEC Input allows for better cable management of the power cord if shorter or longer cords are required
    a. All UPSs include a 6' (1.8m) IEC power cord
11. Energy Star Certified
12. U.S. Department of Energy Compliant for energy efficiency

E. 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# (see above description). 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.

F. Technical Specifications:

ELECTRICAL SPECIFICATIONS

NEXSYS Line Interactive UPS				
Model		UPX-1000R-2 UPX-RLNK-1000R-2 UPX-RLNK-1000R-8	UPX-1500R-2 UPX-RLNK-1500R-2 UPX-RLNK-1500R-8	UPX-2000R-2 UPX-RLNK-2000R-2 UPX-RLNK-2000R-8
	UPS Topology	Line Interactive		
	VA	1000VA	1500VA	1350VA
	Watts	900W	1350W	1800W
	Power Factor	0.9		
Input	Nominal Voltage	120Vac		
	Voltage Range	80-158 Vac		
	Frequency	50/60Hz Autosensing		
	Sensitivity	Adjustable for generator application		
	Input Power Cord Type	SignalSAFE IEC to 5-15P 6' (1.83M)	SignalSAFE IEC to 5-20P 6' (1.83M)	
Output	Waveform on Battery	Pure Sine Wave		
	Voltage Regulation	90Vac min-146Vac max		
	Double Boost	105Vac and 90Vac		
	Double Buck	130Vac and 146Vac		
	Nominal Voltage (Battery Mode)	120Vac ±5%		
	Selectable Battery Voltage	110/120/127 Vac ±5% (Note: 110Vac selection derates UPS to 90%)		
	On Battery Frequency	50Hz or 60Hz ±0.5Hz		
	Number of Outlets	8		
	Outlet Type	NEMA 5-15R	NEMA 5-20R	
	Surge Protection	1000 joules		
	Overload Protection	Circuit Breaker		
	Transfer Time	Typical: 4ms Max: 0-10ms		
	Fan / Audible Noise	45db @ 1m variable speed fan		
	Crest Ratio	3:1		
	Harmonic Distortion	5% max @ 100% linear load, 12% max @ 100% non-linear load		
	BTUs (Line Mode)	70	105	140
	BTUs (Battery Mode)	495	750	990
	Full Load Run Time	4 minutes	3 minutes	3 minutes
	Half Load Run Time	13 minutes	10 minutes	10 minutes

NEXSYS Line Interactive UPS				
Model		UPX-1000R-2 UPX-RLNK-1000R-2 UPX-RLNK-1000R-8	UPX-1500R-2 UPX-RLNK-1500R-2 UPX-RLNK-1500R-8	UPX-2000R-2 UPX-RLNK-2000R-2 UPX-RLNK-2000R-8
Battery	Recharge Time	6-8hrs		
	Battery Maintenance	Hot Swappable Front Access		
	Battery Pack Voltage	36VDC	36VDC	48VDC
	Battery Pack Details	(3) 12V 7Ah Sealed Maintenance Free Lead Acid Batteries	(3) 12V 9Ah Sealed Maintenance Free Lead Acid Batteries	(4) 12V 9Ah Sealed Maintenance Free Lead Acid Batteries
	Replacement Battery Part Number	UPX-RPLBA TT-A	UPX-RPLBATT-B	UPX-RPLBATT-C
Environment	Operating Temperature & Relative Humidity	32 DEG F (0 c) - 104 DEG F (40 c) 0% - 95% non-condensing		
Communication	Storage Temperature	5 DEG F (-15 c) - 113 DEG F (45 c)		
	NEXSYS Management Software	Supports Windows® 7/8/10/11 and Windows Server 2008, 2012, 2016, 2019 Windows 2008/2012 Server Core, Hyper-V 2008/2012		
	Ports	USB, RS232, EPO, Dry Contacts, EXB Auto Detect and RackLink Network Card Option		
Control	Load Shed	Programmable Bank 1 and 2 (standard), Programmable Individual Outlet (optional)		
	Active On / Off	Manually turn power receptacles on or off using the front panel LCD or the UPS Manager Software		
	Scheduling	Fully programmable scheduling available for bank or outlet switching (based on the model purchased)		
RackLink Network Card Option	Features	SNMP V3, HTTP, HTTPS, TLS 1.2, SSH, Imbedded Web GUI w/Dashboard, RADIUS, TCP/IP, Telnet, FTP		
Front LCD Interface	Notification	LED = Normal Mode, AVR Mode, Battery Mode, Internal Fault, Battery Fault		
	Audible Alarms	On Battery, Low Battery, Battery Disconnected, Fault or Overload		
Dimensions	Width x Height x Depth	17.3" (440mm) x 3.4" (86.5mm) x 17.3" (440mm)		17.3" (440mm) x 3.4" (86.5mm) x 23.6" (600mm)
Weight	Product Weight	44.1 lbs. (20kg)		63.05 lbs. (28.6kg)
	Shipping Weight	54.1 lbs. (24.5kg)		71 lbs. (32.2kg)
Certifications	Safety Standards	**cTUVus** - Tested to UL 1778 & CAN CSA-C22.2 standards		
	EMI Standards	FCC Class A		
	Environmental	RoHS 3 / REACH Compliant		
	Energy Efficiency	Energy Star 2.0		
Features	Load Shedding	Yes		
	Site Fault Detection	Yes		
	Cold Start	Yes		
	Standard Warranty	3 Years Limited (2 Years Battery). For warranty information, refer to legrandav.com/policies/warranty_information		

NEXSYS Line Interactive UPS				
Model		UPX-1000R-2 UPX-RLNK-1000R-2 UPX-RLNK-1000R-8	UPX-1500R-2 UPX-RLNK-1500R-2 UPX-RLNK-1500R-8	UPX-2000R-2 UPX-RLNK-2000R-2 UPX-RLNK-2000R-8
Weight	Product Weight	44.1 lbs. (20kg)		63.05 lbs. (28.6kg)
	Shipping Weight	54.1 lbs. (24.5kg)		71 lbs. (32.2kg)
Certifications	Safety Standards	**cTUVus** - Tested to UL 1778 & CAN CSA-C22.2 standards		
	EMI Standards	FCC Class A		
	Environmental	RoHS 3 / REACH Compliant		
	Energy Efficiency	Energy Star 2.0		
Features	Load Shedding	Yes		
	Site Fault Detection	Yes		
	Cold Start	Yes		
	Standard Warranty	3 Years Limited (2 Years Battery). For warranty information, refer to legrandav.com/policies/warranty_information		

2.15 PURE SINE WAVE UNINTERRUPTIBLE POWER SUPPLY WITH SURGE SUPPRESSION AND POWER FILTRATION: REFERENCED PRODUCT APC SMART UPS SMT FLOOR MOUNT UNITERRUPTABLE 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).
2. APC Smart-UPS traditional Tower form factor.
3. PowerChute management software for servers and workstations and advanced UPS management (All major operating systems supported). Connectivity is through serial or USB port (USB not standard on all models). Additional manageability is available through the SmartSlot, an internal accessory slot that allows you to install optional accessories to enhance the performance of your UPS. Network connection with Web browser management and/or environmental monitoring, serial port expansion, and out-of-band management options are available.
4. With pure sine-wave output ensuring compatibility with all connected devices, Intelligent Battery Management ensuring a highly available UPS and an advanced 16 segment bar graph display.

B. TECHNICAL SPECIFICATIONS:

Cable Details	
Form Factor :	External

Dimensions & Weight (Shipping)	
Shipping Depth :	23 in
Shipping Height :	15 in
Shipping Weight :	58.2 lbs
Shipping Width :	13 in

Run Time Details	
Load Type :	Full load
Run Time (Up To) :	7

UPS	
Battery Technology :	Lead acid

Battery	
Enclosure Type :	Internal
Load Type :	At full load
Recharge Time :	3 hours
Run Time (Up To) :	7 min

Cable	
Connectivity Details Length :	6 ft
Connectivity Details Type :	Power cable
Connectivity Details Type :	USB cable

Environmental Parameters	
Humidity Range Operating :	0 – 95%
Max Operating Temperature :	104 °F
Min Operating Temperature :	32 °F
Sound Emission :	45 dBA

Header	
Brand :	APC
Compatibility :	PC
Manufacturer :	APC
Model :	1500VA USB
Packaged Quantity :	1
Product Line :	APC Smart-UPS

Interface Provided	
Connector Type :	25 pin D-Sub (DB-25)
Qty :	1
Type :	Management (RS-232)
Type :	Management (USB)

Miscellaneous	
Color :	Black
Color Category :	Black

Networking	
Remote Management Interface :	RS-232, USB

Power Device	
Form Factor :	External
Frequency Provided :	50/60 Hz
Frequency Required :	50/60 Hz
Input Connector Qty :	1
Input Connector Type :	Power NEMA 5-15
Input Voltage Range :	AC 82 - 144 V
Input Voltage Range (Adjustable) :	AC 75 - 154 V
Output Connector Qty :	8
Power Capacity (VA) :	1440 VA
Power Provided :	1kW
Surge Suppression :	Yes
UPS Output Waveform :	Sinewave
UPS Technology :	Line interactive
Voltage Provided :	AC 120 V
Voltage Provided Margin :	± 5%
Voltage Required :	AC 120 V

Power Output Connectors Details	
Connector Qty :	8
Connector Type :	Power NEMA 5-15

Power Supply	
Device Energy Rating :	459 Joules

Service	
Support Details Full Contract Period :	2 years
Support Details Type :	Limited warranty

Service & Support	
Type :	2-year warranty

Slot Provided	
Free Qty :	1
Total Qty :	1
Type :	SmartSlot

Dimensions & Weight	
Depth :	17.3 in
Height :	8.5 in
Weight :	53.13 lbs
Width :	6.7 in

General	
Product Type :	UPS
Subcategory :	UPS

C. GENERAL

1. Provide with the APC 3-year warranty.

2.16 4-COLOR MIXING OR WHITE LIGHT EMITTING DIODE ELLIPSOIDAL FIXTURE: REFERENCED PRODUCT ETC COLORSOURCE SPOT V LED

A. Basis of Design: ColorSource Spot V as manufactured by ETC Inc. Brings together a five-color light engine with the build-quality and support of an ETC product. Uses a mix of red, green, blue, indigo and lime LED emitters. ETC optics, adapters, and accessories.

1. Standards Compliance:
   a. Listed: cETLus, UL 1598, UL 924, CSA C22.2 No. 250.0.
   b. Compliance: CE.

2. Model ColorSource Spot V with shutter barrel, black.
3. Model ColorSource Spot V, body only, black.
4. Source:
    a. LED Details: 60 Lumileds LUXEON Rebel and LUXEON C LEDs.
    b. Max Lumens: 9300.
    c. Lumens per Watt: 47.2.
    d. L70 Rating: Greater than 54000 hours.
5. Colors:
    a. Colors Used Spot: Red, green, blue, indigo, lime.
    b. Color temperature Range: Color mixing.
    c. Calibrated Array: Yes.
    d. Red Shift: No.
6. Optical:
    a. Beam Angle Range: 5 to 90 degrees. Swappable lens tubes.
    b. Gate Size: 80 mm.
    c. Aperture Size: 6.25 to 14 inches depending on lend tube.
    d. Pattern Projection: Yes.
    e. Pattern Size: A or B.
    f. Camera Flicker Control/Hz Range: 5 kHz and 25 kHz.
7. Control:
    a. Input Method:
        1) DMX-512 via 5-pin XLR connector. Protocols: DMX512, RDM.
        2) City Theatrical Multiverse. Protocols: DMX512, RDM
    b. NFC Configuration: Yes, via Set Light app.
    c. RDM Configuration: Yes.
    d. User Interface Type:
        1) ColorSource Spot V: 7-segment 3 button interface.
    e. Local Control: Yes. (ColorSource Spot V only)
    f. Onboard Presets: Yes, 12. Onboard Sequences: Yes, 5. Onboard Effects: No.
    g. Fixture-to-Fixture Control: Yes.
    h. 15-bit virtual dimming engine.
8. Electrical:
    a. Voltage: 100 to 240 VAC, 50 to 60 Hz.
    b. Input Method: powerCON True1 TOP in and thru.
    c. Inrush First Half Cycle: 55 A at 120 V. 59 A at 240 V.
    d. Fixtures per Circuit:
        1) Eight. (R20 module or similar).
9. Thermal: Operating Temperature: 32 to 104 degrees F.
    a. Fan: Yes. Controllable.
    b. Droop Compensation: Yes.
    c. BTUs/hour: 671.77.

10. Physical: IP Rating: ColorSource Spot V: IP-20.
    a. Materials: Die-cast aluminum. Colors: Black, white, silver, or custom.
    b. Mounting Options: Yoke.
    c. Included Accessories: Hanging yoke, 39 inch power cable, soft-focus diffuser in an A-size gobo holder.

2.17 5-COLOR MIXING LIGHT EMITTING DIODE FRESNEL WASH FIXTURE: REFERENCED PRODUCT ETC COLORSOURCE FRESNEL V MAX LED

A. Basis of Design: ColorSource Fresnel V MAX as manufactured by ETC Inc. An affordable high quality Fresnel wash fixture with motorized zoom. Uses RGBIL color system.

1. Standards Compliance:
    a. Listed: cETLus, UL 1598 & 924, CSA C22.2 No. 250.
    b. Compliance: CE and UKCA.
2. Model ColorSource Fresnel V MAX: Black, White, Silver Gray (custom colors upon request)
3. Arrays:
    a. RGBIL (Red/Green/Blue/Indigo/Lime).
4. Source:
    a. LED Details: 60 Lumileds LUXEON C ES LEDs
    b. Max Lumens: 10,023
    c. Lumens per Watt: 48.
    d. L70 rating: Greater than 54,000 hours.
5. Color:
    a. Color temperature Range: Color mixing.
    b. Calibrated Array: Yes.
    c. Red Shift: No.
6. Optical:
    a. Beam Angle Range: 13-44 degrees
        1) Motorized zoom
    b. Gate Size: N/A.
    c. Aperture Size: 7.48" (190 mm)
    d. Pattern Projection: No.
    e. Pattern Size: N/A.
    f. Camera Flicker Control/Hz Range: Default: 5kHz. RDM: 25,000 Hz (via RDM).
7. Control:
    a. Input Method: DMX-512 via 5-pin XLR connector. Protocols: DMX512, RDM, City Theatrical Multiverse, NFC.
    b. RDM Configuration: Yes.
    c. NFC Configuration: Yes
    d. User Interface Type: 7-segment 3 button, single encoder interface.
        1) Encoder controls local motorized zoom

e. Modes (footprint): 6 modes (standard, RGB, 1 channel, direct, 6 channel & CCT – studio)
f. Local Control: Yes.
g. Onboard Presets: Yes, 12.
h. Onboard Sequences: Yes, 5.
i. Onboard Effects: No.
j. Fixture-to-Fixture Control: Yes.
k. 15-bit virtual dimming engine.
l. The fixture shall be USITT DMX 512A-compatible via In and Thru 5-pin XLR connectors
m. The fixture shall be City Theatrical Multiverse (SHoW Baby)-compatible via wireless DMX (900 MHz/2.4 GHz). Wireless shall be banded on the 2.400 – 2.480 GHz band with a range of 100 m indoors, 500 m line of sight (subject to site conditions). Maximum receivers shall be: DMX (no limit); RDM (varies by transmitter used); Multiverse SHoW Baby (585); Multiverse Transmitter (5,000). Broadcast power shall be 100 mW.
n. The fixture shall be NFC (near field communication)-compatible via ETC's Set Light app (and shall be configurable without power). This enables wireless addressing & configuration of fixtures (either to set new or to pull existing configurations).

8. Electrical:
   a. Voltage: 100 to 240 VAC, 50 to 60 Hz. Input Method: PowerCON True1 in and thru.
   b. Inrush First Half-Cycle: 120 V, 36A; 240 V, 57A.
   c. Fixtures per Circuit (on standard R20 breaker):
      1) 3 (link up to 4 via Power Thru connector)
      2) Note TRUE1 connector rated for 20A (120V/60Hz) and 16A (230V/50Hz).
      3) Wattage: 208 W at 120 V. 205 W at 230 V.
      4) Current Draw: 1.75 A at 120 V. 0.95 A at 230 V.
9. Thermal: Operating Temperature: 32 to 104 degrees F.
   a. Fan: Yes. Controllable: Yes.
   b. Droop Compensation: Yes.
   c. BTUs/hour (120V): 709.
10. Physical:
    a. Materials: Die-cast & extruded aluminum.
    b. Color Options: Black, white, silver, or custom
    c. Mounting Options: Yoke.
    d. IP Rating: IP-20.
    e. Included Accessories: Power cable and hanging yoke.
    f. Weight: 6.24 kg (13.75 lb).
11. Accessories:

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 (half, cross baffle, 3" or 6")
3) Egg crate louvers
4) Standard and studio barn doors
5) Weighted base

12. WARRANTY
a. Fixture: 5 years
b. LED array: 10 years

2.18 ONE PORT NETWORK DATA DISTRIBUTION DEVICE: REFERENCED PRODUCT ETC NET3 ONE 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

2. 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 One Port Gateway as provided by ETC, Inc.

3. Gateways shall communicate over Ethernet directly with at least ETC, Inc.'s entertainment and architectural lighting control products and other Ethernet interfaces.

4. Connections shall be made between gateways, consoles, architectural systems, and PCs over standard Ethernet distribution systems using 10/100BaseT.

5. The unit shall support ESTA ACN and Streaming ACN.

6. The unit shall support the ETCNet2 protocol suite.

7. The unit shall be tested to UL standards and labeled ETL Listed.

8. The unit shall be RoHS Compliant (lead-free).

9. The unit shall be CE compliant.

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 3rd party DMX devices.

D. Mechanical

1. The gateway faceplate shall be constructed of durable cast aluminum. It shall mount in a standard 1 gang masonry deep back box. Faceplates manufactured of plastic shall not be acceptable.

2. Gateways shall be of pleasing appearance, suitable for high visibility architectural locations.

3. Gateways shall be provided in matte black finish.

E. Power

1. Power for the gateway shall be provided either over the Cat5 cable, complying with IEEE 802.3af, or via a power supply capable of an operating range of 10-28vDC. Power consumption shall not be greater than 3 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 2 Network Configuration Editor (NCE) or 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. The One port gateway shall also have hardware dipswitches for a basic address scheme.

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, at a minimum, IEEE 802.3.1 10BASE-T Ethernet specification.

2. All network cabling shall be Cat5 or higher, 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 address) "universes" when using EDMX and 64,279 "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 only as noted on drawings)

1. U-Bolt kit

2. Touring Options – with Cat5 XLR, patch cable.

3. Plug in station covers: 1, 2, and 4 gang.

4. Optional punch down kit

5. ETC Network Configuration Editor (NCE) software

J. System Requirements

1. Provide the quantity and type of gateways required, as scheduled. Gateways and software shall be as manufactured by Electronic Theater Controls Inc. of Middleton, WI.

2. Provide Ethernet hubs 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.

4. Systems that do not provide the above capabilities shall not be acceptable.

2.19 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 3rd 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.

2.20 FOUR PORT NETWORK DATA DISTRIBUTION DEVICE: REFERENCED PRODUCT ETC NET3 FOUR 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 4-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 Network Configuration Editor (NCE). 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 m Sec.).

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 3rd party DMX devices.

D. Mechanical

1. Rack Mount/Portable gateway

a. The rack mount/portable gateway will be fabricated of .16-gauge steel, finished in fine-texture, scratch-resistant, black powder coat. Dimensions shall be 8.5" (22 cm) wide x 8.0" (20 cm) deep x 1.75" (5 cm) high not including tabs.

b. The weight of the gateway shall be 3.5 lbs (1.6 kg) with four connector modules. An individual module shall weight no more than .25 lbs (.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 2 Network Configuration Editor (NCE) or 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. DMX Connector modules

1. Each gateway shall incorporate four connector module locations. Each module shall contain a single connector and its associated electronics for ease of service. Connector module options shall include a male DMX input connector, a female DMX output connector or a terminal strip connector.

2. Each connector module shall be fully opto-isolated from the gateway electronics and from each other.

3. DMX connector modules shall be capable of withstanding fault voltages of up to 250VAC without damage.

I. 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.

J. Accessories

1. Flexible Hanging Bracket kit - bracket shall allow unit to be mounted in 3 orientations, U-Bolt option also available

2. Rack mount kit – a 1U rack-mount bracket that shall support either two complete units or one unit and a Front Access Panel kit. This kit shall allow up to eight ports of DMX in a 1U rack space.

3. Front Access Panel kit – a kit that allows the connectors on the rear of the unit to be accessed from the front of the unit in an equipment rack

4. Universal Power Supply with international plug-set included. Multiple power supplies shall be able to fit in a vertically stacked power strip.

5. ETC Network Configuration Editor (NCE) software

K. System Requirements

1. Provide the quantity and type of gateways required, as scheduled. Gateways and software shall be as manufactured by Electronic Theater 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.

2.21 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 ¾″ labels with white letters on black background (sized to match product). Pigtails and outlets shall be spaced on 3″ centers, or as otherwise specified.

E. NEMA Wall Plates

1. An alternative to surface and recessed outlet boxes, ETC's NEMA style wall plates shall be available for 20A Stage Pin, Edison and Twist-Lock connectors. For use with industry-standard back boxes, the wall plates shall be fabricated of .125 AL and shall be finished with fine-textured, scratch-resistant, black powder coat. Circuit numbers shall be 2″ or ¾″ labels with white letters on black background (sized to match product).

2.22 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.

2.23 DMX ETHERNET GATEWAY – DIN RAIL MOUNTED: REFERENCED PRODUCT ETC DIN RAIL GATEWAY

A. General

1. The lighting control gateway shall be a microprocessor-based unit specifically designed to provide DMX-512 control of lighting systems and transport of RDM configuration and status messages. The gateway shall permit DMX-512 data to be encoded, routed over an Ethernet network and decoded back to DMX-512. The unit shall be a Response Mk2 DIN rail DMX 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 gateway shall support multiple protocols including:
    a. ANSI E1.17 Architecture for Control Networks (ACN)
    b. ANSI E1.31 Streaming ACN (sACN)
    c. ANSI E1.11 USITT DMX512-A
    d. ANSI E1.20 Remote Device Management (RDM)
5. The gateway shall be tested to UL standards and labeled ETL Listed.
6. The gateway shall be RoHS Compliant (lead-free).
7. The gateway shall be CE compliant.
8. The gateway shall have a graphic OLED display and four buttons for identification (soft-labeling), configuration, status reporting and troubleshooting
    a. Labeling shall be user configurable using ANSI E1.17 Architecture for Control Network (ACN), or a purpose built software configuration tool.
    b. The OLED display shall show DMX port configuration indication as well as indicate the presence of valid signal.
    c. Gateways that do not indicate port configuration (input/output) and valid data shall not be acceptable.
9. Each gateway shall have power and data activity LEDs on the front of the gateway

B. DMX Ports

1. DMX Ports shall comply with the requirements of ANSI E1.11 USITT DMX512-A standards.
2. Each DMX port shall be software or locally-configurable for either input or output functionality.
3. DMX input shall be optically-isolated from the gateway electronics.
4. DMX Port shall provide at least 500V isolation to ground and the rest of the electronics
5. Each port shall incorporate one DMX512-A Connection
6. Network gateways that do not indicate input/ output port configuration or presence of valid data shall not be accepted

C. Processor

1. Each gateway shall have sufficient processing power to manage up to 63,999 universes (32,767,488 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 with 3rd party DMX devices.

D. Mechanical

1. The DIN Rail mounted gateways shall be included in an extruded plastic enclosure.
2. Provide "ganged" DIN rail devices with DIN rail system, etc. in a durable, powder coated black metal NEMA enclosure.
3. Three variants of gateways shall be available:
   a. One Port
   b. Two Port
   c. Four Port
4. Two wiring connections shall be required for connection to the lighting system
   a. Ethernet connection that supports standard Cat5 patch cables
   b. DMX input or output connection using is terminal strip or IDC-style connector
5. Optional accessories for rack-mount and pipe applications shall be available from the manufacturer. These accessories shall support installation by an end-user

E. Power

1. Power for the gateway shall be provided over the Category 5 (or better) cable, utilizing IEEE 802.3af compliant Power over Ethernet (PoE). Power consumption using shall not be greater than 7 watts.
2. An optional low-voltage DC power input shall be available utilizing an isolated in-line power supply capable of an operating range of 12-24VDC. The Power supply shall be provided by the gateway manufacturer.
3. The gateway electronics shall be electrically isolated from the power supplied over the Category 5 (or better) cable.

F. Configuration

1. The Gateway must support local or remote configuration.
2. Each gateway on the network shall be individually configurable using freely available software configuration tools. The primary configuration tool shall be Net3 Concert configuration software running on a network connected PC. The PC shall only be required for configuration and shall not be required for normal operation of the system.
3. Each port of the DMX gateway shall control up to 512 DMX addresses, within the confines of 63,999 universes.
4. The specific DMX data input or output by the gateway shall be freely configurable by the user.

5. Duplicate outputs of DMX lines (DMX splitter) and discrete outputs shall be fully supported.
6. Multiple DMX universes may be configured with any length up to 512 total addresses. Any range of DMX input addresses shall support selection and routing to the specified sACN output.
7. Multiple sACN sources may be combined with a priority may be assigned to each source sending data to the gateway
8. 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. Gateways that do not support non-volatile storage of data routing shall not be accepted.

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), 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. ANSI E1.17 Architecture for Control Networks (ACN) and streaming ACN (sACN) shall be supported. Gateways that do not support ANSI E1.17 shall not be acceptable.
5. Each DMX gateway shall control up to 512 DMX addresses, per DMX port within the confines of up to 63,999 universes (32,767,488 addresses) using Streaming ACN (sACN).
    a. Any range of DMX addresses may be selected for each universe.
    b. Multiple sources shall be supported by prioritized Highest Takes Precedence (HTP with priority). Each source shall support assignment of priority to allow override of default HTP behavior.
    c. Each DMX port shall support its own universe and start address.
6. Gateways shall have built in DMX merger capability on a universe or channel-by-channel basis.
7. Gateways shall support have built in priority on a per-universe or channel-by-channel basis. Gateways that do not support prioritized merging of multiple network sources at independent priorities shall not be accepted.

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

1. A Universal Power Supply with international plug-set shall be available. Multiple power supplies shall be able to fit in a vertically stacked power strip.
2. ETC Net3 Concert Configuration and monitoring Software

J. System Requirements

1. Provide the quantity and type of gateways required, as scheduled. Gateways and software shall be as manufactured by ETC Inc. of Middleton, WI.

2.24 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.

2.25 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
            a) 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.

2.26 RACKS AND HARDWARE

A. SWING OUT WALL RACK:

1. EIA compliant 19″ wall mount rack shall be Middle Atlantic Products model # SR-__-__ (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. SR 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-__. SR 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 warrantied to be free from defects in materials or workmanship under normal use and conditions for the lifetime of the rack.
2. 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 warrantied to be free from defects in materials or workmanship under normal use and conditions for the lifetime of the rack.

3. 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. H20. 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.

2.27 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 100º. 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.
8. Mount on the upper rear rack rail and orient to spill lighting down inside the entire interior rear portion of the rack.

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	

2.28 NYLATRON UNDERHUNG HEAD BLOCK: REFERENCED PRODUCT THERN STAGE HB12 SERIES UPRIGHT/UNDERHUNG SINGLE PURCHASE HEAD BLOCK

A. Underhung head block shall be equipped with 12" diameter Nylatron GSM sheave with (six, eight or ten – per drawing requirements) 1/4" wire rope grooves and one 3/4" purchase line groove machined so that the pitch diameters of all grooves are equal. Cast iron sheaves shall not be acceptable. Machine face and concentrically bore hub for installation of a steel bearing support insert. Machine each end of insert for roller bearing cup and external retaining rings. Install tapered roller bearing cone and cup on 1" diameter steel shaft. Sheaves with bearing cups pressed directly into the synthetic material shall not be acceptable. Lock shaft to side plate on head end with 1/4" keeper pin to prevent rotation. Provide washer and fine- threaded nylon insert lock nut on threaded end. Shaft threads shall not bear on side plates.

B. Ten-gauge side plates shall be welded and bolted to 2" X 2" X 1/4" steel base angles, 34" long. Provide six 1" notched tubing spacers and six 5/8" tubing spacers fastened with 3/8" bolts and lock nuts, forming a rigid housing and preventing the purchase line and cables from leaving their grooves. Locate mounting holes in each base angle to allow proper placement under head beam. Attach to beam using four 1/2" welded steel bar clips, fabricated with offset to match head beam flange, and four 1/2" diameter SAE J429 Grade 5 bolts, nuts, flat washers and lock washers.

C. Head block assembly shall be designed for a working load limit of 3,000 pounds at 300 feet per minute.

D. Headblock shall weigh 56 – 64 lbs. (depending on quantity of grooves).

2.29 NYLATRON TENSION FLOOR BLOCK: REFERENCED PRODUCT THERN STAGE FB12 SERIES SINGLE PURCHASE TENSION BLOCK

A. Provide tension block with 12" diameter ASTM A 48, Class 30-35 gray iron sheave with lathe-turned groove for 3/4" rope. Concentrically bore hub for installation of two sealed precision ball bearings on 5/8" diameter steel shaft. Lock shaft to side plate on head end with 3/16" keeper pin to prevent rotation. Provide washer and fine-threaded nylon insert lock nut on threaded end. Shaft threads shall not bear on side plates.

B. Ten-gauge side plates shall be bent to form a 1/4" x 12 1/8" steel backing plate and 1/4" x 2" steel tabbed front kick plate, forming a rigid housing. Front plate shall have bent toe plate to ease movement of tension block. Provide three 5/16" bolts and spacers to keep rope from leaving groove. Entire assembly shall weigh in excess of 44 pounds and ride between tee guides on two guide shoe assemblies.

C. Provide two shoe guides per tension block. Each assembly shall be constructed from two 1/2" x 6" HDPE guide plates and one 1/4" x 2" HDPE spacer plate, sized to properly ride between tee guides located on 6" or 8" centers. Provide two 1/4" x 2" steel backing plates to support guide material, and three 3/8" diameter SAE J429 Grade 5 bolts to attach entire assembly to tension block housing.

2.30 NYLATRON UNDERHUNG THROAT CUT LOFT BLOCK: REFERENCED PRODUCT THERN STAGE LB8-F SERIES THROAT CUT UNDERHUNG LOFT BLOCK

A. Underhung loft block shall be equipped with 8" diameter Nylatron GS sheave grooved for 1/4" cable to meet wire rope manufacturers' recommended practice for both clearance and 30-degree throat taper. Install two sealed precision ball bearings on 5/8" steel shaft. Lock shaft to side plate on head end with 3/16" keeper pin to prevent rotation. Provide washer and fine-threaded nylon insert lock nut on threaded end. Shaft threads shall not bear on side plates.

B. Ten-gauge side plates shall be notched on the load-bearing side to fit up to 3/8" thick loft beam flange and shall be welded to 1" X 1" X .120" steel tube. Provide FIVE 5/8" tubing spacers fastened with 5/16" Grade 5 bolts and lock nuts, forming a rigid housing and preventing the cable from leaving its groove. Secure block to beam with a 5/16" x 2" formed steel "L" clip and 3/4" bolt, nut and lock washer.

C. Entire loft block assembly shall be designed for a working load limit of 875 pounds for 1/4" cable at 300 feet per minute.

D. Provide blocks with quantity of grooves as indicated on the contract drawings (up to a max of 9)..

E. Provide blocks with Thern LB2 series Nylatron idler assemblies with quantity of grooves as indicated on the contract drawings (up to a max of 9).

2.31 NYLATRON UNIVERSAL LOFT BLOCK: REFERENCED PRODUCT THERN STAGE LB8-R/D SERIES LOFT BLOCK

A. Upright or underhung loft block shall be equipped with 8" diameter Nylatron GS sheave grooved for 1/4" cable to meet wire rope manufacturers' recommended practice for both clearance and 30-degree throat taper. Install two sealed precision ball bearings on 5/8" steel shaft. Lock shaft to side plate on head end with 3/16" keeper pin to prevent rotation. Provide washer and fine-threaded nylon insert lock nut on threaded end. Shaft threads shall not bear on side plates.

B. Ten-gauge side plates shall be notched on the load-bearing side to fit up to 3/8" thick loft beam flange and shall be welded to 1" X 1" X .120" steel tube. Provide five 5/8" tubing spacers fastened with 5/16" Grade 5 bolts and lock nuts, forming a rigid housing and preventing the cable from leaving its groove. Secure block to beam with a 5/16" x 2" formed steel "L" clip and 3/4" bolt, nut and lock washer.

C. Entire loft block assembly shall be designed for a working load limit of 875 pounds for 1/4" cable at 300 feet per minute.

D. Provide upright/underhung loftblocks with the quantity of wire rope grooves as indicated on the contract drawings (up to a max of 9).

2.32 NYLATRON WIRE ROPE IDLERS: REFERENCED PRODUCT THERN STAGE LB2-L SERIES LOFT BLOCK IDLERS

A. Loft block idlers shall be provided to carry the weight of the cables and prevent rubbing against adjacent block side plates. They shall not be installed to carry line loads or to act as deflectors or mule blocks.

B. Provide idler assembly attached to the side of each loft block to support and guide all cables as they pass adjacent to the block. Each cable shall be supported by an individual 2" diameter sheave of Nylatron GS molded around steel ball bearing.

C. The sheaves shall have ¼" cable grooves and two sealed, precision ball bearings and shall ride on a ¼" shaft inserted through the block housing.

D. A 3/16" diameter spacer shall mount in the housing and captivate the cables in the grooves.

E. All nuts shall be of the nylon insert self-locking type.

F. Idlers shall be mounted to sides of loftblocks as needed, depending on liftline count. Idler sheave counts shall decrease as liftline count lowers (i.e. the last loft block of each set should have no idlers, the second to the last one should have three, etc.).

G. Provide idler assemblies with the quantity of wire rope grooves as indicated on the contract drawings (up to a max of 9).

2.33 DUAL DRUM CLEW WINCH: REFERENCED PRODUCT THERN CW SERIES

A. Hoist:

1. The hoist shall be a CW2-2500-2M style Manual Clew Winch as manufactured by Thern Stage Equipment, or equal.
2. The hoist shall feature:
    a. Secure Operation with positive load holding brakes and dual drum shaft keys.
    b. Secondary Load Holding with lockout pin to secure drum to frame.
    c. Reliable Operation provided by enclosed worm gearing operating in sealed oil bath.
    d. Lockout pin and removable handle to prevent unauthorized use.
    e. Extended Cable Life with grooved drums as standard.
    f. Minimize Fleet Angle when clew is close to winch through narrow drum compartments and parallel winding.
    g. Convenient Guide Wire Installation using adjustable guide bars with tabs and shaft collars.
    h. Easy Attachment of Wire Rope provided by key hole anchors.
    i. No tools required.
    j. Universal Mounting to wall or base.

k. Drill drive or hand crank operation with downward facing drive shaft, (1) crank handle and (1) specialty drill.
l. Redundant Haul Lines with double compartment drum.

3. Mounting:
   a. Provisions shall be made for accurately mounting the block assembly to the supporting structure in a secure and safe manner with a custom designed and manufactured head block tray. The mounting shall be designed to prevent block movement and prohibit loosening of block or mounting hardware over time by either load or vibration.
   b. When attaching blocks, the anchors shall be selected and installed according to both the manufacturer's recommendations and local code requirements, for the loads and the materials into which they are inserted.
   c. Mounting clips shall be constructed and sized for the block load and mounting condition. They shall be installed so that the block cannot shift on the support structure. When clips are used to grip a beam flange, the clip shall deflect not more than 3mm (7/64 inch) when fully clamped at the block manufacturer's recommended torque values.

4. Operation:
   a. Device shall be operated via an included hand crank.
   b. Device shall be provided with the optional Dewalt drill and drive system and all accessories as indicated.

2.34 BEAM CLAMP: REFERENCED PRODUCT ANVIL INTERNATIONAL FIG. 133 STANDARD DUTY BEAM CLAMP

A. The beam clamp shall be a two-part, formed, 3/8" standard duty, carbon steel beam clamp #133 series style beam clamp (with grade 8 bolt and spacer). Beam clamp shall be available in sizes from 4" to 12" and shall accept a maximum flange thickness of 7/8" and a maximum flange width of 8". Beam clamps shall be rated for a WLL of 1,000 lbs. each. Beam clamps must captivate both sides of each beam flange. The system components shall be two half-clamps, one pipe spacer and one bolt with nut. UL listed when used with 3/8" and ½" rod. Clamp complies with Federal Specification A-A-1192A (Type 21), WW-H-171-E (Type 21), ANSI/MSS SP-69 and MSS SP-58 (Type 21). Available in plain or galvanized finish. The contractor shall provide galvanized finished and shall apply at least (1) coat of rust inhibiting primer and (2) coats of flat black rust inhibiting paint to all sides of each beam clamp part. Use Rust-O-Leum, Krylon or equal. No paint drips, smudges, etc. shall be allowed.

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

A. 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.

B. 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.

C. Beam clamps shall be for use on standard 1 ½' schedule 40 pipe battens.

D. Batten clamps shall have a WLL of 1,400 lbs.

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

A. 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.

B. 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.

C. The trim chain shall be suitable for use with ¼" hardware.

D. The trim chain shall feature a date code on at least every 10^{th} link for traceability.

E. Load limits and safety factors for the chain shall be as follows:

1. Working load limit (WLL): 3,250 lbs.
2. Proof tested load: 6,500 lbs. minimum
3. Ultimate breaking strength: 13,000 lbs. minimum
4. Elongation at break: 20% minimum
5. 4:1 minimum safety factor

F. 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.

2.37 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.

2.38 METAL FRAMING SYSTEM: REFERENCED PRODUCT UNISTRUT METAL FRAMING

A. Unless otherwise noted in the contract documents, all Unistrut must be factory primed with the Perma-Green III coating system and then contractor finished in black (or a matching color to adjacent surfaces as indicated). Shiny gray, bare metal or otherwise unfinished Unistrut shall not be allowed under any circumstances.

B. 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.

C. 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

D. Nuts & Bolts:

1. 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.

2. 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	¼" – 20	5/16" – 18	3/8" – 16	½" – 13	5/8" – 11	¾" – 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)

3. 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.

E. Fittings:

1. 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.

F. Loading:

1. 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.

2. 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

G. 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.

2.39 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.

2.40 TORMENTOR LIGHT LADDER PIPE ASSEMBLY: REFERENCED PRODUCT SSRC-STYLE LIGHT LADDER

A. The light ladder assemblies (tormentor and/or Shakespeare pipe assemblies) shall be constructed of 1 1/2″ nominal black iron pipe with a matte black finish. All assemblies shall be of welded construction and shall be attached to the walls with 8″ x 8″ SSRC style wall flanges (unless otherwise noted on the bid drawings). All pipe assemblies shall be attached with load rated anchors appropriate for the substrate they are mounted into. See T series drawings details for more information on pipe assembly construction, mounting requirements and exact mounting locations. Nominal diameter is the ID size of the pipe. Actual OD shall be larger.

2.41 WALL FLANGE ASSEMBLY: REFERENCED PRODUCT SSRC-8″ X 8″ WALL FLANGE

A. The wall flange shall be constructed of an approx. 1.6″ OD (to accept a 1 1/2″ nominal "leg") black iron pipe welded to an 8″ x 8″ flat steel plate. Pipe shall be perfectly centered in the steel plate. Steel plate shall feature (4) 3/8″ punched holes for bolts – each spaced approx. ¾″ in from each plate edge. Entire plate shall be factory finished with a matte black finish.

2.42 CURTAIN TRACKS: REFERENCED PRODUCT ADC MODEL 380 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.

B. ALL tracks, pulleys, operating cord, hangers, jack chains and misc. hardware must be factory finished in black (either powder coated or black anodized).

2.43 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.

2.44 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.

2.45 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 ½″ 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 ¾″ – 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 ¾" – 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 ¾" – 2" diameter) and two in top bay (from ¾" – 1 ¼" 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 ½" 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 ¼" high x 1 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.

2.46 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. ½" – ¾" 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 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.

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 CHARISMA/FRED KRIEGER EPIC VELOUR
   a. Unit Weight: 24/25 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: ASTM E-84 (a/k/a NFPA 255, UL 723 or UBC 8-1) for flame spread and smoke generation: NFPA 701 (small scale test); Meets British FR Standards for Drapery Fabrics.
      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) 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.
      4) This fabric is rated Class A (Class 1) for flame spread and smoke generation for interior wall & ceiling finish.
   d. Fiber Content: 100% Trevira CS (polyester).

2.47 BILL OF MATERIALS

A. Relay system equipment, console and all accessories and controls - see drawings for equipment, quantities and required coordination with the EC and other related trades.

B. Lighting fixtures: See drawings for quantities, types, lamps, locations, installation requirements, etc.

C. Contractor shall 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.

D. Contractor shall provide gels (cut to size, installed and ready to use) as well as all necessary hardware for all followspot fixtures' boomerang or other color changing apparatus. Provide manufacturer's standard colors. If the manufacturer doesn't furnish colored gels for the boomerangs, then provide Rosco gel colors as determined by the owner or the owner's representative.

E. Theatrical Fixtures: Contractor shall be prepared to swap out, at no additional cost to the owner, any different or additional lenses or fixture barrels for the specified fixtures that may be needed due to field conditions, focus plot intents, etc. and that were not specified in the contract documents (except specialty beam patterns, such as 5, 10, 14, 19, 50, 70 – those lens barrels would be provided at additional cost to the owner). If there are no specific lenses called out on the drawings for the LED fixtures, then the contractor shall still be responsible to provide lenses dictated by the field conditions, focus plot and the consultant – typically this will be a maximum of two lenses per fixture. 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 or consultant, then the contractor shall provide barrel swaps for all affected fixtures so that the focus plot functions as intended – typically this will be only one barrel per fixture.

F. Contractor shall 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. 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, 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.

C. Assess life safety implications of all installation methods and verify there is no compromise of life safety issues.

D. 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.

E. Maintain M.S.D.S. for all materials used where applicable and submit same if requested upon completion.

F. Maintain the integrity of all fire-walls and doors during construction and upon completion.

G. Take all precautions necessary to guard against electromagnetic interference, electrostatic hum and RF interference, especially into the audio and video systems.

H. The contractor shall supply adequate ventilation and will install all equipment for the maximum safety of the operator.

I. 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. No additional payments will be made for material or equipment improperly ordered or sized due to site variations.

J. 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.

K. Provide all hardware and all other required parts to provide a complete system to the extent that such items are not provided by others.

L. 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.

M. Identify any equipment requiring licensing and initiate licensing procedures for all such equipment.

N. Coordinate all work with other on-site trades in order to achieve a coordinated progress at all times.

O. 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.

P. If specific elevations of 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.

Q. 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. LIGHTING SYSTEM:

1. 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.
2. Provide all internal network/DMX style wiring, etc. Needed inside the relay panel & all required interconnections & feeds to external equipment.
3. Control hookup is provided by the factory technician.
4. 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.
5. All wiring that is not in conduit shall be plenum rated wiring (Belden 1585A or equal).
6. All control booth wiring shall be neatly tie wrap bundled and dressed neatly.

7. All lighting or power cables & wiring must be dressed neatly with tie wraps & eyes or ring runs & tucked up against underside of lighting countertop
8. No undue stress shall be placed on any connection by a lack of support of the wiring within the rack.
9. 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.
10. 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.
11. Provide all (rack panels, bottom/top pans, spreader bars, access panels, etc.) blank and/or vent panels as needed to complete each rack with no unfilled spaces, as per rack elevations or as required by alternates to equipment specified. No racks with unfilled panel spaces shall be allowed. Seal all air gaps around conduit entry holes as needed in order to keep air gaps to a minimum.
12. Wiring Standards - Plenum Rated Cable: Unless specifically noted on the drawings, all low voltage wiring is to be CL2/CL3 wiring.
13. No rack rails will be allowed for equipment mounting in the rear of the rack unless otherwise noted in this specification.
14. 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.
15. Route conduits into racks with as few bends as possible – use sweep elbows where necessaryAll wiring shall be protected in conduit until it has reached the internal space of the indicated rack(s).
16. All dimming/lighting system related racks shall be mounted vertically and as intended by the manufacturers. No racks shall be allowed to be mounted horizontally.
17. The contractor shall program the main dimmer rack(s) control module(s) to “hold last look” upon loss of DMX signal. Duration of this hold shall be for 15 minutes (unless the system has been shut down or turned off by the architectural control system). This shall prevent the room from going dark in the case of lighting console failure or inadvertent disconnection of DMX/NET input from lighting control console to the system.

B. RIGGING SYSTEM:

1. 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.
2. 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).
3. All related SO style or other control and power wiring related to the motorized units shall be strain relieved to structure (unless otherwise indicated).
4. All loose control or power cables & wiring must be dressed neatly with tie wraps & eyes or ring runs & tucked up against underside of lighting countertop. No dangling and loose cabling shall be allowed underneath the lighting control area. This means that the contractor shall not be allowed to simply coil up excess cable and lay it on the floor or hang it from the wall or over a junction box. All cabling shall be cut to length (unless specifically indicated to be of certain lengths on the drawings) and all excess to be securely mounted so that it cannot become caught, snagged or otherwise engaged by operators, legs, chairs, etc. All cabling not handled as described above shall be fixed by the contractor at no additional cost to the owner. No excessively long cables (except those called out by length on drawings) shall be allowed.
5. No undue stress shall be placed on any connection by a lack of support of the wiring within the rack, junction box, devices, etc.
6. 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.
7. 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.

8. 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).

C. 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.

D. CONDUITS (OR ASSOCIATED RACEWAY/WIREWAY):

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 wiring in conduit shall be rated as necessary for full load continuous operation of the wiring within the conduit.

3. 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.

4. All conduits shall be concealed unless the owner has been notified in writing and accepts by written approval the location of all exposed conduits.

5. 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.

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.

E. 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.

C. RIGGING EQUIPMENT:
1. All rigging equipment shall be assembled per manufacturer's instructions and tested prior to installation.
2. 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. 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.

G. 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.

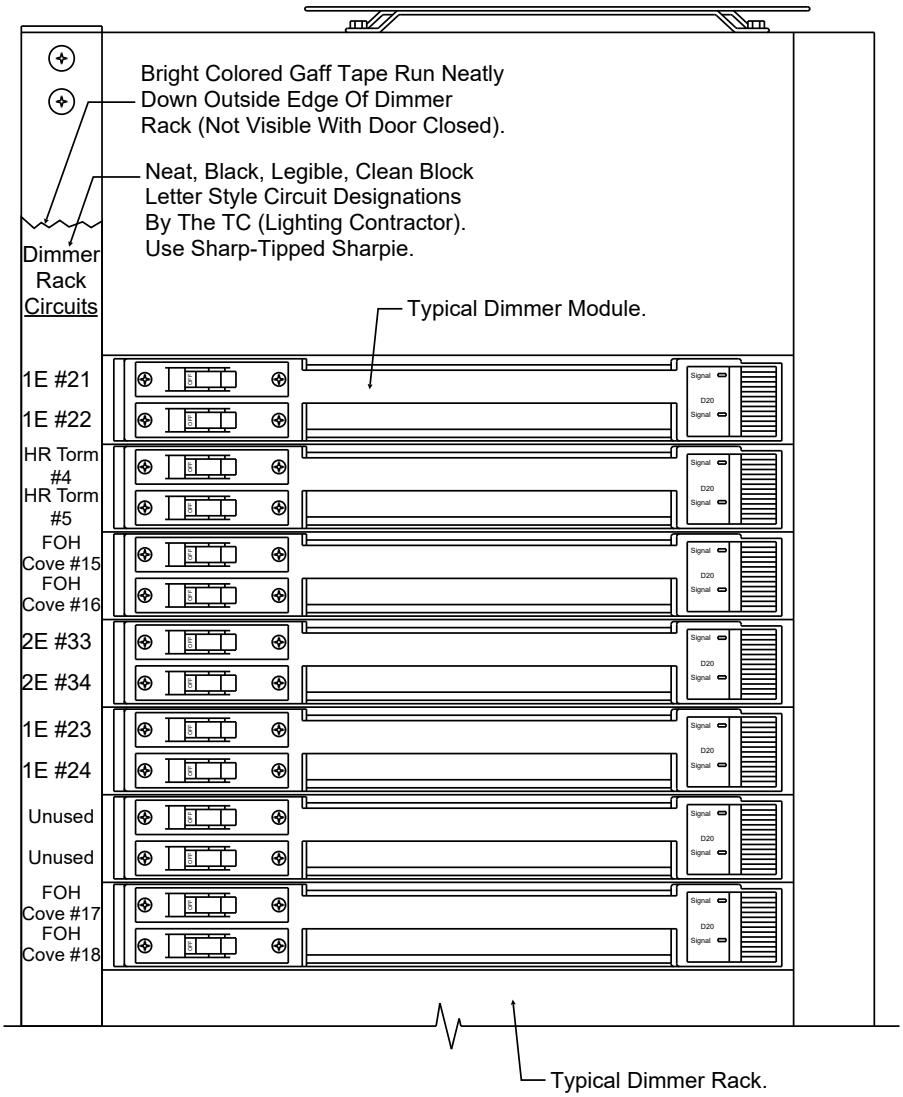
H. No curtains shall be installed prior to the stage floor being swept and wet mopped by the rigging installer in order to remove all dirt, dust, misc. spilled items, etc. Alternatively, the rigging installer may cover the entire stage floor with a single layer (overlapped 12" as needed) of new, clean, 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. 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.

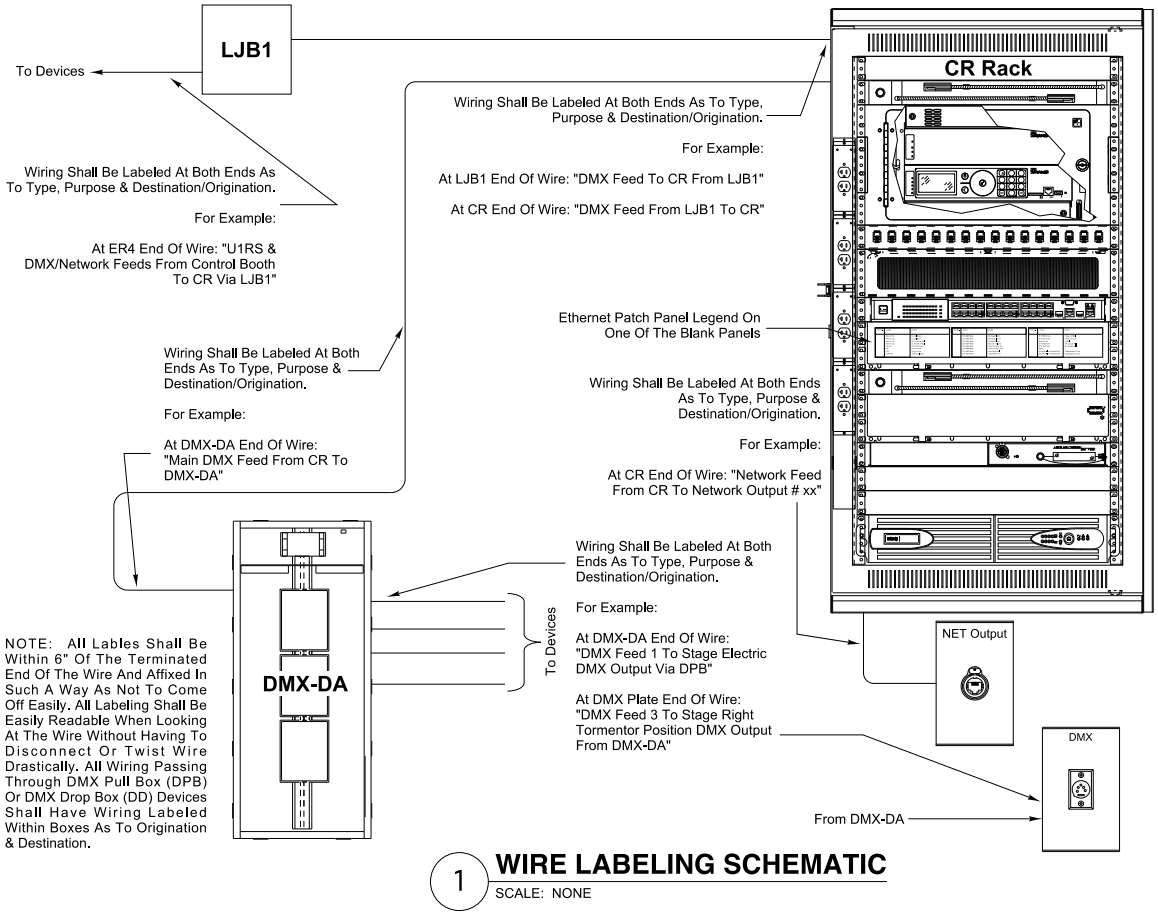
3.5 LABELING:

A. LIGHTING SYSTEM EQUIPMENT:

1. All conduit, switches, cables, wire, JB's, backboxes, controls and outlets will be permanently and logically marked during installation (see drawings for more info). 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.
2. 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.
3. Permanently mark cables with an identifying label at each end in a consistent, logical manner.
4. Color-coding of the entire system shall be logical and adhere to accepted industry standards.
5. 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.
6. The contractor shall label each circuit in each dimmer rack as to its destination (permanent black marker on bright colored gaff tape is acceptable – printed legibly). Contractor may also use any style of durable, stick-on, printed style labeling that will remain adhered, is approved by the manufacturer, does not violate NEC and is large enough to easily read. Example for circuit #32 would be – "1E #32" (First Electric, Circuit #32) OR example for circuit #2 would be – "Cove, Circuit #2" OR example for circuit #102 would be – "Houselights R1" (row 1 of houselights). Contractor shall also provide multiple copies of a typed "spreadsheet-style" sheet showing all circuit assignments along with their destinations, designations, descriptions and locations to the owner for future reference. Place one laminated copy of this sheet on the wall beside the dimmer rack. See diagram below for more info. This includes any existing and to be reused dimmer racks - layout may deviate from what is shown due to physical differences and constraints of existing racks vs diagram that follows. In that case, provide labeling for each such rack that is as similar to what is shown as is possible, while placing labels as needed and in locations that make sense, do not impede airflow, module removal or rack functionality or violate existing rack manufacturer's specifications.



7. 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 theatrical/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. Provide patch panel legends for all network, 0-10V and DMX distribution (separate for each and located near related distribution equipment). Patch naming shall be concise, can be intelligently abbreviated and specific to locations. Matching names shall be located on all wiring (both ends) as well as on output plates.



1 **WIRE LABELING SCHEMATIC**
SCALE: NONE

A. RIGGING SYSTEM EQUIPMENT:

1. 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:
   a. ANSI Z535.1-2006, Safety Color Code
   b. ANSI Z535.2-2011 (R2017), Environmental and Facility Safety Signs
   c. ANSI Z535.3-2006, Criteria for Safety Symbols
   d. ANSI Z535.4-2006, Product Safety Signs and Labels
2. 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.

3. 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.
4. Each set in the system shall have an engraved affixed number (excepting a pipe grid system).
5. All locking rails shall have an individual, permanent number or name displayed at each rope lock. Provisions shall be made for the temporary display of secondary descriptions.
6. A sign shall be displayed at each locking rail stating the capacity of the line sets, electrics, bridges or other equipment controlled from that position. See below for safety signage required and specific locations.
7. 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.
8. Load Types Defined:
    a. 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.
    b. 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.

c. 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.

9. Each J-guide arbor shall have a sign affixed to the back plate at 2-foot intervals stating "CAUTION: Locate spreader plate here." Systems employing wire guide type arbors shall have readily visible signs stating that spreader plates shall be located at 2-foot nominal intervals. Each arbor shall have the set number on the front face of the arbor near the top.
10. 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.
11. Each curtain, leg, electric and border light set shall be so designated.
12. A wall plaque/sign shall be placed at the locking rail 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.
13. 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.
14. The contractor shall flag all counterweight set operating (purchase) lines as detailed below. Typical locations for flags is on all stage electrics, the projection screen and any shell sets. All other sets are typically unflagged and are set by the owner as required per performance, per masking requirements, etc. All “flags” shall be made from a soft, flexible, durable cloth that will not damage or degrade the operating lines or other related system components that it may come into contact with. Method of insertion shall be by carefully inserting cloth through the middle of the operating line rope braiding (without damaging, unbraiding or unraveling the rope) in such a way as to leave a short strip of cloth dangling from either side of the operating line and in full, easy view of set operators. These cloth “flags” or “spike” markers shall be utilized by operators in order to visually indicate all sets “normal” fly-in locations as well as typical arbor locations when shells & projection screens are in use (where applicable). When sets are in correct locations, flag markers shall just clear the top of the rope lock mechanisms. Flags shall be approx. ½” x 4” cloth strips. Flag all sets with colors as follows:
    a. Bright safety yellow flags for all “normal” stage electric set operating positions.

b. Bright red flags for all shell & projection screen sets in typical performance position.

15. SIGNAGE:

a. 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.

b. Provide standard counterweight operations signs and motorized hoist signs as required in written specifications and on drawings.

c. 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.

d. 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.

e. Fire curtain signage with basic operating instructions and warnings shall be posted in the area where the equipment will be operated. Signage shall be in conformance with ANSI-Z535.

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 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. The contractor shall be responsible to provide backups as required, even if those backups do not appear in plans or on the detail drawings.

1. In the case of counterweight rigging systems, utilize industry standard practices for lift lines gauges and conform to all applicable codes.

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 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 toll must be on the job site and closures checked during installation.

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 of 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. 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.

O. 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 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”). This includes, but is not limited to, complete removal of irrelevant, abandoned or protruding hardware, anchorages, misc. holes, mismatched paint on walls/surfaces after removals, excessive dirt/debris left after removals work, etc. as well as touch up painting and/or cleaning of related areas of removal, wall surfaces, etc.). 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. LIGHTING SYSTEMS:

1. 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.
2. 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:
    a. No LED fixture shall be allowed that exceeds an NC10 noise curve as measured 4’ – 0” from any point of the fixture.
    b. NC measurements shall be dBA and measured in 1/3rd octave resolution.
    c. For fan cooled devices, the fans are normally to be set up and operated in auto mode.
    d. 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).
    e. ** Tonality shall be defined as any frequency or frequency bands that are narrower than 1/3rd 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.
3. For relay circuits powering LED fixtures, set dimmer profile to be on in all cues, etc. So that LED fixtures are always powered on during performances. Relays shall be set to be turned off when system is not in use in order to preserve drive electronics' estimated max life cycle. Perform this function in the architectural control system programming software.
4. Program all touch screens, including magic sheets (with graphic overlays of the space as well as with fixtures by group) for the owner’s use.

5. 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.
6. Provide custom signage for the dimmer/relay rack location as indicated. Provide all nomenclature indicated plus additional as applicable. Mount signage on an adjacent wall near the dimmer/relay rack as space allows.
7. 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:
    a. ETC Paradigm Lightdesigner config file
    b. ETC concert config file
    c. ETC console template/show file
    d. All console template files
    e. Network system config files
8. 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.
9. 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.

10. 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.
11. Training & Instruction:
    a. 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.
    b. 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.
    c. 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.
12. LIGHTING SYSTEM NETWORK:
    a. Design and provide all LCD touchscreen layouts as indicated in the written specifications.

b. 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.

c. 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).

d. Instruct the owner on how to make basic system and preset setup changes with a standard web browser (via Lightdesigner access).

e. 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).

13. 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.

14. Perform all DMX and network programming, dimmer assignments, device addressing and related software/firmware setup, LED setup, modes and addressing, etc. All LED fixtures, network gateways, houselighting 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.

15. 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.
16. 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.
17. 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.

B. RIGGING SYSTEMS:
1. All batten ends must line up with each other (for all battens of similar length).
2. All battens of similar trim (both high and low trims) must be even with each other +/- ½".
3. The rigging system must operate without binding of lift or operating lines, scraping of lines against any structural or other members, etc.
4. All system travel shown on the contract documents is approximate and may need to change depending upon actual building conditions, final steel heights, etc. The intent is for the in and out trim heights and the total system travel to be as close as is physically possible to those shown on the drawings.

5. All stage battens shall be trimmed in such a way so that, regardless of system travel, low trim and high trim heights shown on contract drawings, no battens or related attachment hardware shall be allowed to engage the loftblocks, idlers or loftblock sheaves in any way. Upon finished installation, the stage side Nicopress fittings at the end of each liftline should stop shy of the loftblock sheaves by 2-3" (or greater depending upon total allowable system travel). The intent is to realize all of the system travel as is physically possible while still allowing the arbors to rest on the locking rail lower arbor stop when fully in and to engage the upper arbor stop when fully out.
6. All sets shall be installed so that no clew, batten, pipe clamp, shackle, nicopress fitting, cable cradle, trim chain, turnbuckle or misc. hardware can engage a loftblock, idler assembly, headblock or sheave in any way. Positive stops are to be present in the form of a 2" x 2" hardwood stop block for all J-Guide systems and on wire guide locking rails and in the form of a sandwiched fiberguide material (or equal) assembly on each of the guidelines of a wire-guide system or a U-bracket with bumper attached to each headblock. Maintain manufacturer recommended clearances between the top of all arbors and the base angles or sheaves of each headblock.
7. The loft blocks and headblocks shall be free of binding, scraping, etc.
8. All curtains shall be protected by plastic bagging (prior to the beginning of renovations work) and unbagged only after all dirt and dust creating work and paintwork has been completed and cleaned up.
9. 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.
10. No battens shall be allowed to have threaded ends or threaded couplings at all.
11. No battens shall be allowed to have plug welded splices at all.
12. No battens shall be allowed to have compression style splices at all.
13. 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).
14. All clews, clew winches, etc. must travel without hitting adjacent sets.
15. All wire guide system guidelines (2 per clew winch-or per manufacturer's requirements) shall be installed vertically, plumb and with equal tension on all lines. Guideline system tension shall be as recommended by the manufacturer and shall restrict the clew side-to-side "swing" movement so that they cannot swing into adjacent sets.

16. All safety devices shall be demonstrated individually to verify performance.
17. All hand crank/drill drive winch assemblies shall operate as the manufacturer intended and shall not engage other sets during their normal range of operations. Related SO cables or pantograph mechanisms shall not become entangled in any other set(s) or other items during use.
18. 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.
19. All loftblocks shall be clipped onto beams with one side of plate throat into beam flange and the other side captured by an angle iron & threaded rod assembly toe clip system. The contractor shall not overtighten toe clips to the point of deforming them, angling them or bending the threaded rod. Nut should be brought up tight to angle iron but should not be overtorqued to the point where vertical angle iron leg goes out of plumb. Verify exact installation techniques & torque ratings, etc. With the manufacturer and install in such a way as to not cause a derating of the blocks ultimate load carrying capacity or holding power. Install all similar. Toe clips should be tightened so that they closely matche the visual depiction shown here.
20. All connector strips suspended from wire rope pickups such as on a stage rigging system or at a front of house position (and unless specifically shown graphically on the contract drawings with any other configuration), regardless of whether they have been furnished by others, others have furnished misc. connector strip brackets or if they and their related hardware have been listed as existing to remain, must be suspended from inline “centering” strap steel connector strips brackets. U bolt style brackets or any other bracket style that skews the hang shall not be allowed. The rigging system provider/installer shall provide all inline “centering” strap steel connector strips brackets that either do not exist or that are not furnished by others and in sufficient quantities to properly suspend all connector strips.
21. 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).
22. Final curtain presentation requirements:
    a. All curtains must be hung properly and per industry standards and shall not feature excessively long jack chains, tie offs, etc.
    b. 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.

c. 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.

d. 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.

e. 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".

f. All curtains shall be trimmed so that the bottom of each clears the floor by ½" - ¾". 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. GENERAL OVERVIEW OF FOCUS GOALS:

1. The contractor is responsible to implement the owner's intended focus plot for each space included in the contract documents. Each category below relates to each included space individually and separately. Any lighting focus must have the owner's input, in writing, as to the intents of each luminaire's intended physical installation location, DMX address, target, control intents and all related fixture settings. Each space has been

populated with an assortment of fixtures and placed in a generic layout on the contract drawings. It is up to the contractor and owner to fully lay out and detail which fixtures get dedicated to which use.

2. The focus intents should be governed by several pertinent topics and should be posed/requested by the contractor as a series of questions to the owner. These questions should include things such as the following (as presented to the owner and as is pertinent to each related space): Where do your choral groups perform? How tall are your participants? Where do your bands, ensembles, orchestras perform? What are the extents of these instrumental setups? Where is your conductor located? Where do you typically place a podium? Is this space used for school board or other similar types of tabled events? Where would those tables, chairs, etc. typically be set up? Is this space used for general assemblies, study halls, as an overflow space or for other non-specific uses? What are the parameters surrounding lighting usage for each type of event? How much of the stage do you need to light for each category of event listed above? How much of the pit or seating areas do you need to light for each category of event listed above?

3. Typical Fixture Usage:

    a. Strip Style Fixtures: these are fixtures that generate a wide, even swath of light and are used to uniformly wash large areas of the stage for events such as rehearsals, band/choral concerts and for special mood effects.

    b. Par Style Fixtures: these are fixtures that generate wide, soft pools of light that can be aimed at the stage or pit areas from either overhead rigging or front of house positions. These pools of light can be shaped by filters added into the gel frame/holder (wide, narrow, oblong, round, etc.). These fixtures are intended to wash a smaller area with an even distribution of light.

    c. Fresnel Style Fixtures: these are fixtures that generate wide, very soft edged pools of light that can be aimed at the stage or pit area from either overhead rigging or front of house positions. Fresnel fixtures have an adjustable zoom range. These fixtures can also utilize barn doors in order to shape/contain the light beam and are intended to wash various sized areas with an even distribution of light.

    d. Ellipsoidal Style Fixtures: these are spotlight fixtures that generate sharp-edged, round pools of light that vary in width depending on the barrel used and that can be aimed at the stage or pit area from

either overhead rigging or front of house positions. These fixtures can utilize a variety of gel frame/holder accessories as well as drop in gobos and are intended to highlight scenic elements, actors, etc.

e. Cyclorama Style Fixtures: these are fixtures that generate an asymmetrical wash of light with no beam width adjustments. They typically incorporate an integral bounce mirror and spill-control flap, are deployed on a regular spacing criterion and are used to light large vertical surfaces with an even wash of light. They can be either flown or ground stacked.

f. Panel Style Fixtures: these fixtures are typically used in a studio setting as wash fixtures and have similar goals/usages to those listed under either the par or fresnel headings.

g. Moving Head Fixtures: these fixtures can variously be categorized as beam, wash, spot, profile and hybrid fixtures, depending on the basic functions. these fixtures can be used in a variety of ways from generating soft/sharp-edged, round pools of light that vary in width depending on the zoom, shutter and/or iris settings used and that can be aimed at the stage or pit area from either overhead rigging or front of house positions as well as featuring complete remote access to all fixture functions. These fixtures typically have internal frosts, patterns and gobos (some stock and some interchangeable) and are intended to do a variety of lighting effects from highlight scenic elements, actors, etc. to providing breakup and/or gobo pattern throws onto specific scenic elements or even used as spotlights. Moving head fixtures can also create shafts of light, zooming effects, dousing effects, spinning effect and even ballyhoos.

h. Specialty Style Fixtures: these are uncommon fixture types (halo, circular/ring, pen/point, balloon, etc.) that have specific usages that are spelled out by their descriptions and will typically be deployed by the owner as needed for specific event types.

4. Typical Fixture Deployment:

a. Meeting Use: in this application, the fixtures would typically be deployed in order to highlight a podium, a desk or an arrangement of tables set up for various speakers/participants, etc. Typically, the featured object(s) of this light would be lit from at least a couple of angles (front, top, back, sides) in order to give dimensionality to the object and to properly display facial features. This would typically

be accomplished with the use of ellipsoidal style fixtures (or a combination of ellipsoidal and tight wash fixtures), saved as a preset focus and those fixtures left in place for that dedicated use.

b. Choral Use: in this application, the fixtures would typically be deployed in order to evenly light an entire grouping of participants located in a pre-arranged area and typically on some staging/risers. Typically, the feature objects of this light would be lit from the front/sides in a wash of white light. This would typically be accomplished with the use of par or fresnel style fixtures (or possibly wide-patterned ellipsoidal fixtures), saved as a preset focus and those fixtures left in place for that dedicated use.

c. Theatrical Use: in this application, the fixtures are typically deployed for the specific performance piece, scenes, actors, locations, moods, etc. and is almost always arranged by the owner, as needed, for each use. This would typically be accomplished with the use of the owner's entire arsenal of available fixtures, beam patterns and styles. The owner, however, has the option to utilize all indicated focus time for this type of specific deployment, if desired.

d. Zone Focus Use: in this application where the owner has no specific focus goals, the fixtures would typically be deployed in order to provide a zonal wash over the stage and pit areas. Typically, since there are no specific intended objects for the lights, the stage and pit areas are broken up into a series of adjacent 10' x 10' (or other regularly sized) squares of light, each with front, top and back lighting. This would typically be accomplished with the use of strip, par, fresnel and/or ellipsoidal style fixtures, saved as a series of preset area focuses and those fixtures left in place for those zonal uses.

B. FIXTURE FOCUS & GEL:

1. The lighting plot shown on the drawings is generic/diagrammatic and is not necessarily the plot the contractor will hang. Its inclusion on the contract documents is intended to inform the contractor that he has the responsibility to not only provide the fixtures but to also hang, interconnect, address, program, assign/group and focus each fixture and incorporate it into the overall lighting system (both the lighting control console and the architectural control system) per the owner's instructions. Verify with the owner prior to fixture hang the plot they want hung (multi-purpose, specific, zonal, etc.). Failure to do so will result in the contractor having to provide a second, owner-directed focus at no additional cost.

2. Fixtures included on the contract documents shall be unboxed, fully assembled, set up, tested, burned in, all included accessories installed (barn doors, shaping filters, gobos, etc.) and verified fully functional prior to the commencement of any hang/focus. This shall be performed by the contractor.

3. Theatrical Focus: The contractor shall be responsible to hang and focus all fixtures indicated on the bid documents. Theatrical 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 intended to be reinstalled, the contractor shall be responsible to rehang and focus all previously removed fixtures as directed by the owner (this may be in a similar fashion as they were prior to the start of this project or in a new configuration). The contractor must record all details of the previous fixture hang/focus prior to any removals in order to recreate it if needed, including physical fixture locations, interconnections, addressing, etc.).

C. Focus Hours Required (per space).
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/Drill Drive Op 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.

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. The architectural control system shall be programmed so that, whenever any preset or LCD station pushbutton is pressed, all relay modules powering any LED fixtures in the room are immediately powered on. These relay modules shall remain on and shall be turned off by astrological clock for overnight hours as indicated.

g. The dimming system shall be programmed so that, when the lighting control console is powered on, all relay modules are immediately energized (turned on).

h. 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.
6) Interactive Technologies (8 Button Stations): These stations are typically programmed to recall the first seven system presets from the architectural controller and off. Contractor shall program each station to control presets as directed by the owner.

i. 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.
3) LCD Touchscreen: The LCD devices shall be programmed with preset and/or fader pages for the owner's use as described below and on drawings. LCD screens shall "mirror" each other as to the current "state of affairs" so that both screens look identical and that user selected moves are shown on both screens (just as if the user were controlling both) and so that there is a visual confirmation on both screens of the last user selected move, selection or parameter change.
a) Contractor shall provide the owner with a saved version of the final system configuration as a backup copy in case of system failure and/or system reset needs may arise. Provide two copies

(one copy on each of two USB thumb drives. One copy to be placed in a Ziploc bag at or near the architectural control processor or lighting system control area and one copy to be located as per the owner's instructions – preferably in a separate, secure and remote part of the facility).

b) Contractor shall provide the owner with a complete hard-copy listing of all lockout values, unlock codes, visibility values & preset priority values used within the system configuration and with training on how to alter or change those codes. Contractor should also enter all passwords and lockout codes into the "Job Information" section of the Unison configuration file so that they will be saved along with the as-built system configuration.

c) Any disabling of the pushbutton stations by a password entry shall be reset at midnight of each day via the astrological clock function so that preset stations operate normally and are not locked out continually.

E. LIGHTING TOUCHPANEL SETUP:

1. Intent: Touchpanel screen layouts shall be similar to what is shown. Not all control screens have been shown, but a representative sample has been provided so that the contractor gets a real sense of the intent of the look and layout and feel of each touchpanel. Buttons shall be gel style as noted. Touchpanel background shall be a slate/silver grey color with a brushed aluminum look. Buttons shall be a royal blue color. All gel button text shall be black, unless otherwise noted. Dialing and QWERTY keypads, drop down dialog boxes, etc. shall be black background with white text and shall float over other control screens (feather backpanel edges as needed). All buttons shall be high-resolution, crisp edged buttons that do not appear with jagged edges, pixelization, etc. The control screen layout file shall be sized so that it fits onto the allotted memory inside the specified touchpanel. There may be additional screens and controls that the contractor will need to program into the touchpanel system that do not appear in the following descriptions or on the detailed screen layout drawings. The contractor shall provide all screens & programming necessary for a complete system and may need to field tweak or add/delete functionality to the touchscreen system based upon immediate user and consultant feedback. Color selections for screen background, font colors, etc. shown on the contract documents shall be followed unless the owner has a specific preference as to the color scheme, layout, etc.

2. The contractor shall be required to coordinate with other contractors providing touchscreens for this project so that the theme and layout of all touchscreens within this space match.

3. The info button on each screen, if touched, shall bring up a floating, pop-up window on top of and centered on the current screen that gives a brief, but detailed, explanation of the intents of the screen and the parameters the user must select.

4. Each touchpanel screen shall incorporate a standard "Home Screen" that uses the owner's logo as the background behind all button/preset display overlays. Actual logo to be used is TBD by the owner. Contractor is to obtain appropriate file from owner. Size logo on screen as directed by owner.

5. Each touchpanel screen shall incorporate a "Home" button or object on every screen (or physical button on unit – if screen is so equipped) that will take the user to the home screen (Main Menu) whenever this button is activated.

6. Each touchpanel screen shall incorporate a "Back" button or object on every screen, except the Home screen, (or physical button on unit – if screen is so equipped) that will take the user back to the previous page/screen whenever this button is activated.

7. All touchpanel buttons shall be programmed so that, when a button or preset is selected, the active icon highlights or changes color and becomes visually distinguished from all other buttons/presets on the page in order to easily identify and indicate which button or preset has been activated and is currently active.

8. Contractor is to submit all screen layouts (jpeg screen shots are acceptable) to the consultant for final approval prior to loading all software.

9. Contractor is responsible for all touchpanel and control system programming and final touchpanel screen looks, layouts and icons and for interfacing each piece of controlled equipment with the lighting control system and other related systems (such as Crestron interfaces, iPad, iPod, iPhone apps, etc.).

10. The contractor shall provide a minimum of two levels of password/passcode access to the touchscreens and their functionality. There shall be a user level password access, which limits those users to only certain functions. There shall be an administrator level password access,

which provides those users with unlimited access to all system functions present and programmed.

11. The contractor shall provide all touchscreens to mirror each other and so that system selections, etc. performed on one screen automatically show up on all other architectural control screens.

12. The contractor shall provide, as part of his bid price, all touchscreen layout buttons, menus, background, layout, programming, etc.

13. All access to the LCD programming functions, preset changes, clock functions, recording capabilities, etc. shall be password protected.

14. Program the architectural control system LCD displays with a submasters page, rehearsal light preset, choral group preset, several houselighting presets, stage worklight preset, stage wash preset, colored stage wash preset(s) and other presets as determined by the owner or owner's representative and as required in the written specifications. LCD displays shall be programmed so that users without a passcode are unable to access any incandescent houselighting fixtures except turning any included day-to-day fluorescent/LED houselight, catwalk worklight and/or stage & wing worklight fixtures on or off.

15. Create & setup at least 20 preset buttons on pages (10 per page and in addition to other presets as called for in the specifications) and there must be a record button on each page. The intent of this is so that the owner can easily, with password access, save/record "looks" to presets quickly & easily into the architectural control system.

16. A secondary level of password protection shall be setup so that all other LCD and pushbutton stations can be locked out from functioning or altering the lights during an event. The intent of this feature is so that accidental activation of unwanted lighting fixtures during a performance is avoided. Program the astrological clock to reset all LCD and pushbutton station functionality (and deactivate lockout) at midnight of every day - 365 days per year.

17. LCD touchscreens shall be located within the system topology in such a way as to allow snapshotting functions from the lighting control console into the architectural control system LCD and pushbutton units. All LCD touchscreens shall be mirror images of each other (both containing the same screens, information, etc.).

18. LCD touchscreens shall recall all presets and shall incorporate fader and button pages, etc. See above and specifications for more information on LCD programming requirements.

19. Program the LCD screens with basic "color chooser" pages for the LED fixtures (arranged by zone) so that the owner may quickly and easily pick one of 20 colors for any bank of LED's. Color chooser pages shall visually show thumbnails of colors (similar to the output color of the LED fixtures) and allow the user to touch a colored button in order to switch all of the LED's in that bank to that color.

20. LCD screens shall have no limitations as to which fixtures or DMX universes they can access and/or control. I.E. they must be able to recall whatever preset looks the owner wishes them to recall.

F. Sample Screen Shots: (See contract drawings for actual screen shot examples of the intents of the LCD screens that must be included and the general layout of each screen).

G. 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) –

a. Dimmer rack and dimmed modules (incandescent fixture control)

1) Beginning with DMX address #1 and continuing in ascending order without gaps in assignments until all dimmer rack/dimmed modules have been addressed.

b. Relay rack and non-dimmed and/or constant/relay modules (LED & moving head fixture control)

1) 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.

c. Addressing for theatrical fixture lighting devices

1) 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.
2) 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.) *.
3) 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.
    d. *As an alternative, the owner might select to have the side house lighting (galleries, torms, etc.) occur before the stage assignments.
    e. House and work lighting fixtures (incandescent, LED or 0-10V fixture control)
1) All houselighting fixtures (at the top of the address order beyond all other utilized DMX addresses – and within the control system's capabilities).
2) 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				
Description	*Fixture/Dimmer #*	*DMX Channel Assignments*		
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.

H. RIGGING SYSTEMS:

1. Verify that all sets have been balanced properly (if sets must be left slightly out of balance, then it is required that they be slightly arbor heavy).

2. Verify that any motorized units have been installed as per the manufacturer's instructions, that all controls work properly, that minimum clearances have been maintained, that motorized units load sensing and trigger points have been set, that no motorized units either visually or aurally display any anomalies during normal extents of travel, that all maximum travel extents have been set, that arbor stop devices are in place and all bolts tightened, that all exposed sharp locking rail edges that are located so that they may be inadvertently engaged are padded and taped with safety yellow gaff tape and that all curtain tracks and operating lines work and are not tangled, twisted or binding in any way.
3. Verify that the motorized operator control panels are oriented in a way on stage that makes sense to their physical locations (i.e. if the control panel is located on the stage left wall then the first stage electric control buttons would be on the right side of the unit and the others would be numbered in an ascending order to match the physical layout of the unit's physical placements on stage towards the upstage wall).
4. Verify that any pantograph tracks, cable reels, etc. have been set up and calibrated to function without binding, loud noises, etc.
5. Verify all systems inputs, outputs, control stations, set operation, motorized units, curtains and other related equipment functions as intended.

3.12 OWNER INSTRUCTION:

A. LIGHTING SYSTEM:

1. The contractor shall provide a training program for the owner 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 theatrical lighting systems and related equipment. This training time shall not exceed (36) hours. No training block shall be less than four hours in duration. This time is in addition to training times noted below.
2. The contractor shall provide additional programming time for the owner of (12) hours in adjusting basic settings to system presets, misc. reprogramming, etc.
3. The contractor shall provide additional network gateway system software training for the owner of (4) hours in operating, configuring and programming (latest non-beta version) software and in operating, configuring, resetting, managing and changing all network and gateway parameters/assignments.

B. RIGGING SYSTEM:

1. The contractor shall provide a training program for the owner 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. This training time shall not exceed (8) hours. No training block shall be less than four hours in duration. This time is in addition to training times noted below.

C. All owner instruction and programming services shall be provided by the contractor as part of this contract & shall be scheduled and performed within twelve months of the final system turnover date to the owner. Any unused training hours that do not get utilized during that twelve month period shall be considered forfeit.
   1. The turnover date is defined as the date of completion of all open punch list items and final acceptance by the owner.
   2. Attendees/trainees shall be as designated by the owner and may consist of multiple groups requiring separate training sessions on the same topics (all sessions must fit into the training times as allotted above).

D. All owner instruction training hours are exclusive of travel time. Training time hours will begin to elapse at the prearranged hour agreed upon by both the owner and the contractor.

E. Training time may be utilized in any number of ways that may not relate directly to the hands-on training. These required hours can be utilized in order for the contractor to perform additional system programming, set manipulation, customizing layouts, control screen optimizations/changes or any other related work requested and approved by the owner – up to the "not to exceed" hour totals listed in these specifications. Additional training or programming work beyond that indicated in these specifications shall be at additional cost to the owner.

F. Each training session shall be no more than four hours in duration, unless specifically requested by and/or approved by the owner in advance of each session.

G. It is understood that, if there are multiple spaces/locations (e.g., high school auditorium, middle school gym, elementary school cafetorium, etc.), the training sessions noted shall be required independently at each facility.

3.13 TRAINING:

A. Training must provide useful information that covers all major topics of how a system would typically be used by an end user/owner. This also applies to documentation and video training.

B. Provide training only at the request of the owner's authorized representative(s). Make clear (in writing) to the owner's authorized representative(s) that any training

hours not formally requested, scheduled and performed within twelve months of the final system turnover date to the owner shall be forfeited.

C. Track all training hours in writing and provide copies of attendance sheet sign-offs to the owner of who attended, how long each session lasted and what topics were covered.

D. On a job-by-job basis the training sessions may vary significantly. The training hours allotted may be used by the owner as required for any purpose related to the system and in any number of ways that may not relate directly to the hands-on training. These required hours can be utilized in order for the contractor to perform additional system programming, set manipulation, customizing layouts, control screen optimizations/changes or any other related work requested by the owner – up to the "not to exceed" hour totals listed in these specifications.

E. Additional training or programming work beyond that indicated in these specifications or after the initial twelve-month period shall be at additional cost to the owner.

F. Turn over copies of all video recorded training to the owner as described below.

3.14 QUALIFICATIONS OF TRAINERS:

A. All persons performing system training must be experienced operators of the specific equipment they are training others to use. If no one on the contractor's staff has experience on a specific device or piece of equipment, then the contractor must provide qualified third-party personnel in order to perform those training sessions.

3.15 SCHEDULING FOR TRAINING:

A. All training sessions must be scheduled with the owner and by the contractor with at least three weeks advanced 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 hours, it will still expend four hours of allotted training time due the owner.

D. Training session must be scheduled and performed at a time when the space is available and otherwise unoccupied.

E. Coordinate all training sessions with the owner, all uses of the room, any related contractors, attendees, etc. Training sessions, especially those being videotaped,

shall not be allowed while other uses of the room are in session, especially those involving the use of construction equipment, drills, saws, rehearsals, etc.

3.16 EXAMPLE TRAINING SCHEDULE:

LIGHTING SYSTEM:

Typical Training Hour Breakdown		Typical Content
	Hours	
System overview and basic Training	4	Full Walk around, system layout, power sources etc. And an overview of operation. Set up and loading, saving, etc. show files, cue stacks, etc. How to approach a new show.
iPad remote access set up, operation, integration, etc.	4	This session can be the same day as system overview if schedule allows. Understanding the file and Library system, how to update libraries, saving show template files, use of remote devices during show focus, etc.
DMX/RDM Overview	4	Training users on the overall concept of DMX addressing, DMX topology, RDM implementation & assignments, moving fixtures and relocating addresses, etc.
Special Effects	4	Using fixture and/or console special effects, color pickers, cue timing, etc.
Assistance with setting up first Event	4	Show files, presets, global techniques, etc.
On site for first show as tech support	4	
On site for Second show as tech support	4	
Follow Up/Higher Level Training	4	
	32	Total Allotted hours vary on each project, this is just an example.

RIGGING SYSTEM:

Typical Training Hour Breakdown		Typical Content
	Hours	

System overview and basic Training	4	Full Walk around, system layout, any related power sources etc. and an overview of general system operation, terminology, usage, etc.
Emergency Procedures	4	This session can be the same day as system overview if schedule allows. Understanding what to do in a runaway set situation, methods to employ to avoid accidents, standard safety procedures & protocols, etc.
Setting up a stage	4	Training users on the overall concept stage layout, stage setup, set pieces and related elements, attaching scenery, tripping up softgoods, etc.
Motorized Rigging	4	Power sources, all related cablilng, motor starter cabinets and their use, operator control interfaces and their use, pendant remote usage, stage safety procedures with hoists, batten learning, load limits, reset procedures, etc.
Assistance with setting up first Event	4	Show files, presets, global techniques, etc.
On site for first show as tech support	4	
On site for Second show as tech support	4	
Follow Up/Higher Level Training	4	
	32	Total Allotted hours vary on each project, this is just an example.

3.17 INITIAL TRAINING:

A. Walk through the facility and familiarize the owner with where all primary system equipment is and what it does. See below for additional instructions and requirements for training sessions, video recording/documentation, etc.

B. Training on Lighting Control Console Operations (list is not exhaustive):

1. Power up/power down sequences.
2. Touchscreen setup and use.
3. Magic sheet creation and use.
4. Template and show file use.
5. Setting up and using submasters.

6. Setting up cues, scenes, presets, base show files, saving files, importance of backups, working from templates and other primary and commonly used functions.
7. RDM access fixtures & programming.
8. Patching the dimmer/relay racks to the console.
9. Restore techniques for console (back to factory defaults).

C. Training on Lighting Fixtures (list is not exhaustive):

1. RDM access fixtures, on-fixture controls & programming.
2. Fixture cleaning and maintenance.
3. Specialty fixture specifics – moving heads, remote zoom, motor noises, fan speeds, move-in-black requirements, etc.
4. DMX addressing conventions, how to implement changes when physically moving/relocating fixtures, etc.
5. Boot up sequence timing, etc.

D. Training on Lighting System Architectural Controls (list is not exhaustive):

1. Touch screen controls & programming.
2. Pushbutton/fader controls & programming.
3. General station cleaning and maintenance procedures.
4. Lockout functions and release.
5. Use of astrological clock, timed events & sequences, etc.

E. Training on Drill Drive Operations (list is not exhaustive):

1. Overall safety instructions.
2. Set loading & unloading procedures for all scenery, curtains and electrics.
3. Operating limits of rope locks.
4. How to check the balance condition of a set prior to movement.
5. Operational norms – verbal commands on stage.
6. How to deal with large load changes such as curtain removals.
7. Runaway set procedures.
8. Storage of drill and accessories.

F. Training on Dead Hung Operations (list is not exhaustive):

1. Overall safety instructions.
2. Set loading & unloading procedures for all curtains and tracks.
3. Operational norms – verbal commands on stage.
4. Storage of stage curtains.
5. Operation of ropes, pulleys, etc.
6. Usage of flat fabric strap tiebacks, etc.
7. Rigging inspections requirements.

3.18 VIDEO RECORDING OF TRAINING WITH OWNER – INITIAL TRAINING:

A. Record all aspects of the initial owner training with the group of trainees present. A live training session by default may be interrupted with questions or unrelated discussions, which is acceptable. The camera should record through the entire session, unedited.

B. LIGHTING: Provide simple explanations of what each piece of lighting equipment does/what it is intended for, how to properly interface with that equipment (controls, consoles, stations, gateways, etc.), present an overview of general programming parameters as well as what an end user should do if a piece of lighting equipment fails, if the motorized fixtures (if present) were to be shut down or become non-functional, etc.

C. RIGGING: Provide simple explanations of what each piece of rigging equipment does/what it is intended for, how to properly interface with that equipment (controls, levers, ropes, counterweights, etc.), present an overview of general stage etiquette as well as what an end user should do if a piece of rigging equipment fails, if the motorized portions (if present) were to be shut down or become non-functional, etc.

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 should be performed in the contractor's shop, at the owner's site without trainees present or at another location as appropriate. The intent of this training is to give specific, guided instruction on each piece of equipment. Where manufacturer's professionally produced video trainings are available (vie YouTube or manufacturer's website), these will suffice. The contractor should then supplement these with all other video training requirements presented in these specifications. The preference is for the contractor to offload manufacturer training videos onto a thumb drive to present to the owner; however, active links to these videos embedded in the final O&M documentation is an acceptable alternative.

B. LIGHTING – The secondary video training must provide:

1. A video tour (walk-through) of the lighting system equipment present at the owner's site that clearly shows where all primary lighting system equipment is located, gives a brief overview description of what that equipment's primary functions are and what any related devices, screens or indicator lights look like when everything is working properly. This video should not exceed 30 minutes in length.
2. A video tour (walk-through) of the lighting system related power panels, breakers and disconnects feeding the system equipment (dimmer/relay rack, ELTS2, EM devices, etc.), which breaker operates each power feed and what the normal state looks like. Room names, numbers and locations that

conform to site nomenclature should be used throughout. This video should not exceed 10 minutes in length.

3. For all lighting system elements note all control boxes, their use and how to check for trouble status in controls, how to initiate and complete any required reset procedures, etc. This video should not exceed 10 minutes in length.
4. A separate video should include a discussion of emergency procedures, manufacturer 24-hour service hotline phone number, system reset procedures, meanings & intents of safety signage, safe "work-at-height" procedures, overall safety precautions and behaviors, etc. This video should not exceed 15 minutes in length.
5. A separate video should include a series of quick start videos for someone who must use the lighting system equipment who has no idea how to operate any portion of it (A Beginner's Guide). Each related video clip should not exceed 5 minutes in length.
    a. Example:
        1) How to boot up the console.
        2) How to access a show file.
        3) How to run a cue.
        4) How to navigate screen pages, how to find magic sheets and how to operate them.
        5) How to navigate screen pages on individual fixtures (rear fixture control screen), determining and/or changing fixture DMX address, etc.
        6) Basics on lighting priority – why lights might still be on from the architectural control system and how to manage these conflicts, etc.
        7) How to shut down the console and the lighting system.
    b. Additional information examples for anyone who needs to do the following:
        1) RDM protocol and implementation, how to alter fixture DMX parameters via RDM, etc.
        2) Patch lights and dimmers, including RDM functions. This should include what to do when a fixture won't RDM properly.
        3) How to create a lighting cue and edit timing, etc.
        4) How to load faders and sub masters.
        5) How to save a show to USB.
        6) How to load a show from USB.
        7) Patching and grouping – how and why to use groups.
        8) Color and focus functions – how and why to use.
        9) Differences in color gamut between manufacturers of LED's.

C. RIGGING – The secondary video training must provide:

1. A video tour (walk-through) of the rigging system equipment present at the owner's site that clearly shows where all primary rigging system equipment is located, gives a brief overview description of what that equipment's primary functions are and what any related devices, screens or indicator lights look like when everything is working properly. This video should not exceed 30 minutes in length.
2. A video tour (walk-through) of the rigging system related power panels, breakers and disconnects feeding the system equipment (motorized hoists, index lighting, lifts, roll drops, curtain draw machines, etc.), which breaker operates each power feed and what the normal state looks like. Room names, numbers and locations that conform to site nomenclature should be used throughout. This video should not exceed 10 minutes in length.
3. For all motorized elements note the control boxes, their use and how to check for trouble status in controls, how to initiate and complete any required reset procedures, etc. This video should not exceed 10 minutes in length.
4. A separate video should include a brief discussion of the ANSI/ESTA standards for rigging systems inspections, frequency of inspections, why periodic inspections should be considered mandatory life-safety events, what procedures to follow should any rigging equipment malfunction and the necessity contacting the system installer if anything should fail or go wrong with the rigging system or any related devices. This video should not exceed 15 minutes in length.
5. A separate video should include a discussion of emergency procedures, run-away set procedures, system reset procedures, meanings & intents of safety signage, safe "work-at-height" procedures, overall safety precautions and behaviors, etc. This video should not exceed 15 minutes in length.
6. A separate video should include a series of quick start videos for someone who must use the rigging system equipment who has no idea how to operate any portion of it (A Beginner's Guide). Each related video clip should not exceed 5 minutes in length.
    a. Example:
        1) How to properly operate a set.
        2) How to calculate loading on each arbor/batten set, how to determine how many counterweights to add to the arbor and the safest procedure for doing this.
        3) How to navigate and safely operate stage rigging sets during a show and in a near blackout conditions.
        4) Standard verbal stage call-out terminology to employ during set movements.
        5) Necessity of spotters during all set movements.
        6) How to properly store curtains for short/long term storage.

7) How to strike a stage after the final performance.
8) Basics on system maintenance.

D. Video recording general requirements (applies to all training & for record videos):

1. Static shots: The video recording device (camera, tablet and/or phone) must be placed on a tripod or other fixed stand, situated on a stable base and remain in a location that offers a good view of the rigging system, locking rail, arbors and any related equipment or controls being discussed. Handheld video recording of static scenes shall be avoided.
2. Roaming shots: The video recording device must employ motion stabilization (smart device app, post-production stabilization software or physical gimbal, etc.). Shaky, blurry videos shall not be acceptable.
3. Lighting: The lighting must be consistent (training space must be well lit without interruption-supplementary video lighting may be required). Lighting must be adequate for the video recording device and so that final video presentation appears professionally lit and dim/dark views of equipment are avoided. Provide portable lighting as needed to accomplish this.
4. Audio: The audio must be clear throughout (supplementary/advanced micing techniques may need to be utilized), there must be no other noises on the video that mask the verbal communications (HVAC noises, whines, hums, equipment crashing, the use of any construction equipment or power tools, off camera voices, etc. Audio must be recorded so that the trainer's words are clear, are not muffled, so that vocals do not trail off and so all spoken portions of the training videos are easily understandable.
5. Shot Composition: The video recording device must be pointed at the elements/objects being discussed (showing devices, screen shots, etc.). Utilize good framing techniques, close-ups as required and overall generalized shots where appropriate.
6. Topics & Viewability: The topics explored and trained on in the video trainings must be clear, consistent and of value. Text on screens must be readable, so close-up shots will be required when discussing certain elements (especially when discussing user interface screens, touch controls, etc.).
7. Typically, the video recording should be performed by a person other than the one doing the actual training. In this way, the operator can zoom to specific areas being discussed, etc. while the trainer continues presenting.
8. Editing/Final Presentation: All video recordings must be professional throughout from trainer presentation to video editing and final packaging. Video footage must be obtained and then "cut" together into a well-structured, chaptered format from which an owner can access whichever topic of interest or concern they may have without having to view or fast-forward through other discussions. Video edits should not end or cut off

mid-sentence. Edit and title the final video training sessions into logical chapter format. The basis for titles, sections, chapters, etc. shall be the general content of the included equipment.

9. The intent of training videos is for an end user to be able to watch these and to follow along with button pushes, menu choices, etc.; therefore, the videos cannot be shot in a manner where the trainer's body blocks major parts of the screen or where the trainer's back is turned towards the camera and hearing/understanding the trainer is difficult and distant or where screens/buttons cannot be read. In order to allow an end user a clear understanding of system training, additional video may need to be shot by the contractor and edited into the final product with picture-in-picture style or split screen style editing where close up shots are easily readable.
10. The trainer/presenter for each session (especially for the secondary training section videos) must be articulate, speak clearly, properly enunciate his words and professionally present the information in a clear, concise and easily understood manner.
11. Convert each recording to standard formats for playback on Mac/PC based platforms and write to the devices as described below.
12. Provide all training videos on USB stick formats.
13. On the USB stick, include a PDF document that contains all relevant links to the manufacturer's video training series for basic, intermediate and advanced topics/functions. Where manufacturer videos are available, provide these and/or the active links to these videos on the manufacturer's website and/or other relevant sites (YouTube) for the owner's future use and reference.
14. In subsequent advanced 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.
15. Pre-recorded videos for some training sessions that are "canned" but appropriate for the equipment located in this facility are completely acceptable and need not be custom done for/at each and every facility; however, they must be custom compiled into a framework that fits all equipment in the owner's facility and must also include the initial training session(s) video footage.

E. 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 book shall remain with the owner as a reference manual.

F. Provide (1) one copy (brand new and not previously used) of the Stage Rigging Handbook (4th or latest edition) by Jay O. Glerum & Shane Kelly. 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 FOLLOW-UP TRAINING SESSIONS:

A. Follow-up sessions should be recorded on video for record only, except as noted elsewhere, and copies provided for the owner's records. These sessions are not to be confused with either initial or secondary system training intents.

B. Follow-up sessions may include a re-presentation of any previous session's subject matter for a different group of end users or as a refresher to previously trained individuals.

C. Often these sessions will be used for in-rehearsal or show sessions where the contractor is an advisor to the end users/operators during actual show setup and/or system use for the first performance with the new equipment. These sessions do not need to be videoed and/or recorded.

3.21 SIGNAGE:

A. A sign shall be posted in an accessible location (typically on the rack(s) or in the control booth) providing the name, address and phone number of the primary system contractor, manufacturer and supplier (if not already listed) of the system equipment.

3.22 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. Provide (during the warranty period) one (1) rigging system service inspection for preventive maintenance, at a date six (6) months after final acceptance. This will include but not be limited to a full system operational and safety check and tightening of arbor operating lines as required.

H. 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.

I. 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.

4. Drill Drive Rigging Equipment:

a. One year after the completion of installation, the contractor shall return to the site and provide the following services:

1) Complete inspection of the clew winch system.

2) Make all required adjustments.

3) Correct all warranty items.

4) 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.

5) Provide written recommendations for necessary repairs or changes not included in the warranty.

3.23 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. 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 of the performance criteria set forth within this specification.

b. 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. 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. 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. Documentation for all wiring must be completed in at least a neat draft form and on site. This must include as built nomenclature and wiring schedules.

6. 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.
   d. Demonstrate the operation of the drill drive and dead hung rigging system.
   e. Demonstrate operation of all curtains and tracks.
   f. Provide proof of flame certifications.

7. Any time required resolving any of the above conditions will be billed by the consultant at the rate of $100.00 per hour to be deducted from the contractor's remaining balances with the owner. Any time waiting for the contractor to set up test equipment or locate microphones or other required equipment will be billed at the same rate and in the same manner.
8. Any return trips to correct any of the above conditions will be wholly billed to the contractor and deducted from the contractor's remaining balances with the owner at the same rate.

3.24 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:

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. The contractor must verify these conditions can be maintained during testing.
   c. No rehearsals or other activities may take place during tests.

3. STAGE 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. Have factory test report available on site.
d. All lamps burned in and installed, and all fixtures bench focused and installed.
e. Lighting control console set up, monitors in place and on mounts and all cabling and interconnections complete and neatly dressed.
f. All lighting console patching including color and any moving lights must be complete. Console patching for association of scrollers and lights to be completed.
g. Remote Zoom Fixtures: All parameters and categories set, intensity, focus, color and beam palettes set, etc.
h. Architectural presets and control patching complete.
i. LCD screens completely programmed, mirror images of each other and fully functional, including password protection, astrological clocking functions, etc.
j. All lighting system labeling complete, including wire management, yoke and fixture labeling, portable cabling, etc.
k. All nodes and DMX distribution completely programmed and patched.
l. Emergency lighting transfer cabinet system tested and verified, including trigger from fire alarm with the resultant emergency circuits trigger.
m. 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.
n. 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.
o. Network configuration software set up and fully programmed.

4. 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 sets working smoothly.
e. All curtain tracks checked for end stops and binding on tracks.
f. All cable drops for stage electrics properly dressed and not tangling during travel.
g. All audio drops properly dressed onto battens.
h. 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.
i. 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.
j. All curtain track tension floor pulleys (or sandbag pulleys) properly installed and fully functional.
k. All curtains hung, clean, wrinkle-free & crease-free and with the proper documentation on site as to their flame-retardant characteristics.
l. All shackles and turnbuckles properly moused with all wire ties clipped short and clean (with no protruding ends).
m. All batten end caps installed.
n. All standard and custom safety signage correct, site specific and properly installed in all locations called for in the written specifications.
o. Drill drive clew winch equipment fully functional and control system installed and fully functional (including handheld pendant remote).
p. Wire guides evenly and properly taught (with the required amount of tension to keep them from engaging adjacent arbors).
q. All batten end caps installed.

3.25 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. If the owner requests physical copies, these shall be provided at an additional expense to the owner.

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. Lighting Systems 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.

8. Rigging Systems 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:

9. Curtain flame resistance certificates.

10. Sign Off, Programming & Inspection Sheets:

a. The contractor shall be required to provide copies of the following reports and include in the O&M Manual.

b. A custom compiled simplified guide to standard rigging procedures, including, but not limited to, the following items:
1) Industry standard procedures for the handling, loading and unloading of weights, battens, arbors and other pipes
2) 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.
3) The proper procedures for taking curtains down, protecting them from dirt & damage during this process, storing them properly and reinstalling them.
4) How to properly load/offload fixtures from electric sets and FOH cove pipes.

5) Generally accepted stage practices regarding personnel on stage while sets are in operation, moving, being loaded, etc.
6) How operators can spot any imbalanced loading condition on a set that is locked, and the safe handling of such situations.
7) The operation and intent of legs operation.
8) A complete copy of manufacturer's furnished standard stage & dead hung, misc. other rigging safety procedures.
9) The minimum number of persons required for safely loading/unloading sets (four – 2 at the clew winch and 2 on stage) along with proper adult supervision requirements during major set changes (four on stage).
10) The emergency procedures to follow during runaway set situations and other accident avoidance procedures
11) The importance of wearing leather gloves during all set movement and set change operations.
12) 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.
13) 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.
14) 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).
15) *See the training section below for the intents of training and any additional requirements.

11. 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).
12. 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.
13. A complete reduced size set of the final print drawings of the installation ("as builts"), including field changes, routings, locations of sets, set numbering, installation details and other pertinent information.

14. 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.
15. 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.
16. 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.
17. Provide a basic RARR (risk analysis/risk reduction) template for the owner to use (and related risk analysis training) as a guide to analyzing show risks and how to mitigate those risks (risk identification, assessment, strategies, monitoring & review). This should be a short, non-exhaustive & generalized guide. Include in the O&M Manual.
18. 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.
19. A simple list of any required periodic maintenance procedures that need to be performed on the rigging system (clew winches, etc.).
    *See the training section below for the intents of training and any additional requirements.
20. 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.

21. 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.
22. 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.
23. 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.
24. 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.
    a. Maintenance procedures and recommended schedules required for equipment installed that requires regular scheduled maintenance.
    b. 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. As-Built Drawing Set requirements (required of all prime and sub-contractors):

1. As-Built Drawings (AKA as fitted or as installed): This drawing package is a revised set of "red-lined" construction drawings submitted by each installing contractor upon completion of the project. These drawings must accurately record and reflect the equipment installed, all changes made during the construction process and must also show the exact dimensions, geometry and location of all elements of the work completed under the contract. As built drawings should be added to throughout the construction process as the project gets built.
2. The as-built drawing package must include the following:
    a. Clean, consistent look, layout and markup methodology across entire set
    b. Conduit sizes
    c. Wire types pulled (manufacturer, model, AWG, etc.)
    d. All junction box locations, names, internal components, etc.
    e. Conduit routing (actual installation paths with notes as to elevation, access, etc.)
    f. Panel and circuit numbers for all power related devices
    g. Shop drawing changes
    h. Extra work not originally included in the contract
    i. Field changes
    j. Design changes
    k. Modifications
    l. Labels and dates (attesting to when changes were made and why)
    m. Locations and dimensions (if as designed, state such; if not, indicated all deviations). This should include heights AFF, etc.
    n. Legend or Key explaining all markups, color codes, numbering sequences, etc.
    o. Port assignments and related nomenclature (for all DMX, Data, 0-10V, IP, switches, etc.)
    p. Embedment depth, type & size for rigging related anchors
    q. Accurate details for all installed devices
    r. Equipment relocations (due to required or requested field directives, owner requests, obstructions, etc.)
3. As built drawings must be written in legible, plain English without the use of shorthand, abbreviations, codes, etc. Descriptions shall be clear and concise.
4. As built drawings can also be provided with electronic and technology driven interactions such as embedded photos, GPS data and active links to relevant material.
5. Typical markups that would be expected in all as-built drawing sets:
    a. RED markups indicate where something has been REMOVED, RELOCATED or CHANGED from the original design.

b. GREEN markups indicate where something has been ADDED to the original design.
c. YELLOW markups indicate actual routings, locations, etc.
d. BLUE markups indicate special information that has been included regarding the installation of equipment, conduit & wiring.

6. An accurate and useful set of As-Built drawings includes preparation before the commencement of the project, during the installation process by all involved parties and after the final punch list items have been addressed and corrected.
7. Only include drawings in the as-built set that are relevant to the installed systems. For example, the EC would not include detail drawing as-builts for systems or equipment that he had nothing to do with providing and/or installing (such as Brickhouse arbors or AV system touchscreen layouts).
8. Do not include duplicate pages or pages without any markups. Every sheet included in the as-built set must include all relevant markups as listed above.

F. 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 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

SECTION 230500 - COMMON HVAC REQUIREMENTS

PART 1 - GENERAL

1.1 PLANS AND SPECIFICATIONS

A. All work under this title, on drawings or specified, is subject to the general and special contract conditions for the entire project, and the contractor for this portion of the work is required to refer especially thereto, and to the architectural drawings.

B. Drawings are diagrammatic and specifications are complementary and must be so interpreted to determine the full scope of work under this heading. Wherever any material, article, operation or method is either specified or shown on the drawings, this contractor is required to provide each item and perform each prescribed operation according to the designate quality, qualification or condition, furnishing all necessary labor, equipment or incidentals.

C. Wherever the designation "Architect" appears, it shall imply Architect or Engineer. Wherever the term “Contractor” or “MC” appears, it shall imply the Contractor responsible for Division 23, Mechanical Work.

1.2 CONFLICTS

A. If, in the interpretation of contract documents, it appears that the drawings and specifications are not in agreement, the Contractor is to contact the Engineer. The Engineer shall be the final authority. Addenda supersede the provisions which they amend.

B. In the absence of a written clarification by the engineer, the Contractor must install his work in accordance with the more stringent and/or costly condition. Contractor assumes full responsibility for any and all items furnished and installed without the written approval by the Architect or Engineer. Under no circumstances will a change order be approved for work installed that was not approved by the Architect or Engineer.

1.3 DIMENSIONS, LAYOUTS AND OBSTACLES

A. Verify dimensions and elevations from actual field measurements after building construction has sufficiently progressed.

B. Assume full and final responsibility for the accuracy of any or all work performed under this Division and make repairs and corrections as required or directed at no extra cost to the Owner.

C. Layouts of piping, ductwork, and equipment shown on drawings are diagrammatic. Contractor shall verify dimensions and layouts for specific project conditions, field verify any existing conditions, and coordinate with all other trades prior to procurement, fabrication and installation of equipment and material. Existing Conditions shall be field verified by contractor prior to bid submissions. Unknown conditions during construction due to omission of contractor field verification prior to bid shall be resolved by the contractor at no cost to the owner or project. Contractor assumes full responsibility for completeness of installation including coordination of work with other trades.

D. Make actual installations in accord with design layouts, but with necessary adjustments as determined by trade coordination, actual material and equipment procured, field verifications, and other project conditions in order to provide a fully functional and complete system, save and maintainable in all aspects. Any such required adjustments and deviations shall require specific approval of the Engineer/Architect prior to procurement, fabrication, and installation.

E. Take particular care to coordinate all piping, ductwork, and equipment under this Division to prevent conflict and remove and relocate work as may be made necessary by such conflict at no extra cost to the Owner or project.

F. Unless expressly permitted by the Engineer/Architect or shown otherwise on the Drawings, all piping, ducts and similar items shall be installed so that they are concealed except as permitted by the Engineer/Architect in service rooms noted on the Drawings.

G. The Owner or Owner's Representative reserves the right to relocate terminal equipment six (6) feet in any direction from locations indicated on plans, before roughing-in, with no extra cost to the Owner or project.

1.4 REVIEW OF PROPOSED EQUIPMENT AND MATERIALS

A. Submittals:

1. Contractor shall submit a complete list and schedule, including all proposed equipment and materials to the Construction Manager or Owner’s Representative and Engineer for review and approval within 10 business days of contract award..

2. Submit all proposed material, equipment, and fabrication shop drawings to the Engineer for approval prior to procurement, fabrication, and installation.

B. Substitution Requests:

1. Substitutions are defined as any manufacturer and/or model not indicated in drawings or specifications. Requests for substitutions must be made in writing ten (10) days prior to bid date so that an addendum may reach all contractors.

2. In addition to other contract provisions regarding substitution requests, , Contactor must certify by letter that he has checked the proposed substitution products or

materials for conformance to applicable codes, standards, and regulations, specifications, and space limitations and assumes full responsibility thereafter.

3. Approval of substitution requests is at the sole discretion of the Engineer and Owner.

4. If substitutions are proposed after the bids are received, the Contractor shall state amount of credit to the Owner for substitution. Substitutions that are considered equal by the Contractor and carried in bid without approval by Engineer shall be the responsibility of the Contractor. The Engineer and/or Owner shall not be made liable or responsible for losses incurred by the Contractor, due to the rejection of said items for installation.

5. Where equipment requiring different arrangement or connections other than as indicated is acceptable, it shall be the responsibility of this Contractor to furnish revised layouts and install the equipment to operate properly and in harmony with the intent of the drawings and specifications. All changes in the work required by the different arrangement shall be done at no additional cost to the Owner or Project, including but not limited to structural steel modifications. Control and power wiring modifications required by Contractor, imposed modifications, and the additional cost of these modifications, shall be the responsibility of this Contractor.

1.5 PERMITS, CODES AND ORDINANCES

A. The Contractor shall arrange and pay for all permits, inspections, etc., as required by local utilities or applicable agencies.

B. All work and material shall be in complete accordance with the ordinances, regulations, codes, etc., of all political entities exercising jurisdictions.

1.6 QUALITY ASSURANCE

A. Install HVAC Systems in accordance with applicable industry standards.

B. Install HVAC Systems in accordance with manufacturer's installation, operations and maintenance instructions.

1.7 COORDINATION WITH OTHER TRADES

A. Check mechanical drawings with all other trades including electrical, plumbing, fire protection and general construction.

B. Anticipate, avoid, and resolve interferences with other trades.

C. Take particular care to coordinate all piping, ductwork, plumbing and major electrical components above ceiling, to prevent conflict. Remove and relocate work as may be made necessary by such conflict, at no extra cost to the Owner. The use of coordination drawings is recommended but may not be required (refer to Division 1 for additional requirements). Lack of coordination drawings assumes contractor has verified and coordinated all work associated with installation.

D. Obtain decision for approval from project Engineer for proposed grouped installations before proceeding, and for clearance in structure and finish of the building.

E. Verify with drawings all ductwork and equipment layout in concealed areas.

F. The Contractor to coordinate with, receive and install, Owner furnished equipment where indicated.

G. Coordinate location of controls and instrumentation devices, including but not limited to control valves, control dampers, thermowells, pressure probes, flow switches, insertion flow meters, and ultrasonic flow meters, with Building Automation System (BAS) requirements.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Delivery of Materials: Make provisions for delivery and safe storage of all materials. Check and properly receipt material to be "furnished by others" to contractor and assume full responsibility for all materials while in storage with full visible identification and information.

1.9 PROJECT CONDITIONS

A. Existing Conditions: Field verify existing conditions that will determine exact locations, distances, levels, dimensions, elevations, etc. Review all drawings of other trades and report any conflicts to the Architect/Engineer which will affect the project cost. Lack of field verification does not constitute a basis for change orders and additional costs incurred by the owner or project. Contractor assumes full responsibility for completeness of installation including coordination of work with other trades.

B. Existing facilities shall be considered occupied and functioning during the entire duration of construction. Care shall be taken when working in or around occupied spaces. There will be no interruption in mechanical systems or utilities without written approval from the Owner.

1.10 SUPPORTS

A. Mechanical Contractor is responsible for providing all support components necessary for properly supporting HVAC Systems including hangers, rods, anchors, steel, and bases.

PART 2 - PRODUCTS (not used)

PART 3 - EXECUTION

3.1 COMMON HVAC SYSTEMS INSTALLATION REQUIREMENTS

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of HVAC systems.

B. Indicated locations and arrangements were used to size systems and address other design considerations. Install systems as indicated unless deviations to layout are approved by Architect and Engineer.

C. Install systems in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.

D. Install systems indicated to be exposed and in equipment rooms and service areas at right angles or parallel to building walls.

E. Install equipment level and plumb, parallel and perpendicular to other building systems and components, unless otherwise indicated.

F. Install equipment to allow maximum possible headroom unless specific mounting heights are indicated.

G. Diagonal runs of piping and ductwork are prohibited unless specifically indicated otherwise.

H. Install systems above accessible ceilings to allow sufficient space for ceiling panel removal.

I. Install systems and equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference to other installations. Extend grease fittings to accessible locations

J. Install equipment with all required manufacturer’s service clearances maintained.

K. Install systems at indicated slopes.

L. Install systems free of sags and bends.

M. Install fittings for changes in direction and branch connections.

N. Install systems to allow application of insulation.

O. Select system components with pressure rating equal to or greater than system operating pressure.

P. Install escutcheons for penetrations of walls, ceilings, and floors.

Q. Running pipe and ductwork over electrical equipment and in elevator machine rooms is prohibited.

R. Running piping and ductwork into or through interior exit stairways, other than systems serving such stairwells as permitted by the International Building Code, is prohibited.

S. Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe and duct penetrations. Such Penetrations shall be sealed with firestop materials and required fire and smoke rated dampers shall be provided.

T. Install HVAC systems on required supports and bases meeting maximum allowable spans and sized for the specific loads.

U. Install controls and instrumentation devices for HVAC systems required for system operations and as indicated.

END OF SECTION 230500

SECTION 230502 – COMMON HVAC DEMOLITION REQUIREMENTS

PART 1 - GENERAL

1.1 SUMMARY

A. Description of Work: Provide removal systems as indicated and as required for removal and/or abandonment of systems, equipment and devices, etc. made obsolete by this Project, and as required for removal and remodeling by other trades.

1.2 EXISTING CONDITIONS

A. Existing HVAC systems, equipment and devices may not all be shown on the Drawings. Existing conditions, where indicated, are based on preliminary field observations and/or existing conditions documentation made available to the Architect and Engineer and must be verified. Report any discrepancies to the Architect and Engineer before disturbing the existing installation.

B. Prior to bidding, examine the site to determine all actual observable conditions. Additional work or scope changes due to the Contractor's failure to investigate such existing conditions shall not be grounds for change orders or cause additional costs to the owner and project.

1.3 COORDINATION

A. Adjoining Areas: It is expected that the Contractor understands that adjoining areas of the building (or project site) must remain in operation and HVAC Systems and services must remain in operation at all times, unless specifically approved otherwise.

B. Scheduling: Demolition work and any required shut-downs shall be scheduled in conjunction with all other trades and the owner. Contractor cooperation will be expected under all conditions.

C. Area Limits: Construction traffic and removal of debris will be limited to specific areas and routes. Confirm with the Construction Manager or Owner's Representative and Owner.

D. Coordinate and ensure that all equipment affected by the work is de-energized and electrically disconnected by a qualified and authorized contractor or owner's representative prior to proceeding with demolition.

1.4 ADJACENT MATERIALS

A. Protection: During execution of removal work, primary consideration shall be given to protecting from damage, building structure, furnishings, finishes and the like, which are not specifically indicated to be removed.

B. Repairs: Existing items or surfaces to remain, which are damaged as a result of this work shall be refinished, repaired or replaced to the satisfaction of the Owner, at no cost to the Owner or Project.

1.5 TRANSIENT SERVICES

A. Locate and identify any and all services passing through the project area which serve areas outside the work limits.

B. Maintain all services to areas outside the work limits unless specifically authorized otherwise in writing by the Engineer or Owner's Representative. When transient services must be interrupted, provide temporary services for affected areas outside the work limits.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Patching: Materials used for patching shall be in conformance with the applicable sections of the Project Manual. Where materials are not specifically described, but required for proper completion of the Work, they shall be as selected by the Contractor, subject to approval of the Architect and Engineer.

PART 3 - EXECUTION

3.1 INSPECTION/VERIFICATION

A. Inspection: Before commencing work of this Section, carefully inspect the project site and become familiar with existing systems and conditions.

B. Items to be Salvaged: Verify with the Architect, Engineer, and Owner's Representative, all systems, materials and equipment which are to be salvaged, and those which must be removed. The Owner reserves the right to salvage any or all existing materials and equipment at the project site.

3.2 DEMOLITION

A. General: Remove equipment, ductwork, piping, controls and related materials within the project work limits, as indicated.

B. Protection: Perform all removal work in such a manner so that damage to adjacent items and surfaces is minimized.

C. Patching: When materials are removed, patch and finish surfaces to remain to match surrounding surfaces.

D. Disassembly: Disassemble equipment as required for removal through existing openings.

3.3 EXISTING SYSTEMS TO REMAIN

A. General: Protect and maintain access to existing systems which must remain. Reinstall existing systems disturbed.

B. Reconnections: Where systems in adjoining areas or indicated to remain, become disconnected or affected by demolition work, they shall be reconnected as required to restore original operation. Restoration work shall comply with requirements for new work.

3.4 EXISTING SYSTEMS WORK TO BE RELOCATED

A. General: Disconnect, remove, reinstall and reconnect equipment indicated to be relocated and where required to accommodate remodeling or new construction. Extend existing installations as required. Materials and methods used for relocations and extensions shall conform to requirements for new work.

3.5 DISPOSITION OF EXISTING MATERIALS AND EQUIPMENT

A. Items to Salvage: Material and equipment which is indicated (or directed by Owner) to be salvaged, shall be carefully removed and stored where directed on the site.

B. Items to Reuse/Relocate: Carefully remove and store on site, all material and equipment indicated to be reused or relocated. Thoroughly clean, and make any necessary minor repairs to such equipment, prior to installation.

C. Items to Remove: Remove and legally dispose of all other materials and debris resulting from demolition work on a daily basis.

3.6 CLEANING

Remove from the Project Site all dirt, dust and debris resulting from removal operations on a daily basis. Refuse shall not be allowed to block or otherwise impair circulation in corridors, stairs, sidewalks, roadways or other traffic areas.

END OF SECTION 230502

SECTION 230513 - COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes general requirements for single-phase and polyphase, general-purpose, horizontal, small and medium, squirrel-cage induction motors for use on alternating-current power systems up to 600 V and electronically commutated direct current motors, installed at equipment manufacturer's factory or shipped separately by equipment manufacturer for field installation.

1.2 COORDINATION

A. Coordinate features of motors, installed units, and accessory devices to be compatible with the following:

1. Motor controllers.
2. Torque, speed, and horsepower requirements of the load.
3. Ratings and characteristics of supply circuit and required control sequence.
4. Ambient and environmental conditions of installation location.

PART 2 - PRODUCTS

2.1 GENERAL MOTOR REQUIREMENTS

A. Comply with NEMA MG 1 unless otherwise indicated.

B. Comply with IEEE 841 for severe-duty motors.

2.2 MOTOR CHARACTERISTICS

A. Duty: Continuous duty at ambient temperature of 40 deg C and at altitude of 3300 feet above sea level.

B. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.

2.3 POLYPHASE MOTORS

A. Description: NEMA MG 1, Design B, medium induction motor.

B. Efficiency: Premium efficient, as defined in NEMA MG 1.

C. Service Factor: 1.15.

D. Multispeed Motors: Separate winding for each speed.

E. Rotor: Random-wound, squirrel cage.

F. Bearings: Regreasable, shielded, antifriction ball bearings suitable for radial and thrust loading.

G. Temperature Rise: Class B.

H. Insulation: Class F.

I. Code Letter Designation:

1. Motors 15 HP and Larger: NEMA starting Code F or Code G.
2. Motors Smaller Than 15 HP: Manufacturer's standard starting characteristic.

J. Enclosure Material: Cast iron for motor frame sizes 324T and larger; rolled steel for motor frame sizes smaller than 324T.

2.4 ADDITIONAL REQUIREMENTS FOR POLYPHASE MOTORS

A. Motors Used with Reduced-Voltage and Multispeed Controllers: Match wiring connection requirements for controller with required motor leads. Provide terminals in motor terminal

B. box, suited to control method.

C. Motors Used with Variable-Frequency Controllers: Ratings, characteristics, and features coordinated with and approved by controller manufacturer.

1. Windings: Copper magnet wire with moisture-resistant insulation varnish, designed and tested to resist transient spikes, high frequencies, and short time rise pulses produced by pulse-width-modulated inverters.
2. Premium-Efficient Motors: Class B temperature rise; Class F insulation.
3. Inverter-Duty Motors: Class F temperature rise; Class H insulation.
4. Thermal Protection: Comply with NEMA MG 1 requirements for thermally protected motors.

5. Provide microfiber shaft grounding ring kits.

D. Severe-Duty Motors: Comply with IEEE 841, with 1.15 minimum service factor.

2.5 SINGLE-PHASE MOTORS

A. Motors larger than 1/20 hp shall be one of the following, to suit starting torque and requirements of specific motor application:

1. Permanent-split capacitor.
2. Split phase.
3. Capacitor start, inductor run.
4. Capacitor start, capacitor run.

B. Multispeed Motors: Variable-torque, permanent-split-capacitor type, microfiber shaft grounding ring kits.

C. Bearings: Prelubricated, antifriction ball bearings or sleeve bearings suitable for radial and thrust loading.

D. Motors 1/20 HP and Smaller: Shaded-pole type.

E. Thermal Protection: Internal protection to automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature rating of motor insulation. Thermal-protection device shall automatically reset when motor temperature returns to normal range.

2.6 ELECTRONICALLY COMMUTATED MOTORS (ECM)

A. Motors shall be, variable-speed, DC, brushless motors, specifically designed for the voltage, frequency, and phase indicated.

B. Motors shall be complete with and operated by an integrated controller/inverter that operates the wound stator and senses rotor position to electronically commutate the stator.

C. Motors shall be designed for synchronous rotation.

D. Rotors shall be permanent magnet type with near zero rotor losses.

E. Motors shall have built-in soft start and soft speed change ramps.

F. Motors shall be able to be mounted with shaft in horizontal or vertical orientation.

G. Motors shall be permanently lubricated with ball bearings.

H. Motors shall maintain a minimum of 70% efficiency over the entire operating range.

I. Provide microfiber shaft grounding ring kits.

PART 3 - EXECUTION (Not Applicable)

END OF SECTION 230513

SECTION 230517 - SLEEVES AND SLEEVE SEALS FOR HVAC PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Sleeves.
2. Sleeve-seal systems.
3. Sleeve-seal fittings.
4. Grout.
5. Silicone sealants.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

PART 2 - PRODUCTS

2.1 SLEEVES

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

1. Advance Products & Systems, Inc.
2. CALPICO, Inc.
3. GPT; an EnPro Industries company.

B. Cast-Iron Pipe Sleeves: Cast or fabricated of cast or ductile iron and equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop collar.

C. Steel Pipe Sleeves: ASTM A53/A53M, Type E, Grade B, Schedule 40, anti-corrosion coated orzinc coated, with plain ends and integral welded waterstop collar.

D. Galvanized-Steel Sheet Sleeves: 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint.

2.2 SLEEVE-SEAL SYSTEMS

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

1. Advance Products & Systems, Inc.
2. CALPICO, Inc.
3. GPT; an EnPro Industries company.
4. Metraflex Company (The).
5. Proco Products, Inc.

B. Description:

1. Modular sealing-element unit, designed for field assembly, for filling annular space between piping and sleeve.
2. Designed to form a hydrostatic seal of 20-psig.
3. Sealing Elements: EPDM-rubber or Nitrile (Buna N) interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size.
4. Pressure Plates: Carbon steel.
5. Connecting Bolts and Nuts: Carbon steel, with corrosion-resistant coating, ASTM B633 or Stainless steel of length required to secure pressure plates to sealing elements.

2.3 SLEEVE-SEAL FITTINGS

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

1. Advance Products & Systems, Inc.
2. CALPICO, Inc.
3. GPT; an EnPro Industries company.
4. Metraflex Company (The).
5. Proco Products, Inc.

B. Description:

1. Manufactured plastic, sleeve-type, waterstop assembly, made for imbedding in concrete slab or wall.
2. Plastic or rubber waterstop collar with center opening to match piping OD.

2.4 GROUT

A. Description: Nonshrink, recommended for interior and exterior sealing openings in nonfire-rated walls or floors.

B. Standard: ASTM C1107/C1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.

C. Design Mix: 5000-psi, 28-day compressive strength.

D. Packaging: Premixed and factory packaged.

2.5 SILICONE SEALANTS

A. Silicone, S, NS, 25, NT: Single-component, nonsag, plus 25 percent and minus 25 percent movement capability, nontraffic-use, neutral-curing silicone joint sealant, ASTM C920, Type S, Grade NS, Class 25, use NT.

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

a. GE Construction Sealants; Momentive Performance Materials Inc.
b. Pecora Corporation.
c. Permathane®/Acryl-R®; ITW Polymers Sealants North America.
d. Sherwin-Williams Company (The).
e. The Dow Chemical Company.

PART 3 - EXECUTION

3.1 SLEEVE INSTALLATION

A. Install sleeves for piping passing through penetrations in floors, partitions, roofs, and walls.

B. For sleeves that will have sleeve-seal system installed, select sleeves of size large enough to provide 1-inch annular clear space between piping and concrete slabs and walls.

1. Sleeves are not required for core-drilled holes.

C. Install sleeves in concrete floors, concrete roof slabs, and concrete walls as new slabs and walls are constructed.

1. Permanent sleeves are not required for holes in slabs formed by molded-PE or -PP sleeves.
2. Cut sleeves to length for mounting flush with both surfaces.
   a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches above finished floor level.
3. Using grout or silicone sealant, seal space outside of sleeves in slabs and walls without sleeve-seal system.

D. Install sleeves for pipes passing through interior partitions.

1. Cut sleeves to length for mounting flush with both surfaces.
2. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.
3. Seal annular space between sleeve and piping or piping insulation; use sealants appropriate for size, depth, and location of joint.

E. Fire-Resistance-Rated Penetrations, Horizontal Assembly Penetrations, and Smoke-Barrier Penetrations: Maintain indicated fire or smoke rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with fire- and smoke-stop materials. Comply with requirements for firestopping and fill materials specified in Section 078413 "Penetration

F. Firestopping."

3.2 STACK-SLEEVE-FITTING INSTALLATION

A. Install stack-sleeve fittings in new slabs as slabs are constructed.

1. Install fittings that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.
2. Secure flashing between clamping flanges for pipes penetrating floors with membrane waterproofing.
3. Install section of cast-iron soil pipe to extend sleeve to 3 inches above finished floor level.
4. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.
5. Using waterproof silicone sealant, seal space between top hub of stack-sleeve fitting and pipe.

B. Fire-Resistance-Rated, Horizontal Assembly, and Smoke Barrier Penetrations: Maintain indicated fire or smoke rating of floors at pipe penetrations. Seal pipe penetrations with fire- and smoke-stop materials. Comply with requirements for firestopping specified in Section 078413 "Penetration Firestopping."

3.3 SLEEVE-SEAL-SYSTEM INSTALLATION

A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at service piping entries into building.

B. Select type, size, and number of sealing elements required for piping material and size and for sleeve ID or hole size. Position piping in center of sleeve. Center piping in penetration, assemble sleeve-seal-system components, and install in annular space between piping and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make a watertight seal.

3.4 SLEEVE-SEAL-FITTING INSTALLATION

A. Install sleeve-seal fittings as new walls and slabs are constructed.

B. Assemble fitting components of length to be flush with both surfaces of concrete slabs and walls. Position waterstop flange to be centered in concrete slab or wall.

C. Secure nailing flanges to concrete forms.

D. Using grout or silicone sealant, seal space around outside of sleeve-seal fittings.

3.5 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Leak Test: After allowing for a full cure, test sleeves and sleeve seals for leaks. Repair leaks and retest until no leaks exist.

B. Sleeves and sleeve seals will be considered defective if they do not pass tests and inspections.

3.6 SLEEVE AND SLEEVE-SEAL SCHEDULE

A. Use sleeves and sleeve seals for the following piping-penetration applications:

1. Exterior Concrete Walls Above Grade:
   a. Piping Smaller Than NPS 6 : Cast-iron sleeves.
   b. Piping NPS 6 and Larger: Sleeve-seal fittings.
2. Exterior Concrete Walls Below Grade:
   a. Piping Smaller Than NPS 6: Cast-iron pipe sleeves with sleeve-seal system.
      1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.

b. Piping NPS 6 and Larger: Steel pipe sleeves with sleeve-seal system.
   1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.

3. Concrete Slabs-on-Grade:
   a. Piping Smaller Than NPS 6: Cast-iron pipe sleeves with sleeve-seal system.
      1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.
   b. Piping NPS 6 and Larger: Steel pipe sleeves with sleeve-seal system.
      1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.
4. Concrete Slabs Above Grade:
   a. Piping Smaller Than NPS 6: Steel pipe sleeves.
   b. Piping NPS 6 and Larger: Steel pipe sleeves.
5. Interior Partitions:
   a. Piping Smaller Than NPS 6: Steel pipe sleeves.
   b. Piping NPS 6 and Larger: Galvanized-steel sheet sleeves.

END OF SECTION 230517

SECTION 230518 - ESCUTCHEONS FOR HVAC PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Escutcheons.
2. Floor plates.

1.2 DEFINITIONS

A. Existing Piping to Remain: Existing piping that is not to be removed and that is not otherwise indicated to be removed, removed and salvaged, or removed and reinstalled.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. BrassCraft Manufacturing Co.; a Masco company.
2. Dearborn Brass.
3. Keeney Manufacturing Company (The).
4. Mid-America Fittings, Inc.
5. ProFlo; a Ferguson Enterprises, Inc. brand.

2.2 ESCUTCHEONS

A. One-Piece, Steel Type: With polished, chrome-plated finish and setscrew fastener.

B. One-Piece, Stainless-Steel Type: With polished stainless-steel finish.

C. One-Piece, Cast-Brass Type: With polished, chrome-plated finish and setscrew fastener.

D. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped steel with polished, chrome-plated finish and spring-clip fasteners.

E. One-Piece, Stamped-Steel Type: With polished, chrome-plated finish and spring-clip fasteners.

F. Split-Plate, Stamped-Steel Type: With polished, chrome-plated finish; concealed hinge; and spring-clip fasteners.

2.3 FLOOR PLATES

A. Split Floor Plates: Steel with concealed hinge.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install escutcheons for piping penetrations of walls, ceilings, and finished floors.

B. Install escutcheons with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.

1. Escutcheons for New Piping and Relocated Existing Piping:
    a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep pattern.
    b. Chrome-Plated Piping: One-piece steel or split-plate steel with polished, chrome-plated finish.
    c. Insulated Piping: One-piece steel with polished, chrome-plated finish.
    d. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece steel with polished, chrome-plated finish.
    e. Bare Piping in Unfinished Service Spaces: One-piece steel with polished, chrome-plated finish.
    f. Bare Piping in Equipment Rooms: One-piece steel with polished, chrome-plated finish.
2. Escutcheons for Existing Piping to Remain:
    a. Chrome-Plated Piping: Split-plate, stamped steel with concealed hinge with polished, chrome-plated finish.
    b. Insulated Piping: Split-plate, stamped steel with concealed hinge with polished, chrome-plated finish.

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.

1. New Piping and Relocated Existing Piping: Split floor plate.
2. Existing Piping to Remain: Split floor plate.

3.2 FIELD QUALITY CONTROL

A. Using new materials, replace broken and damaged escutcheons and floor plates.

END OF SECTION 230518

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SECTION 230519 - METERS AND GAUGES FOR HVAC PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Thermometers, liquid in glass.
2. Duct-thermometer mounting brackets.
3. Thermowells.
4. Pressure gauges, dial type.
5. Gauge attachments.
6. Test plugs.
7. Test-plug kits.
8. Sight flow indicators.

1.2 ACTION SUBMITTALS

A. Product Data:

1. Thermometers, liquid in glass.
2. Duct-thermometer mounting brackets.
3. Thermowells.
4. Pressure gauges, dial type.
5. Gauge attachments.
6. Test plugs.
7. Test-plug kits.
8. Sight flow indicators.

B. Product Data Submittals: For each type of product.

C. Shop Drawings:

1. Include diagrams for power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

A. Product Certificates: For each type of meter.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For meters and gauges to include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 THERMOMETERS, LIQUID IN GLASS

A. Thermometers, Liquid in Glass - Metal Case, Industrial Style:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Flo Fab Inc.
   b. Miljoco Corporation.
   c. Trerice, H. O. Co.
   d. Weiss Instruments, Inc.
   e. Weksler Glass Thermometer Corp.
2. Source Limitations: Provide liquid-in-glass, metal-case, industrial-style thermometers from single manufacturer.
3. Standard: ASME B40.200.
4. Case: Cast aluminum; 7-inch nominal size unless otherwise indicated.
5. Case Form: Adjustable angle unless otherwise indicated.
6. Tube: Glass with magnifying lens and blue or red organic liquid, mercury free.
7. Tube Background: Nonreflective aluminum with permanent scale markings graduated in deg F.
8. Window: Glass or acrylic plastic.
9. Stem: Aluminum and of length to suit installation.
   a. Design for Air-Duct Installation: With ventilated shroud.
   b. Design for Thermowell Installation: Bare stem.
10. Connector: 1-1/4 inches, with ASME B1.1 or ASME B1.20.1 screw threads to fit thermowell.
11. Accuracy: Plus or minus 1 percent of span range or one scale division, to a maximum of 1.5 percent of span.

2.2 DUCT-THERMOMETER MOUNTING BRACKETS

A. Description: Flanged bracket with screw holes, for attachment to air duct and made to hold thermometer stem.

2.3 THERMOWELLS

A. Thermowells:

1. Standard: ASME B40.200.
2. Description: Pressure-tight, socket-type fitting made for insertion in piping tee fitting.
3. Material for Use with Copper Tubing: Copper.
4. Material for Use with Steel Piping: Type 304 stainless steel.
5. Type: Stepped shank unless straight or tapered shank is indicated.
6. External Threads: NPS 1/2, NPS 3/4, or NPS 1 , with ASME B1.20.1 pipe threads.
7. Internal Threads: 1/2, 3/4, and 1 inch, with ASME B1.1 screw threads.
8. Bore: Diameter required to match thermometer bulb or stem.
9. Insertion Length: Length required to match thermometer bulb or stem.
10. Lagging Extension: Include on thermowells for insulated piping and tubing.
11. Bushings: For converting size of thermowell's internal screw thread to size of thermometer connection.

B. Heat-Transfer Medium: Mixture of graphite and glycerin.

2.4 PRESSURE GAUGES, DIAL TYPE

A. Pressure Gauges, Dial Type - Direct Mounted, Metal Case:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Ametek U.S. Gauge.
   b. Ashcroft Inc.
   c. Flo Fab Inc.
   d. Miljoco Corporation.
   e. Trerice, H. O. Co.
   f. WATTS; A Watts Water Technologies Company.
   g. Weiss Instruments, Inc.
   h. Weksler Glass Thermometer Corp.
2. Source Limitations: Provide dial-type, direct-mounted, metal-case pressure gauges from single manufacturer.
3. Standard: ASME B40.100.
4. Case: Liquid-filled type(s); cast aluminum or drawn steel; 4-1/2-inch nominal diameter.
5. Pressure-Element Assembly: Bourdon tube.
6. Pressure Connection: Brass, with NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe threads and bottom-outlet type unless back-outlet type is indicated.

7. Movement: Mechanical, with link to pressure element and connection to pointer.
8. Dial: Nonreflective aluminum with permanent scale markings graduated in psi.
9. Pointer: Dark-colored metal.
10. Window: Glass or acrylic plastic.
11. Ring: Metal.
12. Accuracy: Grade A, plus or minus 1 percent of middle half of span.

B. Pressure Gauges, Dial Type - Remote Mounted, Metal Case:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Ashcroft Inc.
   b. Flo Fab Inc.
   c. Miljoco Corporation.
   d. Tel-Tru Manufacturing Company.
   e. Trerice, H. O. Co.
   f. WATTS; A Watts Water Technologies Company.
   g. Weiss Instruments, Inc.
2. Source Limitations: Provide dial-type, remote-mounted, metal-case pressure gauges from a single manufacturer.
3. Standard: ASME B40.100.
4. Case: Liquid-filled type;; 4-1/2-inch nominal diameter with back flange and holes for panel mounting.
5. Pressure-Element Assembly: Bourdon tube.
6. Pressure Connection: Brass, with NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe threads and bottom-outlet type unless back-outlet type is indicated.
7. Movement: Mechanical, with link to pressure element and connection to pointer.
8. Dial: Nonreflective aluminum with permanent scale markings graduated in psi.
9. Pointer: Dark-colored metal.
10. Window: Glass or acrylic plastic.
11. Ring: Metal.
12. Accuracy: Grade A, plus or minus 1 percent of middle half of span.

2.5 GAUGE ATTACHMENTS

A. Snubbers: ASME B40.100, brass; with NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe threads and piston-type surge-dampening device. Include extension for use on insulated piping.

B. Siphons: Loop-shaped section of steel pipe with NPS 1/4 or NPS 1/2 pipe threads.

C. Valves: Brass or stainless steel needle, with NPS 1/4 or NPS 1/2 ASME B1.20.1 pipe threads.

2.6 TEST PLUGS

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

1. IMI Flow Design, Inc.
2. Peterson Equipment Co., Inc.
3. Trerice, H. O. Co.
4. WATTS; A Watts Water Technologies Company.
5. Weiss Instruments, Inc.
6. Weksler Glass Thermometer Corp.

B. Source Limitations: Provide test plugs from single manufacturer.

C. Description: Test-station fitting made for insertion in piping tee fitting.

D. Body: Brass or stainless steel with core inserts and gasketed and threaded cap. Include extended stem on units to be installed in insulated piping.

E. Thread Size: NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe thread.

F. Minimum Pressure and Temperature Rating: 500 psig at 200 deg F.

G. Core Inserts: EPDM self-sealing rubber.

2.7 TEST-PLUG KITS

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

1. Blue Ribbon Corp.
2. Peterson Equipment Co., Inc.

B. Source Limitations: Provide test-plug kits from single manufacturer.

C. Furnish one test-plug kit(s) containing one thermometer(s), one pressure gauge and adapter, and carrying case. Thermometer sensing elements, pressure gauge, and adapter probes are to be of diameter to fit test plugs and of length to project into piping.

D. High-Range Thermometer: Small, bimetallic insertion type with 1- to 2-inch diameter dial and tapered-end sensing element. Dial range is to be at least 0 to 220 deg F.

E. Carrying Case: Metal or plastic, with formed instrument padding.

2.8 SIGHT FLOW INDICATORS

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

1. ARCHON Industries, Inc.
2. Dwyer Instruments, Inc.
3. KOBOLD Instruments, Inc. - USA.
4. OPW Engineered Systems; OPW Fluid Transfer Group; a Dover company.

B. Source Limitations: Provide sight flow indicators from single manufacturer.

C. Description: Piping inline-installation device for visual verification of flow.

D. Construction: Bronze or stainless steel body, with sight glass and ball, flapper, or paddle wheel indicator, and threaded or flanged ends.

E. Minimum Pressure Rating: 125 psig.

F. Minimum Temperature Rating: 200 deg F.

G. End Connections for NPS 2 (DN 50) and Smaller: Threaded.

H. End Connections for NPS 2-1/2 (DN 65) and Larger: Flanged.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install thermowells with socket extending to center of pipe and in vertical position in piping tees.

B. Install thermowells of sizes required to match thermometer connectors. Include bushings if required to match sizes.

C. Install thermowells with extension on insulated piping.

D. Fill thermowells with heat-transfer medium.

E. Install direct-mounted thermometers in thermowells and adjust vertical and tilted positions.

F. Install remote-mounted thermometer bulbs in thermowells and install cases on panels; connect cases with tubing, and support tubing to prevent kinks. Use minimum tubing length.

G. Install pipe-mounted thermal-energy temperature sensors in thermowells and extend wiring to indicator.

H. Install duct-thermometer-mounting brackets in walls of ducts. Attach to duct with screws.

I. Install direct-mounted pressure gauges in piping tees with pressure gauge located on pipe at the most readable position.

J. Install remote-mounted pressure gauges on panel.

K. Install valve and snubber in piping for each pressure gauge for fluids (except steam).

L. Install valve and syphon fitting in piping for each pressure gauge for steam.

M. Install test plugs in piping tees.

N. Install flow indicators in piping systems in accessible positions for easy viewing.

O. Install permanent indicators on walls or brackets in accessible and readable positions.

P. Install connection fittings in accessible locations for attachment to portable indicators.

Q. Install thermometers in the following locations:

1. Inlet and outlet of each hydronic zone.
2. Inlet and outlet of each hydronic boiler.
3. Two inlets and two outlets of each chiller.
4. Inlet and outlet of each hydronic coil in air-handling units.
5. Two inlets and two outlets of each hydronic heat exchanger.
6. Inlet and outlet of each thermal-storage tank.
7. Outside-, return-, supply-, and mixed-air ducts.

R. Install pressure gauges in the following locations:

1. Discharge of each pressure-reducing valve.

2. Inlet and outlet of each chiller chilled-water and condenser-water connection.
3. Suction and discharge of each pump.

3.2 CONNECTIONS

A. Install meters and gauges adjacent to machines and equipment to allow space for service and maintenance of meters, gauges, machines, and equipment.

3.3 ADJUSTING

A. After installation, calibrate meters according to manufacturer's written instructions.

B. Adjust faces of meters and gauges to proper angle for best visibility.

3.4 THERMOMETER SCHEDULE

A. Thermometers at inlet and outlet are to be the following:

1. Industrial-style, liquid-in-glass type.

B. Thermometer stems are to be of length to match thermowell insertion length.

3.5 THERMOMETER SCALE-RANGE SCHEDULE

A. Scale Range for Chilled-Water Piping:

1. Minus 40 to plus 160 deg F.

B. Scale Range for Condenser-Water Piping:

1. 0 to 150 deg F.

C. Scale Range for Heating, Hot-Water Piping:

1. 0 to 250 deg F.

D. Scale Range for Steam and Steam-Condensate Piping:

1. 0 to 250 deg F.

E. Scale Range for Air Ducts:

1. Minus 40 to plus 160 deg F.

3.6 PRESSURE-GAUGE SCHEDULE

A. Pressure gauges are to be the following:

1. Liquid-filled, direct mounted, metal case.

3.7 PRESSURE-GAUGE SCALE-RANGE SCHEDULE

A. Scale Range for Chilled-Water Piping:

1. 0 to 160 psi.

B. Scale Range for Condenser-Water Piping:

1. 0 to 160 psi.

C. Scale Range for Heating, Hot-Water Piping:

1. 0 to 160 psi.

D. Scale Range for Steam Piping:

1. 0 to 100 psi.

END OF SECTION 230519

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SECTION 230523.15 - GATE VALVES FOR HVAC PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Iron gate valves.

1.2 DEFINITIONS

A. CWP: Cold working pressure.

B. NRS: Nonrising stem.

C. OS&Y: Outside screw and yoke.

D. RS: Rising stem.

E. SWP: Steam working pressure.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of valve.

1.4 DELIVERY, STORAGE, AND HANDLING

Information in this article is paraphrased from MSS publications.

A. Prepare valves for shipping as follows:

1. Protect internal parts against rust and corrosion.
2. Protect threads, flange faces, grooves, press connections, and weld ends.
3. Set gate valves closed to prevent rattling.

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.

C. Use sling to handle large valves; rig sling to avoid damage to exposed parts. Do not use handwheels, stems, or other components as lifting or rigging points unless specifically indicated for this purpose in manufacturer's written instructions.

PART 2 - PRODUCTS

2.1 SOURCE LIMITATIONS

A. Obtain each type of valve from single source from single manufacturer.

2.2 PERFORMANCE REQUIREMENTS

A. ASME Compliance:

1. ASME B1.20.1 for threads for threaded-end valves.
2. ASME B16.1 for flanges on iron valves.
3. ASME B16.5 for flanges on metric standard piping.
4. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
5. ASME B16.34 for flanged, threaded, and welding ends.

B. AWWA Compliance: Comply with AWWA C606 for grooved-end connections.

C. Valve Pressure-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. RS Valves in Insulated Piping: With 2-inch stem extensions.

F. Valve Bypass and Drain Connections: MSS SP-45.

2.3 IRON GATE VALVES

A. Iron Gate Valves, NRS, Class 125:

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Description:

a. Standard: MSS SP-70, Type I.
b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.
c. NPS 14 to NPS 24, CWP Rating: 150 psig.
d. Body Material: ASTM A126, gray iron with bolted bonnet.
e. Ends: Flanged.
f. Trim: Bronze.
g. Disc: Solid wedge.
h. Packing and Gasket: Asbestos free.

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. Examine press joint surfaces. Verify that they are clean and free from dents and burrs and that O-ring seals are in place and undamaged.

F. Do not attempt to repair defective valves; replace with new valves.

3.2 INSTALLATION OF VALVES

A. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.

B. Provide support of piping adjacent to valves such that no force is imposed upon valves.

C. Locate valves for easy access and where not blocked by equipment, other piping, or building components.

D. Install valves so that stems are horizontal or slope upward from centerline of pipe.

E. Install valves in position that does not project into aisles or block access to other equipment.

F. Install valves in position to allow full stem and manual operator movement.

G. Verify that joints of each valve have been properly installed and sealed to ensure that there is no leakage or damage.

H. Install chainwheels on manual operators for gate valves NPS 4 and larger and more than 96 inches above floor. Extend chains to 60 inches above finished floor.

I. Install valve tags. Comply with requirements in Section 230553 "Identification for HVAC Piping and Equipment" for valve tags and schedules.

J. Adhere to manufacturer's written installation instructions. When soldering or brazing valves, do not heat valves above maximum permitted temperature. Do not use solder with melting point temperature above valve of manufacturer's recommended maximum.

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: Gate valves.

B. If valves with specified SWP classes or CWP ratings are unavailable, 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 Steel Piping, NPS 2 and Smaller: Threaded ends.
2. For Steel Piping, NPS 2-1/2 to NPS 4: Flanged ends, except where threaded valve-end option is indicated in valve schedules.
3. For Steel Piping, NPS 5 and Larger: Flanged ends.
4. For Grooved-End Steel Piping, except for Steam and Steam Condensate Piping: Valve ends may be grooved.

3.5 LOW-PRESSURE STEAM VALVE SCHEDULE - 15 PSIG OR LESS

A. Pipe NPS 2 and Smaller: Bronze gate valves, RS, Class 125.

B. Pipe NPS 2-1/2 and Larger: Iron gate valves, RS, Class 125.

3.6 STEAM-CONDENSATE VALVE SCHEDULE

A. Pipe NPS 2 and Smaller: Bronze gate valves, RS, Class 125.

B. Pipe NPS 2-1/2 and Larger: Iron gate valves, RS, Class 125.

END OF SECTION 230523.15

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SECTION 230529 - HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Metal pipe hangers and supports.
2. Trapeze pipe hangers.
3. Metal framing systems.
4. Thermal-hanger shield inserts.
5. Fastener systems.
6. Pipe stands.
7. Equipment stands.
8. Equipment supports.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1.3 INFORMATIONAL SUBMITTALS

A. Welding certificates.

1.4 QUALITY ASSURANCE

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

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

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Structural Performance: Hangers and supports for HVAC piping and equipment shall withstand the effects of gravity loads and stresses within limits and under conditions indicated according to ASCE/SEI 7.

1. Design supports for multiple pipes, including pipe stands, capable of supporting combined weight of supported systems, system contents, and test water.
2. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.

2.2 METAL PIPE HANGERS AND SUPPORTS

A. Carbon-Steel Pipe Hangers and Supports:

1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
2. Galvanized Metallic Coatings: Pregalvanized, hot-dip galvanized, or electro-galvanized.
3. Nonmetallic Coatings: Plastic coated, or epoxy powder-coated.
4. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
5. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel.

B. Stainless Steel Pipe Hangers and Supports:

1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
2. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
3. Hanger Rods: Continuous-thread rod, nuts, and washer made of stainless steel.

C. Copper Pipe and Tube Hangers:

1. Description: MSS SP-58, Types 1 through 58, copper-plated steel, factory-fabricated components.
2. Hanger Rods: Continuous-thread rod, nuts, and washer made of copper-plated steel.

2.3 TRAPEZE PIPE HANGERS

A. Description: MSS SP-58, Type 59, shop- or field-fabricated pipe-support assembly made from structural carbon-steel shapes with MSS SP-58 carbon-steel hanger rods, nuts, saddles, and U-bolts.

2.4 PLASTIC PIPE HANGERS

A. Description: Similar to MSS SP-58, Types 1 through 58, factory-fabricated steel pipe hanger except hanger is made of plastic.

B. Hanger Rods: Continuous-thread rod, nuts, and washer made of galvanized steel.

C. Flammability: ASTM D635, ASTM E84, and UL 94.

2.5 METAL FRAMING SYSTEMS

A. MFMA Manufacturer Metal Framing Systems:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. ABB, Electrification Business.
   b. B-line; Eaton, Electrical Sector.
   c. Flex-Strut Inc.
   d. MIRO Industries.
   e. Unistrut; Atkore International.
   f. Wesanco, Inc.

2. Description: Shop- or field-fabricated, pipe-support assembly made of steel channels, accessories, fittings, and other components for supporting multiple parallel pipes.
3. Standard: Comply with MFMA-4 factory-fabricated components for field assembly.
4. Channels: Continuous slotted carbon-steel channel with inturned lips.
5. Channel Width: Selected for applicable load criteria.
6. Channel Nuts: Formed or stamped nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
7. Hanger Rods: Continuous-thread rod, nuts, and washer made of galvanized steel.
8. Metallic Coating: Hot-dip galvanized.
9. Paint Coating: For Pools, epoxy, acrylic, or urethane, color selected by architect.

B. Non-MFMA Manufacturer Metal Framing Systems:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Anvil International/Smith-Cooper International; Tailwind Capital, LLC.
   b. CADDY; nVent.
   c. MIRO Industries.
   d. PHD Manufacturing, Inc.
   e. RectorSeal HVAC; a CSW Industrials Company.

2. Description: Shop- or field-fabricated, pipe-support assembly made of steel channels, accessories, fittings, and other components for supporting multiple parallel pipes.
3. Standard: Comply with MFMA-4 factory-fabricated components for field assembly.
4. Channels: Continuous slotted carbon-steel channel with inturned lips.
5. Channel Width: Select for applicable load criteria.
6. Channel Nuts: Formed or stamped nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
7. Hanger Rods: Continuous-thread rod, nuts, and washer made of galvanized steel.
8. Metallic Coating: Hot-dip galvanized.
9. Paint Coating: For pools, epoxy, acrylic, or urethane color selected by architect.

2.6 THERMAL-HANGER SHIELD INSERTS

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

1. Buckaroos, Inc.
2. CADDY; nVent.
3. National Pipe Hanger Corporation.
4. Pipe Shields Inc.
5. Piping Technology & Products, Inc.
6. Rilco Manufacturing Co., Inc.

B. Insulation-Insert Material for Cold Piping: ASTM C552, Type II cellular glass with 100-psi or ASTM C591, Type VI, Grade 1 polyisocyanurate with 125-psi minimum compressive strength and vapor barrier.

C. Insulation-Insert Material for Hot Piping: ASTM C552, Type II cellular glass with 100-psi or ASTM C591, Type VI, Grade 1 polyisocyanurate with 125-psi minimum compressive strength.

D. For Trapeze or Clamped Systems: Insert and shield shall cover entire circumference of pipe.

E. For Clevis or Band Hangers: Insert and shield shall cover lower 180 degrees of pipe.

F. Insert Length: Extend 2 inches beyond sheet metal shield for piping operating below ambient air temperature.

2.7 FASTENER SYSTEMS

A. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Hilti, Inc.
   b. ITW Ramset/Red Head; Illinois Tool Works, Inc.
   c. MKT Fastening, LLC.
   d. Simpson Strong-Tie Co., Inc.

B. Mechanical-Expansion Anchors: Insert-wedge-type anchors for use in hardened portland cement concrete; with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. B-line; Eaton, Electrical Sector.
   b. Empire Tool and Manufacturing Co., Inc.
   c. Hilti, Inc.
   d. ITW Ramset/Red Head; Illinois Tool Works, Inc.
   e. MKT Fastening, LLC.

2. Indoor Applications: Zinc-coated steel.
3. Outdoor Applications: Stainless steel.

2.8 PIPE STANDS

A. General Requirements for Pipe Stands: Shop- or field-fabricated assemblies made of manufactured corrosion-resistant components to support roof-mounted piping.

B. Compact Pipe Stand:

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

b. Eberl Iron Works, Inc.
c. MIRO Industries.
d. PHP Systems/Design.
e. RectorSeal HVAC; a CSW Industrials Company.

2. Description: Single base unit with integral-rod roller, pipe clamps, or V-shaped cradle to support pipe, for roof installation without membrane penetration.
3. Base: Single, vulcanized rubber, molded polypropylene, or polycarbonate.
4. Hardware: Galvanized steel or polycarbonate.
5. Accessories: Protection pads.

C. Low-Profile, Single Base, Single-Pipe Stand:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. CADDY; nVent.
   b. Eberl Iron Works, Inc.
   c. MIRO Industries.
   d. PHP Systems/Design.

2. Description: Single base with vertical and horizontal members, and pipe support, for roof installation without membrane protection.
3. Base: Single, vulcanized rubber, molded polypropylene, or polycarbonate.
4. Vertical Members: Two, stainless-steel, continuous-thread 1/2-inch rods.
5. Horizontal Member: Adjustable horizontal, stainless-steel pipe support channels.
6. Pipe Supports: Roller.
7. Hardware: Stainless steel.
8. Accessories: Protection pads.
9. Height: 12 inches above roof.

D. High-Profile, Single Base, Single-Pipe Stand:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. CADDY; nVent.
   b. Eberl Iron Works, Inc.
   c. MIRO Industries.
   d. PHP Systems/Design.

2. Description: Single base, vertical and horizontal members, and pipe support, for roof installation without membrane penetration.
3. Base: Single vulcanized rubber or molded polypropylene.
4. Vertical Members: Two, stainless-steel, continuous-thread 1/2-inch rods.

5. Horizontal Member: One, adjustable height, stainless-steel pipe support slotted channel or plate.
6. Pipe Supports: Roller.
7. Hardware: Stainless steel.
8. Height: 36 inches above roof.

E. High-Profile, Multiple-Pipe Stand:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. CADDY; nVent.
   b. Eberl Iron Works, Inc.
   c. MIRO Industries.
   d. PHP Systems/Design.
   e. RectorSeal HVAC; a CSW Industrials Company.

2. Description: Assembly of bases, vertical and horizontal members, and pipe supports, for roof installation without membrane penetration.
3. Bases: Two or more; molded polypropylene.
4. Vertical Members: Two or more, stainless-steel channels.
5. Horizontal Members: One or more, adjustable height, stainless-steel pipe support.
6. Pipe Supports: Roller.
7. Hardware: Stainless steel.
8. Height: 36 inches above roof.

2.9 EQUIPMENT SUPPORTS

A. Description: Welded, shop- or field-fabricated equipment support made from structural carbon-steel shapes.

2.10 OUTDOOR EQUIPMENT STANDS

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

1. CADDY; nVent.
2. Eberl Iron Works, Inc.
3. MIRO Industries.
4. RectorSeal HVAC; a CSW Industrials Company.
5. Description: Individual foot supports with elevated adjustable channel cross bars and clamps/fasteners/bolts for ground or roof supported outdoor equipment

components, without roof membrane penetration, in a pre-fabricated system that can be modularly-assembled on site.

6. Foot Material: Rubber or polypropylene.
7. Rails Material: Hot dip galvanized carbon steel.
8. Wind/Sliding Load Resistance: Up to 100 mph minimum.

2.11 MATERIALS

A. Aluminum: ASTM B221.

B. Carbon Steel: ASTM A1011/A1011M.

C. Structural Steel: ASTM A36/A36M, carbon-steel plates, shapes, and bars; galvanized.

D. Stainless Steel: ASTM A240/A240M.

E. Threaded Rods: Continuously threaded. Zinc-plated or galvanized steel for indoor applications and stainless steel for outdoor applications. Mating nuts and washers of similar materials as rods.

F. Grout: ASTM C1107/C1107M, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout; suitable for interior and exterior applications.

1. Properties: Nonstaining, noncorrosive, and nongaseous.
2. Design Mix: 5000-psi, 28-day compressive strength.

PART 3 - EXECUTION

3.1 APPLICATION

A. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb.

3.2 HANGER AND SUPPORT INSTALLATION

A. Metal Pipe-Hanger Installation: Comply with MSS SP-58. Install hangers, supports, clamps, and attachments as required to properly support piping from the building structure.

B. Metal Trapeze Pipe-Hanger Installation: Comply with MSS SP-58. Arrange for grouping of parallel runs of horizontal piping, and support together on field-fabricated trapeze pipe hangers.

1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size or install intermediate supports for smaller diameter pipes as specified for individual pipe hangers.
2. Field fabricate from ASTM A36/A36M, carbon-steel shapes selected for loads being supported. Weld steel according to AWS D1.1/D1.1M.

C. Metal Framing System Installation: Arrange for grouping of parallel runs of piping, and support together on field-assembled strut systems.

D. Thermal-Hanger Shield Installation: Install in pipe hanger or shield for insulated piping.

E. Fastener System Installation:

1. Install powder-actuated fasteners for use in lightweight concrete or concrete slabs less than 4 inches thick in concrete after concrete is placed and completely cured. Use operators that are licensed by powder-actuated tool manufacturer. Install fasteners according to powder-actuated tool manufacturer's operating manual.
2. Install mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.

F. Pipe Stand Installation:

1. Pipe Stand Types except Curb-Mounted Type: Assemble components and mount on smooth roof surface. Do not penetrate roof membrane.
2. Curb-Mounted-Type Pipe Stands: Assemble components or fabricate pipe stand and mount on permanent, stationary roof curb. See Section 077200 "Roof Accessories" for curbs.

G. Install hangers and supports complete with necessary attachments, inserts, bolts, rods, nuts, washers, and other accessories.

H. Equipment Support Installation: Fabricate from welded-structural-steel shapes.

I. Install hangers and supports to allow controlled thermal and seismic movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.

J. Install lateral bracing with pipe hangers and supports to prevent swaying.

K. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.

L. Load Distribution: Install hangers and supports so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.

M. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and to not exceed maximum pipe deflections allowed by ASME B31.9 for building services piping.

N. Insulated Piping:

1. Attach clamps and spacers to piping.
    a. Piping Operating above Ambient Air Temperature: Clamp may project through insulation.
    b. Piping Operating below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.
    c. Do not exceed pipe stress limits allowed by ASME B31.9 for building services piping.

2. Install MSS SP-58, Type 39, protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.
    a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.

3. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.
    a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.

4. Shield Dimensions for Pipe: Not less than the following:
    a. NPS 1/4 to NPS 3-1/2: 12 inches long and 0.048 inch thick.
    b. NPS 4: 12 inches long and 0.06 inch thick.
    c. NPS 5 and NPS 6: 18 inches long and 0.06 inch thick.
    d. NPS 8 to NPS 14: 24 inches long and 0.075 inch thick.
    e. NPS 16 to NPS 24: 24 inches long and 0.105 inch thick.

5. Pipes NPS 8 and Larger: Include wood or reinforced calcium-silicate-insulation inserts of length at least as long as protective shield.
6. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.

3.3 EQUIPMENT SUPPORTS

A. Fabricate structural-steel stands to suspend equipment from structure overhead or to support equipment above floor.

B. Grouting: Place grout under supports for equipment and make bearing surface smooth.

C. Provide lateral bracing, to prevent swaying, for equipment supports.

3.4 METAL FABRICATIONS

A. Cut, drill, and fit miscellaneous metal fabrications for trapeze pipe hangers and equipment supports.

B. Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded because of shipping size limitations.

C. Field Welding: Comply with AWS D1.1/D1.1M procedures for shielded, metal arc welding; appearance and quality of welds; and methods used in correcting welding work; and with the following:

1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
2. Obtain fusion without undercut or overlap.
3. Remove welding flux immediately.
4. Finish welds at exposed connections so no roughness shows after finishing and so contours of welded surfaces match adjacent contours.

3.5 ADJUSTING

A. Hanger Adjustments: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.

B. Trim excess length of continuous-thread hanger and support rods to 1-1/2 inches.

3.6 PAINTING

A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.

1. Apply paint by brush or spray to provide a minimum dry film thickness of 2.0 mils.

B. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A780/A780M.

3.7 HANGER AND SUPPORT SCHEDULE

A. Specific hanger and support requirements are in Sections specifying piping systems and equipment.

B. Comply with MSS SP-58 for pipe-hanger selections and applications that are not specified in piping system Sections.

C. Use hangers and supports with galvanized metallic coatings for piping and equipment that will not have field-applied finish.

D. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.

E. Use carbon-steel pipe hangers and supports metal trapeze pipe hangers and metal framing systems and attachments for general service applications.

F. Use stainless steel pipe hangers and stainless steel or corrosion-resistant attachments for hostile environment applications such as crawlspaces, exterior, mechanical rooms and natatoriums.

G. Use copper-plated pipe hangers and copper or stainless steel attachments for copper piping and tubing.

H. Use padded hangers for piping that is subject to scratching.

I. Use thermal-hanger shield inserts for insulated piping and tubing.

J. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated, stationary pipes NPS 1/2 to NPS 30.
2. Yoke-Type Pipe Clamps (MSS Type 2): For suspension of up to 1050 deg F, pipes NPS 4 to NPS 24, requiring up to 4 inches of insulation.
3. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes NPS 3/4 to NPS 36, requiring clamp flexibility and up to 4 inches of insulation.

4. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes NPS 1/2 to NPS 24 if little or no insulation is required.
5. Pipe Hangers (MSS Type 5): For suspension of pipes NPS 1/2 to NPS 4, to allow off-center closure for hanger installation before pipe erection.
6. Adjustable, Swivel Split- or Solid-Ring Hangers (MSS Type 6): For suspension of noninsulated, stationary pipes NPS 3/4 to NPS 8.
7. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8.
8. Adjustable Band Hangers (MSS Type 9): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8.
9. Adjustable, Swivel-Ring Band Hangers (MSS Type 10): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8.
10. Split Pipe Ring with or without Turnbuckle Hangers (MSS Type 11): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 8.
11. Extension Hinged or Two-Bolt Split Pipe Clamps (MSS Type 12): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 3.
12. U-Bolts (MSS Type 24): For support of heavy pipes NPS 1/2 to NPS 30.
13. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.
14. Pipe Saddle Supports (MSS Type 36): For support of pipes NPS 4 to NPS 36, with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate.
15. Pipe Stanchion Saddles (MSS Type 37): For support of pipes NPS 4 to NPS 36, with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate, and with U-bolt to retain pipe.
16. Adjustable Pipe Saddle Supports (MSS Type 38): For stanchion-type support for pipes NPS 2-1/2 to NPS 36 if vertical adjustment is required, with steel-pipe base stanchion support and cast-iron floor flange.
17. Single-Pipe Rolls (MSS Type 41): For suspension of pipes NPS 1 to NPS 30, from two rods if longitudinal movement caused by expansion and contraction might occur.
18. Adjustable Roller Hangers (MSS Type 43): For suspension of pipes NPS 2-1/2 to NPS 24, from single rod if horizontal movement caused by expansion and contraction might occur.
19. Complete Pipe Rolls (MSS Type 44): For support of pipes NPS 2 to NPS 42 if longitudinal movement caused by expansion and contraction might occur but vertical adjustment is unnecessary.
20. Pipe Roll and Plate Units (MSS Type 45): For support of pipes NPS 2 to NPS 24 if small horizontal movement caused by expansion and contraction might occur and vertical adjustment is unnecessary.

21. Adjustable Pipe Roll and Base Units (MSS Type 46): For support of pipes NPS 2 to NPS 30 if vertical and lateral adjustment during installation might be required in addition to expansion and contraction.

K. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers NPS 3/4 to NPS 24.
2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers NPS 3/4 to NPS 24 if longer ends are required for riser clamps.

L. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches for heavy loads.
2. Steel Clevises (MSS Type 14): For 120 to 450 deg F piping installations.
3. Swivel Turnbuckles (MSS Type 15): For use with MSS Type 11, split pipe rings.
4. Malleable-Iron Sockets (MSS Type 16): For attaching hanger rods to various types of building attachments.
5. Steel Weldless Eye Nuts (MSS Type 17): For 120 to 450 deg F piping installations.

M. Building Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction, to attach to top flange of structural shape.
3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
6. C-Clamps (MSS Type 23): For structural shapes.
7. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.
8. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.
9. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.
10. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.

11. Malleable-Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.
12. Welded-Steel Brackets: For support of pipes from below or for suspending from above by using clip and rod. Use one of the following for indicated loads:
    a. Light (MSS Type 31): 750 lb.
    b. Medium (MSS Type 32): 1500 lb.
    c. Heavy (MSS Type 33): 3000 lb.
13. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
14. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.
15. Horizontal Travelers (MSS Type 58): For supporting piping systems subject to linear horizontal movement where headroom is limited.

N. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel-Pipe-Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.
2. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.
3. Thermal-Hanger Shield Inserts: For supporting insulated pipe.

O. Spring Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Restraint-Control Devices (MSS Type 47): Where indicated to control piping movement.
2. Spring Cushions (MSS Type 48): For light loads if vertical movement does not exceed 1-1/4 inches.
3. Spring-Cushion Roll Hangers (MSS Type 49): For equipping Type 41, roll hanger with springs.
4. Spring Sway Braces (MSS Type 50): To retard sway, shock, vibration, or thermal expansion in piping systems.
5. Variable-Spring Hangers (MSS Type 51): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from hanger.
6. Variable-Spring Base Supports (MSS Type 52): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from base support.
7. Variable-Spring Trapeze Hangers (MSS Type 53): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from trapeze support.

8. Constant Supports: For critical piping stress and if necessary to avoid transfer of stress from one support to another support, critical terminal, or connected equipment. Include auxiliary stops for erection, hydrostatic test, and load-adjustment capability. These supports include the following types:
    a. Horizontal (MSS Type 54): Mounted horizontally.
    b. Vertical (MSS Type 55): Mounted vertically.
    c. Trapeze (MSS Type 56): Two vertical-type supports and one trapeze member.

P. Comply with MSS SP-58 for trapeze pipe-hanger selections and applications that are not specified in piping system Sections.

Q. Comply with MFMA-103 for metal framing system selections and applications that are not specified in piping system Sections.

R. Use mechanical-expansion anchors instead of building attachments where required in concrete construction.

END OF SECTION 230529

SECTION 230553 - IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Equipment labels.
2. Warning signs and labels.
3. Warning tape.
4. Pipe labels.
5. Duct labels.
6. Valve tags.
7. Warning tags.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Equipment-Label Schedule: Include a listing of all equipment to be labeled with the proposed content for each label.

C. Valve-numbering scheme.

D. Valve Schedules: Provide for each piping system. Include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 EQUIPMENT LABELS

A. Plastic Labels for Equipment:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Brady Corporation.
   b. Brimar Industries, Inc.
   c. Craftmark Pipe Markers.
   d. Marking Services, Inc.

2. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch thick, with predrilled holes for attachment hardware.
3. Letter and Background Color: As indicated for specific application under Part 3.
4. Maximum Temperature: Able to withstand temperatures of up to 160 deg F.
5. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
6. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances of up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
7. Fasteners: Stainless steel rivets or self-tapping screws.
8. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

B. Label Content: Include equipment's Drawing designation or unique equipment number, Drawing numbers where equipment is indicated (plans, details, and schedules), and the Specification Section number and title where equipment is specified.

2.2 WARNING SIGNS AND LABELS

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

1. Brady Corporation.
2. Brimar Industries, Inc.
3. Craftmark Pipe Markers.
4. Marking Services Inc.

B. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch thick, with predrilled holes for attachment hardware.

C. Letter and Background Color: As indicated for specific application under Part 3.

D. Maximum Temperature: Able to withstand temperatures of up to 160 deg F.

E. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.

F. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances of up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.

G. Fasteners: Stainless steel rivets or self-taping screws.

H. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

I. Arc-Flash Warning Signs: Provide arc-flash warning signs in locations and with content in accordance with requirements of OSHA and NFPA70E and other applicable codes and standards.

J. Label Content: Include caution and warning information plus emergency notification instructions.

2.3 WARNING TAPE

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

1. Brady Corporation.
2. Brimar Industries, Inc.
3. Craftmark Pipe Markers.

B. Material: Vinyl.

C. Minimum Thickness: 0.005 inch.

D. Letter, Pattern, and Background Color: As indicated for specific application under Part 3.

E. Waterproof Adhesive Backing: Suitable for indoor or outdoor use.

F. Maximum Temperature: 160 deg F.

G. Minimum Width: 4 inches.

2.4 PIPE LABELS

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

1. Brady Corporation.
2. Brimar Industries, Inc.
3. Craftmark Pipe Markers.
4. Marking Services Inc.

B. General Requirements for Manufactured Pipe Labels: Preprinted, color coded, with lettering indicating service and showing flow direction in accordance with ASME A13.1.

C. Letter and Background Color: As indicated for specific application under Part 3.

D. Self-Adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.

E. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings. Also include:

1. Pipe size.
2. Flow-Direction Arrows: Include flow-direction arrows on distribution piping. Arrows may be either integral with label or applied separately.
3. Lettering Size: At least 1/2 inch for viewing distances of up to 72 inches and proportionately larger lettering for greater viewing distances.

2.5 DUCT LABELS

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

1. Brady Corporation.
2. Brimar Industries, Inc.
3. Craftmark Pipe Markers.
4. Marking Services Inc.

B. Self-Adhesive Duct Labels: Printed plastic with contact-type, permanent-adhesive backing.

C. Letter and Background Color: As indicated for specific application under Part 3.

D. Maximum Temperature: Able to withstand temperatures up to 160 deg F.

E. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.

F. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances of up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.

G. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

H. Duct Label Contents: Include identification of duct service using same designations or abbreviations as used on Drawings. Also include the following:

1. Duct size.
2. Flow-Direction Arrows: Include flow-direction arrows on distribution ducts. Arrows may be either integral with label or may be applied separately.
3. Lettering Size: At least 1/2 inch for viewing distances of up to 72 inches and proportionately larger lettering for greater viewing distances.

2.6 VALVE TAGS

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

1. Brady Corporation.
2. Brimar Industries, Inc.
3. Craftmark Pipe Markers.
4. Marking Services Inc.

B. Description: Stamped or engraved with 1/4-inch letters for piping system abbreviation and 1/2-inch numbers.

1. Tag Material: Brass, 0.04-inch minimum thickness, with predrilled or stamped holes for attachment hardware.
2. Fasteners: Brass wire or S-hook.

C. Letter and Background Color: As indicated for specific application under Part 3.

D. Valve Schedules: For each piping system, on 8-1/2-by-11-inch bond paper. Tabulate valve number, piping system, system abbreviation (as shown on valve tag), location of valve (room or space), normal-operating position (open, closed, or modulating), and variations for identification. Mark valves for emergency shutoff and similar special uses.

1. Include valve-tag schedule in operation and maintenance data.

2.7 WARNING TAGS

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

1. Brady Corporation.
2. Brimar Industries, Inc.
3. Craftmark Pipe Markers.

4. Marking Services Inc.

B. Description: Preprinted accident-prevention tags of plasticized card stock.

1. Size: 3 by 5-1/4 inches minimum.
2. Fasteners: Brass grommet and wire.
3. Nomenclature: Large-size primary caption, such as "DANGER," "CAUTION," or "DO NOT OPERATE."
4. Letter and Background Color: As indicated for specific application under Part 3.

PART 3 - EXECUTION

3.1 PREPARATION

A. Clean piping and equipment surfaces of incompatible primers, paints, and encapsulants, as well as dirt, oil, grease, release agents, and other substances that could impair bond of identification devices.

3.2 INSTALLATION, GENERAL REQUIREMENTS

A. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.

B. Coordinate installation of identifying devices with locations of access panels and doors.

C. Install identifying devices before installing acoustical ceilings and similar concealment.

D. Locate identifying devices so that they are readily visible from the point of normal approach.

3.3 INSTALLATION OF EQUIPMENT LABELS, WARNING SIGNS, AND LABELS

A. Permanently fasten labels on each item of mechanical equipment.

B. Sign and Label Colors:

1. White letters on an ANSI Z535.1 safety-blue background.

C. Locate equipment labels where accessible and visible.

D. Arc-Flash Warning Signs: Provide arc-flash warning signs on electrical disconnects and other equipment where arc-flash hazard exists, as indicated on Drawings, and in

accordance with requirements of OSHA and NFPA 70E, and other applicable codes and standards.

3.4 INSTALLATION OF WARNING TAPE

A. Warning Tape Color and Pattern: Yellow background with black diagonal stripes.

B. Install warning tape on pipes and ducts, with cross-designated walkways providing less than 6 ft. of clearance.

C. Locate tape so as to be readily visible from the point of normal approach.

3.5 INSTALLATION OF PIPE LABELS

A. Install pipe labels showing service and flow direction with permanent adhesive on pipes.

B. Pipe-Label Locations: Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:

1. Within 3 ft. of each valve and control device.
2. At access doors, manholes, and similar access points that permit view of concealed piping.
3. Within 3 ft. of equipment items and other points of origination and termination.
4. Spaced at maximum intervals of 25 ft. along each run. Reduce intervals to 10 ft. in areas of congested piping, ductwork, and equipment.

C. Do not apply plastic pipe labels or plastic tapes directly to bare pipes conveying fluids at temperatures of 125 deg F or higher. Where these pipes are to remain uninsulated, use a short section of insulation or use stenciled labels.

D. Flow-Direction Arrows: Use arrows to indicate direction of flow in pipes, including pipes where flow is allowed in both directions.

E. Pipe-Label Color Schedule:

1. Chilled-Water Piping: White letters on an ANSI Z535.1 safety-green background.
2. Condenser-Water Piping: White letters on an ANSI Z535.1 safety-green background.
3. Heating Water Piping: White letters on an ANSI Z535.1 safety-green background.
4. Refrigerant Piping: White letters on an ANSI Z535.1 safety-blue background.

5. Low-Pressure Steam Piping: Black letters on an ANSI Z535.1 safety-yellow background.
6. High-Pressure Steam Piping: Black letters on an ANSI Z535.1 safety-yellow background.
7. Steam Condensate Piping: Black letters on an ANSI Z535.1 safety-yellow background.
8. Toxic and Corrosive Fluids: Black letters on an ANSI Z535.1 safety-orange background.
9. Flammable Fluids: Black letters on an ANSI Z535.1 safety-yellow background.
10. Combustible Fluids: White letters on an ANSI Z535.1 safety-brown background.

3.6 INSTALLATION OF DUCT LABELS

A. Install self-adhesive duct labels showing service and flow direction with permanent adhesive on air ducts.

1. Provide labels in the following color codes:
   a. For air supply ducts: White letters on blue background.
   b. For air return ducts: White letters on blue background**.**
   c. For exhaust-, outside-, relief-, return-, and mixed-air ducts: White letters on blue background.

B. Locate label near each point where ducts enter into and exit from concealed spaces and at maximum intervals of 20 ft. where exposed or are concealed by removable ceiling system.

3.7 INSTALLATION OF VALVE TAGS

A. Install tags on valves and control devices in piping systems, except check valves, valves within factory-fabricated equipment units, shutoff valves, and HVAC terminal devices and similar roughing-in connections of end-use fixtures and units. List tagged valves in a valve schedule in the operating and maintenance manual.

B. Valve-Tag Application Schedule: Tag valves according to size, shape, and color scheme and with captions similar to those indicated in "Valve-Tag Size and Shape" Subparagraph below.

1. Valve-Tag Size and Shape:
   a. Chilled Water: 1-1/2 inches, round.
   b. Condenser Water: 1-1/2 inches, round.
   c. Refrigerant: 1-1/2 inches, round.
   d. Hot Water: 1-1/2 inches, round.

e. Gas: 1-1/2 inches, round.
f. Low-Pressure Steam: 1-1/2 inches, round.
g. High-Pressure Steam: 1-1/2 inches, round.
h. Steam Condensate: 1-1/2 inches, round.

2. Valve-Tag Colors:
   a. For each piping system, use the same lettering and background coloring system on valve tags as used for the Pipe Label Schedule text and background.

3.8 INSTALLATION OF WARNING TAGS

A. Warning Tag Color: Black letters on an ANSI Z535.1 safety-yellow background.

B. Attach warning tags, with proper message, to equipment and other items where scheduled.

END OF SECTION 230553

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SECTION 230593 - TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Balancing Air Systems:
    a. Variable-air-volume systems.
2. Balancing steam systems.
3. Testing, Adjusting, and Balancing Equipment:
    a. Motors.
    b. Heat-transfer coils.
4. Testing, adjusting, and balancing existing systems and equipment.
5. Sound tests.
6. Vibration tests.
7. Duct leakage tests.
8. Control system verification.

1.2 DEFINITIONS

A. AABC: Associated Air Balance Council.

B. BAS: Building automation systems.

C. NEBB: National Environmental Balancing Bureau.

D. TAB: Testing, adjusting, and balancing.

E. TABB: Testing, Adjusting, and Balancing Bureau.

F. TAB Specialist: An independent entity meeting qualifications to perform TAB work.

G. TDH: Total dynamic head.

1.3 PREINSTALLATION MEETINGS

A. TAB Conference: If requested by the Owner, conduct a TAB conference at Project site after approval of the TAB strategies and procedures plan to develop a mutual understanding of the details. Provide a minimum of 14 days' advance notice of scheduled meeting time and location.

1. Minimum Agenda Items:
    a. The Contract Documents examination report.
    b. The TAB plan.
    c. Needs for coordination and cooperation of trades and subcontractors.
    d. Proposed procedures for documentation and communication flow.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: Within 30 days of Contractor's Notice to Proceed, submit documentation that the TAB specialist and this Project's TAB team members meet the qualifications specified in "Quality Assurance" Article.

B. Contract Documents Examination Report: Within 60 days of Contractor's Notice to Proceed, submit the Contract Documents review report as specified in Part 3.

C. Strategies and Procedures Plan: Within 60 days of Contractor's Notice to Proceed, submit TAB strategies and step-by-step procedures as specified in "Preparation" Article.

D. System Readiness Checklists: Within 60 days of Contractor's Notice to Proceed, submit system readiness checklists as specified in "Preparation" Article.

E. Examination Report: Submit a summary report of the examination review required in "Examination" Article.

F. Certified TAB reports.

G. Sample report forms.

H. Instrument calibration reports, to include the following:

1. Instrument type and make.
2. Serial number.
3. Application.
4. Dates of use.
5. Dates of calibration.

1.5 QUALITY ASSURANCE

A. TAB Specialists Qualifications: Certified by AABC.

1. TAB Field Supervisor: Employee of the TAB specialist and certified by AABC.
2. TAB Technician: Employee of the TAB specialist and certified by AABC as a TAB technician.

B. TAB Specialists Qualifications: Certified by NEBB.

1. TAB Field Supervisor: Employee of the TAB specialist and certified by NEBB.
2. TAB Technician: Employee of the TAB specialist and certified by NEBB as a TAB technician.

C. Instrumentation Type, Quantity, Accuracy, and Calibration: Comply with requirements in ASHRAE 111, Section 4, "Instrumentation."

D. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6.7.2.3 - "System Balancing."

1.6 FIELD CONDITIONS

A. Full Owner Occupancy: Owner will occupy the site and existing building during entire TAB period. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.

B. Partial Owner Occupancy: Owner may occupy completed areas of building before Substantial Completion. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine the Contract Documents to become familiar with Project requirements and to discover conditions in systems designs that may preclude proper TAB of systems and equipment.

B. Examine installed systems for balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers. Verify that locations of these balancing devices are applicable for intended purpose and are accessible.

C. Examine the approved submittals for HVAC systems and equipment.

D. Examine design data including HVAC system descriptions, statements of design assumptions for environmental conditions and systems output, and statements of philosophies and assumptions about HVAC system and equipment controls.

E. Examine ceiling plenums and underfloor air plenums used for supply, return, or relief air to verify that they are properly separated from adjacent areas. Verify that penetrations in plenum walls are sealed and fire-stopped if required.

F. Examine equipment performance data including fan and pump curves.

1. Relate performance data to Project conditions and requirements, including system effects that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.
2. Calculate system-effect factors to reduce performance ratings of HVAC equipment when installed under conditions different from the conditions used to rate equipment performance. To calculate system effects for air systems, use tables and charts found in AMCA 201, "Fans and Systems," or in SMACNA's "HVAC Systems - Duct Design." Compare results with the design data and installed conditions.

G. Examine system and equipment installations and verify that field quality-control testing, cleaning, and adjusting specified in individual Sections have been performed.

H. Examine test reports specified in individual system and equipment Sections.

I. Examine HVAC equipment and verify that bearings are greased, belts are aligned and tight, filters are clean, and equipment with functioning controls is ready for operation.

J. Examine terminal units, such as variable-air-volume boxes, and verify that they are accessible and their controls are connected and functioning.

K. Examine strainers. Verify that startup screens have been replaced by permanent screens with indicated perforations.

L. Examine control valves for proper installation for their intended function of throttling, diverting, or mixing fluid flows.

M. Examine heat-transfer coils for correct piping connections and for clean and straight fins.

N. Examine system pumps to ensure absence of entrained air in the suction piping.

O. Examine operating safety interlocks and controls on HVAC equipment.

P. Report deficiencies discovered before and during performance of TAB procedures. Observe and record system reactions to changes in conditions. Record default set points if different from indicated values.

3.2 PREPARATION

A. Prepare a TAB plan that includes the following:

1. Equipment and systems to be tested.
2. Strategies and step-by-step procedures for balancing the systems.
3. Instrumentation to be used.
4. Sample forms with specific identification for all equipment.

B. Perform system-readiness checks of HVAC systems and equipment to verify system readiness for TAB work. Include, at a minimum, the following:

1. Airside:
    a. Verify that leakage and pressure tests on air distribution systems have been satisfactorily completed.
    b. Duct systems are complete with terminals installed.
    c. Volume, smoke, and fire dampers are open and functional.
    d. Clean filters are installed.
    e. Fans are operating, free of vibration, and rotating in correct direction.
    f. Variable-frequency controllers' startup is complete and safeties are verified.
    g. Automatic temperature-control systems are operational.
    h. Ceilings are installed.
    i. Windows and doors are installed.
    j. Suitable access to balancing devices and equipment is provided.

2. Hydronics:
    a. Verify leakage and pressure tests on water distribution systems have been satisfactorily completed.
    b. Piping is complete with terminals installed.
    c. Water treatment is complete.
    d. Systems are flushed, filled, and air purged.
    e. Strainers are pulled and cleaned.

f. Control valves are functioning per the sequence of operation.
g. Shutoff and balance valves have been verified to be 100 percent open.
h. Pumps are started and proper rotation is verified.
i. Pump gage connections are installed directly at pump inlet and outlet flanges or in discharge and suction pipe prior to valves or strainers.
j. Variable-frequency controllers' startup is complete and safeties are verified.
k. Suitable access to balancing devices and equipment is provided.

3.3 GENERAL PROCEDURES FOR TESTING AND BALANCING

A. Perform testing and balancing procedures on each system according to the procedures contained in AABC's "National Standards for Total System Balance" and in this Section.

B. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary for TAB procedures.

1. After testing and balancing, patch probe holes in ducts with same material and thickness as used to construct ducts.
2. After testing and balancing, install test ports and duct access doors that comply with requirements in Section 233300 "Air Duct Accessories."
3. Install and join new insulation that matches removed materials. Restore insulation, coverings, vapor barrier, and finish according to Section 230713 "Duct Insulation," Section 230716 "HVAC Equipment Insulation," and Section 230719 "HVAC Piping Insulation."

C. Mark equipment and balancing devices, including damper-control positions, valve position indicators, fan-speed-control levers, and similar controls and devices, with paint or other suitable, permanent identification material to show final settings.

D. Take and report testing and balancing measurements in inch-pound (IP) units.

3.4 GENERAL PROCEDURES FOR BALANCING AIR SYSTEMS

A. Prepare test reports for both fans and outlets. Obtain manufacturer's outlet factors and recommended testing procedures. Cross-check the summation of required outlet volumes with required fan volumes.

B. Prepare schematic diagrams of systems' "as-built" duct layouts.

C. For variable-air-volume systems, develop a plan to simulate diversity.

D. Determine the best locations in main and branch ducts for accurate duct-airflow measurements.

E. Check airflow patterns from the outdoor-air louvers and dampers and the return- and exhaust-air dampers through the supply-fan discharge and mixing dampers.

F. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.

G. Verify that motor starters are equipped with properly sized thermal protection.

H. Check dampers for proper position to achieve desired airflow path.

I. Check for airflow blockages.

J. Check condensate drains for proper connections and functioning.

K. Check for proper sealing of air-handling-unit components.

L. Verify that air duct system is sealed as specified in Section 233113 "Metal Ducts."

3.5 PROCEDURES FOR VARIABLE-AIR-VOLUME SYSTEMS

A. Adjust the variable-air-volume systems as follows:

1. Verify that the system static pressure sensor is located two-thirds of the distance down the duct from the fan discharge.
2. Verify that the system is under static pressure control.
3. Select the terminal unit that is most critical to the supply-fan airflow. Measure inlet static pressure, and adjust system static pressure control set point so the entering static pressure for the critical terminal unit is not less than the sum of the terminal-unit manufacturer's recommended minimum inlet static pressure plus the static pressure needed to overcome terminal-unit discharge system losses.
4. Calibrate and balance each terminal unit for maximum and minimum design airflow as follows:
    a. Adjust controls so that terminal is calling for maximum airflow. Some controllers require starting with minimum airflow. Verify calibration procedure for specific project.
    b. Measure airflow and adjust calibration factor as required for design maximum airflow. Record calibration factor.
    c. When maximum airflow is correct, balance the air outlets downstream from terminal units.
    d. Adjust controls so that terminal is calling for minimum airflow.
    e. Measure airflow and adjust calibration factor as required for design minimum airflow. Record calibration factor. If no minimum calibration is available, note any deviation from design airflow.

f. When in full cooling or full heating, ensure that there is no mixing of hot-deck and cold-deck airstreams unless so designed.
g. On constant volume terminals, in critical areas where room pressure is to be maintained, verify that the airflow remains constant over the full range of full cooling to full heating. Note any deviation from design airflow or room pressure.

5. After terminals have been calibrated and balanced, test and adjust system for total airflow. Adjust fans to deliver total design airflows within the maximum allowable fan speed listed by fan manufacturer.
   a. Set outside-air, return-air, and relief-air dampers for proper position that simulates minimum outdoor-air conditions.
   b. Set terminals for maximum airflow. If system design includes diversity, adjust terminals for maximum and minimum airflow so that connected total matches fan selection and simulates actual load in the building.
   c. Where duct conditions allow, measure airflow by Pitot-tube traverse. If necessary, perform multiple Pitot-tube traverses to obtain total airflow.
   d. Where duct conditions are not suitable for Pitot-tube traverse measurements, a coil traverse may be acceptable.
   e. If a reliable Pitot-tube traverse or coil traverse is not possible, measure airflow at terminals and calculate the total airflow.

6. Measure fan static pressures as follows:
   a. Measure static pressure directly at the fan outlet or through the flexible connection.
   b. Measure static pressure directly at the fan inlet or through the flexible connection.
   c. Measure static pressure across each component that makes up the air-handling system.
   d. Report any artificial loading of filters at the time static pressures are measured.

7. Set final return and outside airflow to the fan while operating at maximum return airflow and minimum outdoor airflow.
   a. Balance the return-air ducts and inlets the same as described for constant-volume air systems.
   b. Verify that terminal units are meeting design airflow under system maximum flow.

8. Re-measure the inlet static pressure at the most critical terminal unit and adjust the system static pressure set point to the most energy-efficient set point to maintain the optimum system static pressure. Record set point and give to controls contractor.

9. Verify final system conditions as follows:
    a. Re-measure and confirm that minimum outdoor, return, and relief airflows are within design. Readjust to match design if necessary.
    b. Re-measure and confirm that total airflow is within design.
    c. Re-measure final fan operating data, rpms, volts, amps, and static profile.
    d. Mark final settings.
    e. Test system in economizer mode. Verify proper operation and adjust if necessary. Measure and record all operating data.
    f. Verify tracking between supply and return fans.

3.6 PROCEDURES FOR STEAM SYSTEMS

A. Measure and record upstream and downstream pressure of each piece of equipment.

B. Measure and record upstream and downstream steam pressure of pressure-reducing valves.

C. Check settings and operation of automatic temperature-control valves, self-contained control valves, and pressure-reducing valves. Record final settings.

D. Check settings and operation of each safety valve. Record settings.

E. Verify the operation of each steam trap.

3.7 PROCEDURES FOR MOTORS

A. Motors 1/2 HP and Larger: Test at final balanced conditions and record the following data:

1. Manufacturer's name, model number, and serial number.
2. Motor horsepower rating.
3. Motor rpm.
4. Phase and hertz.
5. Nameplate and measured voltage, each phase.
6. Nameplate and measured amperage, each phase.
7. Starter size and thermal-protection-element rating.
8. Service factor and frame size.

B. Motors Driven by Variable-Frequency Controllers: Test manual bypass of controller to prove proper operation.

3.8 PROCEDURES FOR HEAT-TRANSFER COILS

A. Measure, adjust, and record the following data for each steam coil:

1. Dry-bulb temperature of entering and leaving air.
2. Airflow.
3. Inlet steam pressure.

3.9 DUCT LEAKAGE TESTS

A. Witness the duct pressure testing performed by Installer.

B. Verify that proper test methods are used and that leakage rates are within specified tolerances.

C. Report deficiencies observed.

3.10 CONTROLS VERIFICATION

A. In conjunction with system balancing, perform the following:

1. Verify temperature control system is operating within the design limitations.
2. Confirm that the sequences of operation are in compliance with Contract Documents.
3. Verify that controllers are calibrated and function as intended.
4. Verify that controller set points are as indicated.
5. Verify the operation of lockout or interlock systems.
6. Verify the operation of valve and damper actuators.
7. Verify that controlled devices are properly installed and connected to correct controller.
8. Verify that controlled devices travel freely and are in position indicated by controller: open, closed, or modulating.
9. Verify location and installation of sensors to ensure that they sense only intended temperature, humidity, or pressure.

B. Reporting: Include a summary of verifications performed, remaining deficiencies, and variations from indicated conditions.

3.11 TOLERANCES

A. Set HVAC system's airflow rates and water flow rates within the following tolerances:

1. Supply, Return, and Exhaust Fans and Equipment with Fans: Plus or minus 10 percent.
2. Air Outlets and Inlets: Plus or minus 10 percent.
3. Heating-Water Flow Rate: Plus or minus 10 percent.
4. Cooling-Water Flow Rate: Plus or minus 10 percent.

B. Maintaining pressure relationships as designed shall have priority over the tolerances specified above.

3.12 PROGRESS REPORTING

A. Initial Construction-Phase Report: Based on examination of the Contract Documents as specified in "Examination" Article, prepare a report on the adequacy of design for systems balancing devices. Recommend changes and additions to systems balancing devices to facilitate proper performance measuring and balancing. Recommend changes and additions to HVAC systems and general construction to allow access for performance measuring and balancing devices.

3.13 FINAL REPORT

A. General: Prepare a certified written report; tabulate and divide the report into separate sections for tested systems and balanced systems.

1. Include a certification sheet at the front of the report's binder, signed and sealed by the certified testing and balancing engineer.
2. Include a list of instruments used for procedures, along with proof of calibration.
3. Certify validity and accuracy of field data.

B. Final Report Contents: In addition to certified field-report data, include the following:
1. Fan curves.
2. Manufacturers' test data.
3. Field test reports prepared by system and equipment installers.
4. Other information relative to equipment performance; do not include Shop Drawings and Product Data.

C. General Report Data: In addition to form titles and entries, include the following data:

1. Title page.
2. Name and address of the TAB specialist.
3. Project name.
4. Project location.
5. Architect's name and address.

6. Engineer's name and address.
7. Contractor's name and address.
8. Report date.
9. Signature of TAB supervisor who certifies the report.
10. Table of Contents with the total number of pages defined for each section of the report. Number each page in the report.
11. Summary of contents including the following:
    a. Indicated versus final performance.
    b. Notable characteristics of systems.
    c. Description of system operation sequence if it varies from the Contract Documents.

12. Nomenclature sheets for each item of equipment.
13. Data for terminal units, including manufacturer's name, type, size, and fittings.
14. Notes to explain why certain final data in the body of reports vary from indicated values.
15. Test conditions for fans and pump performance forms including the following:
    a. Settings for outdoor-, return-, and exhaust-air dampers.
    b. Conditions of filters.
    c. Cooling coil, wet- and dry-bulb conditions.
    d. Face and bypass damper settings at coils.
    e. Fan drive settings including settings and percentage of maximum pitch diameter.
    f. Inlet vane settings for variable-air-volume systems.
    g. Settings for supply-air, static-pressure controller.
    h. Other system operating conditions that affect performance.

D. System Diagrams: Include schematic layouts of air and hydronic distribution systems. Present each system with single-line diagram and include the following:

1. Quantities of outdoor, supply, return, and exhaust airflows.
2. Water and steam flow rates.
3. Duct, outlet, and inlet sizes.
4. Pipe and valve sizes and locations.
5. Terminal units.
6. Balancing stations.
7. Position of balancing devices.

E. Air-Handling-Unit Test Reports: For air-handling units with coils, include the following:

1. Unit Data:
    a. Unit identification.
    b. Location.

c. Make and type.
d. Model number and unit size.
e. Manufacturer's serial number.
f. Unit arrangement and class.
g. Discharge arrangement.
h. Sheave make, size in inches , and bore.
i. Center-to-center dimensions of sheave and amount of adjustments in inches.
j. Number, make, and size of belts.
k. Number, type, and size of filters.

2. Motor Data:
a. Motor make, and frame type and size.
b. Horsepower and rpm.
c. Volts, phase, and hertz.
d. Full-load amperage and service factor.
e. Sheave make, size in inches, and bore.
f. Center-to-center dimensions of sheave and amount of adjustments in inches.

3. Test Data (Indicated and Actual Values):
a. Total airflow rate in cfm.
b. Total system static pressure in inches wg.
c. Fan rpm.
d. Discharge static pressure in inches wg.
e. Filter static-pressure differential in inches wg.
f. Cooling-coil static-pressure differential in inches wg.
g. Heating-coil static-pressure differential in inches wg.
h. Outdoor airflow in cfm.
i. Return airflow in cfm.
j. Outdoor-air damper position.
k. Return-air damper position.

F. Apparatus-Coil Test Reports:

1. Coil Data:
a. System identification.
b. Location.
c. Coil type.
d. Number of rows.
e. Fin spacing in fins per inch o.c.
f. Make and model number.
g. Face area in sq. ft..

h. Tube size in NPS.
i. Tube and fin materials.
j. Circuiting arrangement.

2. Test Data (Indicated and Actual Values):
   a. Airflow rate in cfm.
   b. Average face velocity in fpm.
   c. Air pressure drop in inches wg.
   d. Outdoor-air, wet- and dry-bulb temperatures in deg F.
   e. Return-air, wet- and dry-bulb temperatures in deg F.
   f. Entering-air, wet- and dry-bulb temperatures in deg F.
   g. Leaving-air, wet- and dry-bulb temperatures in deg F.
   h. Water flow rate in gpm.
   i. Water pressure differential in feet of head or psig.
   j. Entering-water temperature in deg F.
   k. Leaving-water temperature in deg F.
   l. Refrigerant expansion valve and refrigerant types.
   m. Refrigerant suction pressure in psig.
   n. Refrigerant suction temperature in deg F.
   o. Inlet steam pressure in psig.

G. Fan Test Reports: For supply, return, and exhaust fans, include the following:

1. Fan Data:
   a. System identification.
   b. Location.
   c. Make and type.
   d. Model number and size.
   e. Manufacturer's serial number.
   f. Arrangement and class.
   g. Sheave make, size in inches, and bore.
   h. Center-to-center dimensions of sheave and amount of adjustments in inches.

2. Motor Data:
   a. Motor make, and frame type and size.
   b. Horsepower and rpm.
   c. Volts, phase, and hertz.
   d. Full-load amperage and service factor.
   e. Sheave make, size in inches, and bore.
   f. Center-to-center dimensions of sheave, and amount of adjustments in inches.
   g. Number, make, and size of belts.

3. Test Data (Indicated and Actual Values):
    a. Total airflow rate in cfm.
    b. Total system static pressure in inches wg.
    c. Fan rpm.
    d. Discharge static pressure in inches wg.
    e. Suction static pressure in inches wg.

H. Round, Flat-Oval, and Rectangular Duct Traverse Reports: Include a diagram with a grid representing the duct cross-section and record the following:

1. Report Data:
    a. System and air-handling-unit number.
    b. Location and zone.
    c. Traverse air temperature in deg F.
    d. Duct static pressure in inches wg.
    e. Duct size in inches.
    f. Duct area in sq. ft.
    g. Indicated airflow rate in cfm.
    h. Indicated velocity in fpm.
    i. Actual airflow rate in cfm.
    j. Actual average velocity in fpm.
    k. Barometric pressure in psig.

I. Instrument Calibration Reports:

1. Report Data:
    a. Instrument type and make.
    b. Serial number.
    c. Application.
    d. Dates of use.
    e. Dates of calibration.

3.14 VERIFICATION OF TAB REPORT

A. The TAB specialist's test and balance engineer shall conduct the inspection in the presence of Construction Manager or Owner’s Representative and the commissioning authority.

B. The Architect and/or the Commissioning authority shall randomly select measurements, documented in the final report, to be rechecked. Rechecking shall be limited to either 10 percent of the total measurements recorded or the extent of measurements that can be accomplished in a normal 8-hour business day.

C. If rechecks yield measurements that differ from the measurements documented in the final report by more than the tolerances allowed, the measurements shall be noted as "FAILED."

D. If the number of "FAILED" measurements is greater than 10 percent of the total measurements checked during the final inspection, the testing and balancing shall be considered incomplete and shall be rejected.

E. If TAB work fails, proceed as follows:

1. TAB specialists shall recheck all measurements and make adjustments. Revise the final report and balancing device settings to include all changes; resubmit the final report and request a second final inspection.
2. If the second final inspection also fails, Owner may contract the services of another TAB specialist to complete TAB work according to the Contract Documents and deduct the cost of the services from the original TAB specialist's final payment.
3. If the second verification also fails, design professional may contact AABC Headquarters regarding the AABC National Performance Guaranty.

F. Prepare test and inspection reports.

3.15 ADDITIONAL TESTS

A. Within 90 days of completing TAB, perform additional TAB to verify that balanced conditions are being maintained throughout and to correct unusual conditions.

B. Seasonal Periods: If initial TAB procedures were not performed during near-peak summer and winter conditions, perform additional TAB during near-peak summer and winter conditions.

END OF SECTION 230593

SECTION 230713 - DUCT INSULATION

PART 1 - GENERAL

1.1 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include thermal conductivity, water-vapor permeance thickness, and jackets (both factory- and field-applied if any).

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

1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
2. Detail insulation application at elbows, fittings, dampers, specialties and flanges for each type of insulation.
3. Detail application of field-applied jackets.
4. Detail application at linkages of control devices.

1.2 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified Installer.

B. Material Test Reports: From a qualified testing agency acceptable to authorities having jurisdiction indicating, interpreting, and certifying test results for compliance of insulation materials, sealers, attachments, cements, and jackets, with requirements indicated. Include dates of tests and test methods employed.

C. Field quality-control reports.

1.3 QUALITY ASSURANCE

A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or craft training program.

B. Mockups: Before installing insulation, build mockups for each type of insulation and finish listed below to demonstrate quality of insulation application and finishes. Build mockups in the location indicated or, if not indicated, as directed by Architect. Use materials indicated for the completed Work.

1. Ductwork Mockups:
    a. One 10-foot section each of rectangular and round straight duct.
    b. One each of a 90-degree mitered round and rectangular elbow, and one each of a 90-degree radius round and rectangular elbow.
    c. One rectangular branch takeoff and one round branch takeoff from a rectangular duct. One round tee fitting.
    d. One rectangular and round transition fitting.
    e. Four support hangers for round and rectangular ductwork.
    f. Each type of damper and specialty.

2. For each mockup, fabricate cutaway sections to allow observation of application details for insulation materials, adhesives, mastics, attachments, and jackets.
3. Notify Architect seven days in advance of dates and times when mockups will be constructed.
4. Obtain Architect's approval of mockups before starting insulation application.
5. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.
6. Maintain mockups during construction in an undisturbed condition as a standard for judging the completed Work.
7. Demolish and remove mockups when directed.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Packaging: Insulation material containers are to be marked with the manufacturer's name, appropriate ASTM standard designation, type and grade, and maximum use temperature.

1.5 COORDINATION

A. Coordinate sizes and locations of supports, hangers, and insulation shields.

B. Coordinate clearance requirements with duct Installer for duct insulation application. Before preparing ductwork Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.

1.6 SCHEDULING

A. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products in accordance with ASTM E84, by a testing agency acceptable to authorities having jurisdiction. Factory label insulation, jacket materials, adhesive, mastic, tapes, and cement material containers with appropriate markings of applicable testing agency.

1. All Insulation Installed Indoors and Outdoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.

2.2 INSULATION MATERIALS

A. Comply with requirements in "Duct Insulation Schedule, General," "Indoor Duct and Plenum Insulation Schedule," and "Aboveground, Outdoor Duct and Plenum Insulation Schedule" articles for where insulating materials are to be applied.

B. Products do not contain asbestos, lead, mercury, or mercury compounds.

C. Products that come in contact with stainless steel have a leachable chloride content of less than 50 ppm when tested in accordance with ASTM C871.

D. Insulation materials for use on austenitic stainless steel are qualified as acceptable in accordance with ASTM C795.

E. Foam insulation materials do not use CFC or HCFC blowing agents in the manufacturing process.

F. Glass-Fiber Blanket: Glass fibers bonded with a thermosetting resin; suitable for maximum use temperature up to 450 deg F in accordance with ASTM C411. Comply with ASTM C553, Type II, and ASTM C1290, Type III with factory-applied FSK jacket. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Johns Manville; a Berkshire Hathaway company.
   b. Knauf Insulation.
   c. Manson Insulation Inc.
   d. Owens Corning.

G. Glass-Fiber Board Insulation: Glass fibers bonded with a thermosetting resin; suitable for maximum use temperature between 35 deg F and 250 deg F for jacketed and between 35 deg F and 450 deg F for unfaced in accordance with ASTM C411. Comply with ASTM C612, Type IA or Type IB. For duct and plenum applications, provide insulation with factory-applied FSK jacket. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Johns Manville; a Berkshire Hathaway company.
   b. Knauf Insulation.
   c. Manson Insulation Inc.
   d. Owens Corning.

H. Glass-Fiber, Pipe and Tank: Glass fibers bonded with a thermosetting resin; suitable for maximum use temperature between 35 deg F and 850 deg F, in accordance with ASTM C411. Comply with ASTM C1393.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Johns Manville; a Berkshire Hathaway company.
   b. Knauf Insulation.
   c. Manson Insulation Inc.
   d. Owens Corning.

2. Semirigid board material with factory-applied FSK jacket.
3. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

I. Polyolefin: Polyethylene thermal plastic insulation. Comply with ASTM C1427, Type I, Grade 1 for tubular materials and Type II, Grade 1 for sheet materials.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Armacell LLC.
   b. Nomaco.
   c. Sekisui Voltek, LLC.

d. Thermaduct.

2.3 FIRE-RATED INSULATION SYSTEMS

A. Fire-Rated Board: Structural-grade, press-molded, xonolite calcium silicate, fireproofing board suitable for operating temperatures up to 1700 deg F. Comply with ASTM C656, Type II, Grade 6. Tested and certified to provide a 2-hour fire rating by an NRTL acceptable to authorities having jurisdiction.

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. Johns Manville; a Berkshire Hathaway company.

B. Fire-Rated Blanket: High-temperature, flexible, blanket insulation with FSK jacket that is tested and certified to provide a 2-hour fire rating by an NRTL acceptable to authorities having jurisdiction.

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. 3M.
   b. Thermal Ceramics.
   c. Unifrax Corporation.

2.4 ADHESIVES

A. Materials are compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated.

B. Glass-Fiber and Mineral Wool Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Childers Brand; H. B. Fuller Construction Products.
   b. Eagle Bridges - Marathon Industries.
   c. Foster Brand; H. B. Fuller Construction Products.
   d. Mon-Eco Industries, Inc.

C. ASJ Adhesive, and FSK Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Childers Brand; H. B. Fuller Construction Products.
   b. Eagle Bridges - Marathon Industries.
   c. Foster Brand; H. B. Fuller Construction Products.
   d. Mon-Eco Industries, Inc.

D. PVC Jacket Adhesive: Compatible with PVC jacket.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Johns Manville; a Berkshire Hathaway company.
   b. Proto Corporation.
   c. Sekisui Voltek, LLC.
   d. Speedline Corporation.

2.5 MASTICS AND COATINGS

A. Materials are compatible with insulation materials, jackets, and substrates.

B. Vapor-Retarder Mastic, Water Based, Interior Use: Suitable for indoor use on below ambient services.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Childers Brand; H. B. Fuller Construction Products.
   b. Foster Brand; H. B. Fuller Construction Products.
   c. Knauf Insulation.
   d. Vimasco Corporation.

2. Water-Vapor Permeance: Comply with ASTM C755, Section 7.2.2, Table 2, for insulation type and service conditions.
3. Service Temperature Range: Minus 20 to plus 180 deg F.
4. Comply with MIL-PRF-19565C, Type II, for permeance requirements.
5. Color: White.

C. Vapor-Retarder Mastic, Solvent Based, Exterior Use: Suitable for outdoor use on below ambient services.

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

   a. Childers Brand; H. B. Fuller Construction Products.

b. Eagle Bridges - Marathon Industries.
c. Foster Brand; H. B. Fuller Construction Products.

2. Water-Vapor Permeance: Comply with ASTM C755, Section 7.2.2, Table 2, for insulation type and service conditions.
3. Service Temperature Range: Minus 50 to plus 220 deg F.
4. Color: White.

D. Breather Mastic: Water based; suitable for indoor and outdoor use on above ambient services.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Childers Brand; H. B. Fuller Construction Products.
   b. Eagle Bridges - Marathon Industries.
   c. Foster Brand; H. B. Fuller Construction Products.
   d. Knauf Insulation.
   e. Vimasco Corporation.

2. Water-Vapor Permeance: ASTM E96/E96M, greater than 1.0 perm at manufacturer's recommended dry film thickness.
3. Service Temperature Range: Minus 20 to plus 180 deg F.
4. Color: White.

2.6 LAGGING ADHESIVES

A. Description: Comply with MIL-A-3316C, Class I, Grade A and are compatible with insulation materials, jackets, and substrates.

1. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over duct insulation.
2. Service Temperature Range: 0 to plus 180 deg F.
3. Color: White.

2.7 SEALANTS

A. FSK and Metal Jacket Flashing Sealants:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Childers Brand; H. B. Fuller Construction Products.
   b. Eagle Bridges - Marathon Industries.

c. Foster Brand; H. B. Fuller Construction Products.
d. Mon-Eco Industries, Inc.

2. Materials are compatible with insulation materials, jackets, and substrates.
3. Fire- and water-resistant, flexible, elastomeric sealant.
4. Service Temperature Range: Minus 40 to plus 250 deg F.
5. Color: Aluminum.

B. ASJ Flashing Sealants, and Vinyl and PVC Jacket Flashing Sealants:

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. Childers Brand; H. B. Fuller Construction Products.
   b. Foster Brand; H. B. Fuller Construction Products.

2. Materials are compatible with insulation materials, jackets, and substrates.
3. Fire- and water-resistant, flexible, elastomeric sealant.
4. Service Temperature Range: Minus 40 to plus 250 deg F.
5. Color: White.

2.8 FACTORY-APPLIED JACKETS

A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:

1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C1136, Type I.
2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C1136, Type I.
3. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C1136, Type II.
4. FSP Jacket: Aluminum-foil, fiberglass-reinforced scrim with polyethylene backing; complying with ASTM C1136, Type II.
5. Vinyl Jacket: White vinyl with a permeance of 1.3 perms when tested in accordance with ASTM E96/E96M, Procedure A, and complying with NFPA 90A and NFPA 90B.
6. ASJ+: All-service jacket composed of aluminum foil reinforced with glass scrim bonded to a kraft paper interleaving with an outer film leaving no paper exposed; complying with ASTM C1136, Types I, II, III, IV, and VII.
7. PSK Jacket: Aluminum foil, fiberglass-reinforced scrim with polyethylene backing; complying with ASTM C1136, Type II.

2.9 FIELD-APPLIED JACKETS

A. Field-applied jackets comply with ASTM C921, Type I, unless otherwise indicated.

B. FSK Jacket: Aluminum-foil-face, fiberglass-reinforced scrim with kraft-paper backing.

C. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Johns Manville; a Berkshire Hathaway company.
   b. P.I.C. Plastics, Inc.
   c. Proto Corporation.
   d. Speedline Corporation.

2. Adhesive: As recommended by jacket material manufacturer.
3. Color: White.

D. Metal Jacket:

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. Johns Manville; a Berkshire Hathaway company.
   b. RPR Products, Inc.

2. Aluminum Jacket: Comply with ASTM B209, Alloy 3003, 3005, 3105, or 5005, Temper H-14.
   a. Factory cut and rolled to size.
   b. Finish and thickness are indicated in field-applied jacket schedules.
   c. Moisture Barrier: 3-mil- thick polysurlyn.

2.10 FIELD-APPLIED FABRIC-REINFORCING MESH

A. Woven Glass-Fiber Mesh: Approximately 6 oz./sq. yd. with a thread count of 5 strands by 5 strands/sq. in. for covering ducts.

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. Childers Brand; H. B. Fuller Construction Products.

b. Foster Brand; H. B. Fuller Construction Products.

B. Woven Polyester Mesh: Approximately 1 oz./sq. yd. with a thread count of 10 strands by 10 strands/sq. in., in a Leno weave, for ducts.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Childers Brand; H. B. Fuller Construction Products.
   b. Foster Brand; H. B. Fuller Construction Products.
   c. Vimasco Corporation.

2.11 FIELD-APPLIED CLOTHS

A. Woven Glass-Fiber Cloth: Comply with MIL-C-20079H, Type I, plain weave, and presized a minimum of 8 oz./sq. yd..

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. Alpha Associates, Inc.

2.12 TAPES

A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C1136.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. 3M Industrial Adhesives and Tapes Division.
   b. Avery Dennison Corporation, Specialty Tapes Division.
   c. Ideal Tape Co., Inc., an American Biltrite Company.
   d. Knauf Insulation.

2. Width: 3 inches.
3. Thickness: 11.5 mils.
4. Adhesion: 90 ounces force/inch in width.
5. Elongation: 2 percent.
6. Tensile Strength: 40 lbf/inch in width.
7. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.

B. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C1136.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. 3M Industrial Adhesives and Tapes Division.
   b. Avery Dennison Corporation, Specialty Tapes Division.
   c. Ideal Tape Co., Inc., an American Biltrite Company.
   d. Knauf Insulation.

2. Width: 3 inches75 mm.
3. Thickness: 6.5 mils.
4. Adhesion: 90 ounces force/inch in width.
5. Elongation: 2 percent.
6. Tensile Strength: 40 lbf/inch in width.
7. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.

C. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive; suitable for indoor and outdoor applications.

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. 3M Industrial Adhesives and Tapes Division.
   b. Ideal Tape Co., Inc., an American Biltrite Company.

2. Width: 2 inches.
3. Thickness: 6 mils.
4. Adhesion: 64 ounces force/inch in width.
5. Elongation: 500 percent.
6. Tensile Strength: 18 lbf/inch in width.

D. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. 3M Industrial Adhesives and Tapes Division.
   b. Avery Dennison Corporation, Specialty Tapes Division.
   c. Ideal Tape Co., Inc., an American Biltrite Company.
   d. Knauf Insulation.

2. Width: 2 inches50 mm.
3. Thickness: 3.7 mils.
4. Adhesion: 100 ounces force/inch in width.
5. Elongation: 5 percent.
6. Tensile Strength: 34 lbf/inch in width.

2.13 SECUREMENTS

A. Bands:

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. Johns Manville; a Berkshire Hathaway company.
   b. RPR Products, Inc.

2. Aluminum: ASTM B209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch thick, 1/2 inch wide with wing seal or closed seal.

B. Insulation Pins and Hangers:

1. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch- or larger diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch galvanized carbon-steel washer.
   a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      1) AGM Industries, Inc.
      2) CL WARD & Family Inc.
      3) Gemco.
      4) Midwest Fasteners, Inc.
      5) Nelson Stud Welding.

2. Metal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:
   a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      1) AGM Industries, Inc.
      2) Gemco.
      3) Midwest Fasteners, Inc.

   b. Baseplate: Perforated, galvanized carbon-steel sheet, 0.030 inch thick by 2 inches square.
   c. Spindle: Copper- or zinc-coated, low-carbon steel, fully annealed, 0.106-inch- diameter shank, length to suit depth of insulation indicated.
   d. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.

3. Nonmetal Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- thick nylon sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.
   a. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
      1) Gemco.
      2) Midwest Fasteners, Inc.

C. Staples: Outward-clinching insulation staples, nominal 3/4-inch- wide, stainless steel or Monel.

D. Wire: 0.062-inch soft-annealed, stainless steel.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. C & F Wire.
   b. Johns Manville; a Berkshire Hathaway company.
   c. RPR Products, Inc.

2.14 CORNER ANGLES

A. Aluminum Corner Angles: 0.040 inch thick, minimum 1 by 1 inch, aluminum in accordance with ASTM B209, Alloy 3003, 3005, 3105, or 5005; Temper H-14.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of insulation application.

1. Verify that systems to be insulated have been tested and are free of defects.
2. Verify that surfaces to be insulated are clean and dry.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

3.3 GENERAL INSTALLATION REQUIREMENTS

A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of ducts and fittings.

B. Install insulation materials, vapor barriers or retarders, jackets, and thicknesses required for each item of duct system as specified in insulation system schedules.

C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, compress, or otherwise damage insulation or jacket.

D. Install insulation with longitudinal seams at top and bottom of horizontal runs.

E. Install multiple layers of insulation with longitudinal and end seams staggered.

F. Keep insulation materials dry during application and finishing. Replace insulation materials that get wet during storage or in the installation process before being properly covered and sealed in accordance with Contract Documents.

G. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.

H. Install insulation with least number of joints practical.

I. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.

1. Install insulation continuously through hangers and around anchor attachments.
2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.

J. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.

K. Install insulation with factory-applied jackets as follows:

1. Draw jacket tight and smooth, but not to the extent of creating wrinkles or areas of compression in the insulation.

2. Cover circumferential joints with 3-inch- wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches o.c.
3. Overlap jacket longitudinal seams at least 1-1/2 inches. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 2 inches o.c.
    a. For below ambient services, apply vapor-barrier mastic over staples.
4. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.
5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to duct flanges and fittings.

L. Cut insulation in a manner to avoid compressing insulation.

M. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

N. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

3.4 PENETRATIONS

A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.

1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches below top of roof flashing.
4. Seal jacket to roof flashing with flashing sealant.

B. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.

1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor

insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.

3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches.
4. Seal jacket to wall flashing with flashing sealant.

C. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.

D. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Terminate insulation at fire damper sleeves for fire-rated wall and partition penetrations. Externally insulate damper sleeves to match adjacent insulation and overlap duct insulation at least 2 inches.

1. Comply with requirements in Section 078413 "Penetration Firestopping."

E. Insulation Installation at Floor Penetrations:

1. Duct: For penetrations through fire-rated assemblies, terminate insulation at fire damper sleeves and externally insulate damper sleeve beyond floor to match adjacent duct insulation. Overlap damper sleeve and duct insulation at least 2 inches.
2. Seal penetrations through fire-rated assemblies.

3.5 INSTALLATION OF FLEXIBLE ELASTOMERIC AND POLYOLEFIN INSULATION

A. Comply with manufacturer's written installation instructions and ASTM C1710.

B. Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

C. Square and Rectangular Ducts and Plenums:

1. Provide 1/4 inch more per side for a tight, compression fit.
2. Cut sheet insulation with the following dimensions:
   a. Width of duct plus 1/4 inch, one piece.
   b. Height of duct plus 1/4 inch, plus thickness of insulation, two pieces.
   c. Width of duct plus 1/4 inch, plus two times the thickness of insulation, one piece.

3. Insulate the bottom of the duct with the sheet from (a) above, then the sides with the two sheets from (b) above, and finally the top of the duct with the sheet from (c) above.

4. Insulation without self-adhering backing:
    a. Apply 100 percent coverage of manufacturer adhesive on the metal surface, then the insulation, except for the last 1/4 inch where sheets will butt together.
    b. Roll sheet down into position.
    c. Press two sheets together under compression and apply adhesive at the butt joint to seal the two sheets together.

5. Insulation with self-adhering backing:
    a. Peel back release paper in 6- to 8-inch increments and line up sheet.
    b. Press firmly to activate adhesive.
    c. Align material and continue to line up correctly, pressing firmly while slowly removing release paper.
    d. Allow 1/4-inch overlap for compression at butt joints.
    e. Apply adhesive at the butt joint to seal the two sheets together.

6. Insulate duct brackets following manufacturer's written installation instructions.

D. Circular Ducts:

1. Determine the circumference of the duct, using a strip of insulation the same thickness as to be used.
2. Cut the sheet to the required size.
3. Apply 100 percent coverage of manufacturer adhesive on the metal surface then the insulation.
4. Apply manufacturer adhesive to the cut surfaces along 100 percent of the longitudinal seam. Press together the seam at the ends and then the middle. Close the entire seam starting from the middle.

3.6 INSTALLATION OF GLASS-FIBER AND MINERAL-WOOL INSULATION

A. Blanket Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.

B. Comply with manufacturer's written installation instructions.

1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 percent coverage of duct and plenum surfaces.
2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
3. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:

a. On duct sides with dimensions 18 inches and smaller, place pins along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints, and 16 inches o.c.
b. On duct sides with dimensions larger than 18 inches, place pins 16 inches o.c. each way, and 3 inches maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
d. Do not overcompress insulation during installation.
e. Impale insulation over pins and attach speed washers.
f. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.

4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches from one edge and one end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch outward-clinching staples, 1 inch o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.
   a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
   b. Install vapor stops for ductwork and plenums operating below 50 deg F at 18-foot intervals. Vapor stops consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to two times the insulation thickness, but not less than 3 inches.

5. Overlap unfaced blankets a minimum of 2 inches on longitudinal seams and end joints. At end joints, secure with steel bands spaced a maximum of 18 inches o.c.
6. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.
7. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch- wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches o.c.

C. Board Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.

1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 percent coverage of duct and plenum surfaces.

2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
3. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:
    a. On duct sides with dimensions 18 inches and smaller, place pins along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints, and 16 inches o.c.
    b. On duct sides with dimensions larger than 18 inches, space pins 16 inches o.c. each way, and 3 inches maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
    c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
    d. Do not overcompress insulation during installation.
    e. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.

4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches from one edge and one end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch outward-clinching staples, 1 inch o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.
    a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
    b. Install vapor stops for ductwork and plenums operating below 50 deg F at 18-foot intervals. Vapor stops consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to two times the insulation thickness, but not less than 3 inches.

5. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Groove and score insulation to fit as closely as possible to outside and inside radius of elbows. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.
6. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch- wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches o.c.

3.7 FIELD-APPLIED JACKET INSTALLATION

A. Where glass-cloth jackets are indicated, install directly over bare insulation or insulation with factory-applied jackets.

1. Draw jacket smooth and tight to surface with 2-inch overlap at seams and joints.
2. Embed glass cloth between two 0.062-inch- thick coats of lagging adhesive.
3. Completely encapsulate insulation with coating, leaving no exposed insulation.

B. Where FSK jackets are indicated, install as follows:

1. Draw jacket material smooth and tight.
2. Install lap or joint strips with same material as jacket.
3. Secure jacket to insulation with manufacturer's recommended adhesive.
4. Install jacket with 1-1/2-inch laps at longitudinal seams and 3-inch- wide joint strips at end joints.
5. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-barrier mastic.

C. Where PVC jackets are indicated, install with 1-inch overlap at longitudinal seams and end joints; for horizontal applications, install with longitudinal seams along top and bottom of tanks and vessels. Seal with manufacturer's recommended adhesive.

1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.

D. Where metal jackets are indicated, install with 2-inch overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless steel bands 12 inches o.c. and at end joints.

3.8 FIRE-RATED INSULATION SYSTEM INSTALLATION

A. Comply with manufacturer's written installation instructions.

B. Where fire-rated insulation system is indicated, secure system to ducts and duct hangers and supports to maintain a continuous fire rating.

C. Insulate duct access panels and doors to achieve same fire rating as duct.

D. Install firestopping at penetrations through fire-rated assemblies.

3.9 DUCT AND PLENUM INSULATION SCHEDULE

A. Interior supply air ductwork.

1. Concealed Locations: Mineral-Fiber Blanket; R-6.
2. Exposed Locations: Mineral-Fiber Board; R-6.
3. Exception: Supply air ductwork exposed to view in conditioned spaces served by ductwork shall not be insulated.

B. Interior outdoor air ductwork and plenums.

1. Concealed Locations: Mineral-Fiber Blanket; R-12
2. Exposed Locations: Mineral-Fiber Board; R-12

C. Interior exhaust air ductwork and plenums (3 feet from penetration of building exterior or isolation damper, whichever is longer).

1. Concealed Locations: Mineral-Fiber Blanket; R-12
2. Exposed Locations: Mineral-Fiber Board; R-12

D. Items Not Insulated:

1. Metal ducts with duct line of sufficient thickness to comply with energy code and ASHRAE/IESNA 90.1.
2. Double-wall ducts with interstitial insulation of sufficient thickness to comply with energy code and ASHRAE/IESNA 90.1.
3. Factory-insulated flexible ducts.
4. Factory-insulated plenums and casings.
5. Flexible connectors.
6. Vibration-control devices.
7. Factory-insulated access panels and doors.

END OF SECTION 230713

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SECTION 230719 - HVAC PIPING INSULATION

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes insulation for HVAC piping systems.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product. Include thermal conductivity, water-vapor permeance thickness, and jackets (both factory and field applied if any).

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

1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
2. Detail attachment and covering of heat tracing inside insulation.
3. Detail insulation application at pipe expansion joints for each type of insulation.
4. Detail insulation application at elbows, fittings, flanges, valves, and specialties for each type of insulation.
5. Detail removable insulation at piping specialties.
6. Detail application of field-applied jackets.
7. Detail application at linkages of control devices.

1.3 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified Installer.

B. Material Test Reports: From a qualified testing agency acceptable to authorities having jurisdiction indicating, interpreting, and certifying test results for compliance of insulation materials, sealers, attachments, cements, and jackets, with requirements indicated. Include dates of tests and test methods employed.

C. Field quality-control reports.

1.4 QUALITY ASSURANCE

A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the Department of Labor, Bureau of Apprenticeship and Training.

B. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products in accordance with ASTM E84, by a testing agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.

1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Packaging: Insulation material containers shall be marked by manufacturer with appropriate ASTM standard designation, type and grade, and maximum use temperature.

1.6 COORDINATION

A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

B. Coordinate clearance requirements with piping Installer for piping insulation application. Before preparing piping Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.

C. Coordinate installation and testing of heat tracing.

1.7 SCHEDULING

A. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.

B. Complete installation and concealment of plastic materials as rapidly as possible in each area of construction.

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

A. Comply with requirements in "Piping Insulation Schedule, General," "Indoor Piping Insulation Schedule," "Outdoor, Aboveground Piping Insulation Schedule," and "Outdoor, Underground Piping Insulation Schedule" articles for where insulating materials shall be applied.

B. Products shall not contain asbestos, lead, mercury, or mercury compounds.

C. Products that come into contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested in accordance with ASTM C871.

D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable in accordance with ASTM C795.

E. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

F. Flexible Elastomeric: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C534/C534M, Type I for tubular materials, Type II for sheet materials.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Aeroflex USA.
   b. Airex Manufacturing.
   c. Armacell LLC.
   d. K-Flex USA.

G. Mineral-Fiber, Preformed Pipe: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C547.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Johns Manville; a Berkshire Hathaway company.
   b. Knauf Insulation.
   c. Manson Insulation Inc.
   d. Owens Corning.
2. Preformed Pipe Insulation: Type I, Grade A with factory-applied ASJ.
3. 850 deg F.
4. Factory fabricate shapes in accordance with ASTM C450 and ASTM C585.
5. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

2.2 INSULATING CEMENTS

A. Mineral-Fiber Insulating Cement: Comply with ASTM C195.

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. Ramco Insulation, Inc.

B. Mineral-Fiber, Hydraulic-Setting Insulating and Finishing Cement: Comply with ASTM C449.

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. Ramco Insulation, Inc.

2.3 ADHESIVES

A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated.

B. Flexible Elastomeric and Polyolefin Adhesive: Solvent-based adhesive.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Aeroflex USA.
   b. Armacell LLC.
   c. K-Flex USA.
2. Flame-spread index shall be 25 or less and smoke-developed index shall be 50 or less as tested in accordance with ASTM E84.
3. Wet Flash Point: Below 0 deg F.
4. Service Temperature Range: 40 to 200 deg F.
5. Color: Black.

C. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Childers Brand; H. B. Fuller Construction Products.
   b. Foster Brand; H. B. Fuller Construction Products.
   c. Mon-Eco Industries, Inc.

D. ASJ Adhesive and FSK and PVDC Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A, for bonding insulation jacket lap seams and joints.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Childers Brand; H. B. Fuller Construction Products.
   b. Foster Brand; H. B. Fuller Construction Products.
   c. Mon-Eco Industries, Inc.

E. PVC Jacket Adhesive: Compatible with PVC jacket.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Johns Manville; a Berkshire Hathaway company.
   b. P.I.C. Plastics, Inc.
   c. Speedline Corporation.
   d. The Dow Chemical Company.

2.4 MASTICS AND COATINGS

A. Materials shall be compatible with insulation materials, jackets, and substrates.

B. Vapor-Retarder Mastic, Water Based: Suitable for indoor use on below-ambient services.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Childers Brand; H. B. Fuller Construction Products.
   b. Foster Brand; H. B. Fuller Construction Products.
   c. Knauf Insulation.
   d. Vimasco Corporation.
2. Water-Vapor Permeance: Comply with ASTM E96/E96M or ASTM F1249.
3. Service Temperature Range: 0 to plus 180 deg F.
4. Comply with MIL-PRF-19565C, Type II, for permeance requirements, with supplier listing on DOD QPD - Qualified Products Database.
5. Color: White.

C. Vapor-Retarder Mastic, Solvent Based, Outdoor Use: Suitable for outdoor use on below-ambient services.

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. Childers Brand; H. B. Fuller Construction Products.

b. Foster Brand; H. B. Fuller Construction Products.
2. Water-Vapor Permeance: Comply with ASTM E96/E96M or ASTM F1249.
3. Service Temperature Range: Minus 50 to plus 220 deg F.
4. Color: White.

2.5 LAGGING ADHESIVES

A. Adhesives shall comply with MIL-A-3316C, Class I, Grade A, and shall be compatible with insulation materials, jackets, and substrates.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Childers Brand; H. B. Fuller Construction Products.
   b. Foster Brand; H. B. Fuller Construction Products.
   c. Vimasco Corporation.
2. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over pipe insulation.
3. Service Temperature Range: 0 to plus 180 deg F.
4. Color: White.

2.6 SEALANTS

A. Materials shall be as recommended by the insulation manufacturer and shall be compatible with insulation materials, jackets, and substrates.

B. Joint Sealants:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Childers Brand; H. B. Fuller Construction Products.
   b. Foster Brand; H. B. Fuller Construction Products.
   c. Mon-Eco Industries, Inc.
2. Permanently flexible, elastomeric sealant.
   a. Service Temperature Range: Minus 150 to plus 250 deg F.
   b. Color: White or gray.

C. FSK and Metal Jacket Flashing Sealants:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Childers Brand; H. B. Fuller Construction Products.
   b. Foster Brand; H. B. Fuller Construction Products.
   c. Mon-Eco Industries, Inc.

2. Fire- and water-resistant, flexible, elastomeric sealant.
3. Service Temperature Range: Minus 40 to plus 250 deg F.
4. Color: Aluminum.

D. ASJ Flashing Sealants and PVDC and PVC Jacket Flashing Sealants:

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. Childers Brand; H. B. Fuller Construction Products.
2. Fire- and water-resistant, flexible, elastomeric sealant.
3. Service Temperature Range: Minus 40 to plus 250 deg F.
4. Color: White.

2.7 FACTORY-APPLIED JACKETS

A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:

1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C1136, Type I.
2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C1136, Type I.
3. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C1136, Type II.

2.8 FIELD-APPLIED JACKETS

A. Field-applied jackets shall comply with ASTM C1136, Type I, unless otherwise indicated.

B. FSK Jacket: Aluminum-foil-face, fiberglass-reinforced scrim with kraft-paper backing.

C. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Johns Manville; a Berkshire Hathaway company.
   b. P.I.C. Plastics, Inc.
   c. Proto Corporation.
   d. Speedline Corporation.
2. Adhesive: As recommended by jacket material manufacturer.
3. Color: White.

4. Factory-fabricated fitting covers to match jacket if available; otherwise, field fabricate.
    a. Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, unions, reducers, end caps, soil-pipe hubs, traps, mechanical joints, and P-trap and supply covers for lavatories.

D. Metal Jacket:

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. RPR Products, Inc.
2. Aluminum Jacket: Comply with ASTM B209, Alloy 3003, 3005, 3105, or 5005, Temper H-14.
    a. Factory cut and rolled to size.
    b. Finish and thickness are indicated in field-applied jacket schedules.
    c. Moisture Barrier for Indoor Applications: 3-mil-thick, heat-bonded polyethylene and kraft paper.
    d. Moisture Barrier for Outdoor Applications: 3-mil-thick, heat-bonded polyethylene and kraft paper.
    e. Factory-Fabricated Fitting Covers:
        1) Same material, finish, and thickness as jacket.
        2) Preformed two-piece or gore, 45- and 90-degree, short- and long-radius elbows.
        3) Tee covers.
        4) Flange and union covers.
        5) End caps.
        6) Beveled collars.
        7) Valve covers.
        8) Field fabricate fitting covers only if factory-fabricated fitting covers are not available.

E. Self-Adhesive Outdoor Jacket: 60-mil- thick, laminated vapor barrier and waterproofing membrane for installation over insulation located aboveground outdoors; consisting of a rubberized bituminous resin on a cross-laminated polyethylene film covered with white aluminum-foil facing.

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. Polyguard Products, Inc.

2.9 TAPES

A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C1136.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. 3M Industrial Adhesives and Tapes Division.
   b. Avery Dennison Corporation, Specialty Tapes Division.
   c. Ideal Tape Co., Inc., an American Biltrite Company.
   d. Knauf Insulation.
2. Width: 3 inches.
3. Thickness: 11.5 mils.
4. Adhesion: 90 ounces force/inch in width.
5. Elongation: 2 percent.
6. Tensile Strength: 40 lbf/inch in width.
7. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.

B. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C1136.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. 3M Industrial Adhesives and Tapes Division.
   b. Avery Dennison Corporation, Specialty Tapes Division.
   c. Ideal Tape Co., Inc., an American Biltrite Company.
   d. Knauf Insulation.
2. Width: 3 inches.
3. Thickness: 6.5 mils.
4. Adhesion: 90 ounces force/inch in width.
5. Elongation: 2 percent.
6. Tensile Strength: 40 lbf/inch in width.
7. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.

C. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive; suitable for indoor and outdoor applications.

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. 3M Industrial Adhesives and Tapes Division.
   b. Ideal Tape Co., Inc., an American Biltrite Company.

2. Width: 2 inches.
3. Thickness: 6 mils.
4. Adhesion: 64 ounces force/inch in width.
5. Elongation: 500 percent.
6. Tensile Strength: 18 lbf/inch in width.

D. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. 3M Industrial Adhesives and Tapes Division.
   b. Avery Dennison Corporation, Specialty Tapes Division.
   c. Ideal Tape Co., Inc., an American Biltrite Company.
   d. Knauf Insulation.
2. Width: 2 inches.
3. Thickness: 3.7 mils.
4. Adhesion: 100 ounces force/inch in width.
5. Elongation: 5 percent.
6. Tensile Strength: 34 lbf/inch in width.

2.10 SECUREMENTS

A. Bands:

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. RPR Products, Inc.
2. Stainless Steel: ASTM A240/A240M, Type 304 or Type 316; 0.015 inch thick, 1/2 inch wide with wing seal or closed seal.
3. Aluminum: ASTM B209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch thick, 1/2 inch wide with wing seal or closed seal.
4. Springs: Twin spring set constructed of stainless steel, with ends flat and slotted to accept metal bands. Spring size is determined by manufacturer for application.

B. Staples: Outward-clinching insulation staples, nominal 3/4 inch wide, stainless steel or Monel.

C. Wire: 0.062-inch soft-annealed, galvanized steel.

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. C & F Wire.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of insulation application.

1. Verify that systems to be insulated have been tested and are free of defects.
2. Verify that surfaces to be insulated are clean and dry.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Clean and dry surfaces to receive insulation. Remove materials that will adversely affect in

B. sulation application.

C. Clean and prepare surfaces to be insulated.

D. Coordinate insulation installation with the tradesman installing heat tracing. Comply with requirements for heat tracing that apply to insulation.

E. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless steel surfaces, use demineralized water.

3.3 GENERAL INSTALLATION REQUIREMENTS

A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of piping, including fittings, valves, and specialties.

B. Install insulation materials, forms, vapor barriers or retarders, jackets, and of thicknesses required for each item of pipe system, as specified in insulation system schedules.

C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.

D. Install insulation with longitudinal seams at top and bottom of horizontal runs.

E. Install multiple layers of insulation with longitudinal and end seams staggered.

F. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.

G. Keep insulation materials dry during storage, application, and finishing. Replace insulation materials that get wet.

H. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.

I. Install insulation with least number of joints practical.

J. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.

1. Install insulation continuously through hangers and around anchor attachments.
2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends attached to structure with vapor-barrier mastic.
3. Install insert materials and insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.

K. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.

L. Install insulation with factory-applied jackets as follows:

1. Draw jacket tight and smooth.
2. Cover circumferential joints with 3-inch- wide strips, of same material as insulation jacket. Secure strips with adhesive and outward-clinching staples along both edges of strip, spaced 4 inches o.c.
3. Overlap jacket longitudinal seams at least 1-1/2 inches. Install insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward-clinching staples along edge at 2 inches (50 mm) o.c.
    a. For below-ambient services, apply vapor-barrier mastic over staples.
4. Cover joints and seams with tape, in accordance with insulation material manufacturer's written instructions, to maintain vapor seal.
5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to pipe flanges and fittings.

M. Cut insulation in a manner to avoid compressing insulation more than 25 percent of its nominal thickness.

N. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

O. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches in similar fashion to butt joints.

P. For above-ambient services, do not install insulation to the following:

1. Vibration-control devices.
2. Testing agency labels and stamps.
3. Nameplates and data plates.

3.4 PENETRATIONS

A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.

1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches below top of roof flashing.
4. Seal jacket to roof flashing with flashing sealant.

B. Insulation Installation at Underground Exterior Wall Penetrations: Terminate insulation flush with sleeve seal. Seal terminations with flashing sealant.

C. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.

1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches.
4. Seal jacket to wall flashing with flashing sealant.

D. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.

E. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions.

F. Insulation Installation at Floor Penetrations:

1. Pipe: Install insulation continuously through floor penetrations.

3.5 GENERAL PIPE INSULATION INSTALLATION

A. Requirements in this article generally apply to all insulation materials, except where more specific requirements are specified in various pipe insulation material installation articles.

B. Insulation Installation on Fittings, Valves, Strainers, Flanges, Mechanical Couplings, and Unions:

1. Install insulation over fittings, valves, strainers, flanges, mechanical couplings, unions, and other specialties with continuous thermal and vapor-retarder integrity unless otherwise indicated.
2. Insulate pipe elbows using preformed fitting insulation made from same material and density as that of adjacent pipe insulation. Each piece shall be butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.
3. Insulate tee fittings with preformed fitting insulation of same material and thickness as that used for adjacent pipe. Cut sectional pipe insulation to fit. Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.
4. Insulate valves using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as that used for adjacent pipe. Overlap adjoining pipe insulation by not less than 2 times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.
5. Insulate strainers using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as that used for adjacent pipe. Overlap adjoining pipe insulation by not less than 2 times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Fill joints, seams, and irregular surfaces with insulating cement. Insulate strainers, so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and

jacket. Provide a removable reusable insulation cover. For below-ambient services, provide a design that maintains vapor barrier.

6. Insulate flanges, mechanical couplings, and unions using a section of oversized preformed pipe insulation to fit. Overlap adjoining pipe insulation by not less than 2 times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Stencil or label the outside insulation jacket of each union with the word "union" matching size and color of pipe labels.
7. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below-ambient services and a breather mastic for above-ambient services. Reinforce the mastic with fabric-reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.
8. For services not specified to receive a field-applied jacket, except for flexible elastomeric and polyolefin, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing, using PVC tape.

C. Insulate instrument connections for thermometers, pressure gages, pressure temperature taps, test connections, flow meters, sensors, switches, and transmitters on insulated pipes. Shape insulation at these connections by tapering it to and around the connection with insulating cement and finish with finishing cement, mastic, and flashing sealant.

D. Install removable insulation covers at all serviceable locations such as unions, gauges, petes plugs control valves, strainers, and equipment connections. Installation shall conform to the following:

1. Make removable flange and union insulation from sectional pipe insulation of same thickness as that on adjoining pipe. Install same insulation jacket as that of adjoining pipe insulation.
2. When flange and union covers are made from sectional pipe insulation, extend insulation from flanges or union at least 2 times the insulation thickness over adjacent pipe insulation on each side of flange or union. Secure flange cover in place with stainless steel or aluminum bands. Select band material compatible with insulation and jacket.
3. Construct removable valve insulation covers in same manner as for flanges, except divide the two-part section on the vertical center line of valve body.
4. When covers are made from block insulation, make two halves, each consisting of mitered blocks wired to stainless steel fabric. Secure this wire frame, with its attached insulation, to flanges with tie wire. Extend insulation at least 2 inches over adjacent pipe insulation on each side of valve. Fill space between flange or union cover and pipe insulation with insulating cement. Finish cover assembly with insulating cement applied in two coats. After first coat is dry, apply and trowel second coat to a smooth finish.

5. Unless a PVC jacket is indicated in field-applied jacket schedules, finish exposed surfaces with a metal jacket.

3.6 INSTALLATION OF FLEXIBLE ELASTOMERIC INSULATION

A. Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

B. Insulation Installation on Pipe Flanges:

1. Install pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of sheet insulation of same thickness as that of pipe insulation.
4. Secure insulation to flanges and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install mitered sections of pipe insulation.
2. Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed valve covers manufactured of same material as that of pipe insulation when available.
2. When preformed valve covers are not available, install cut sections of pipe and sheet insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.
4. Secure insulation to valves and specialties, and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

3.7 INSTALLATION OF MINERAL-FIBER INSULATION

A. Insulation Installation on Straight Pipes and Tubes:

1. Secure each layer of preformed pipe insulation to pipe with wire or bands, and tighten bands without deforming insulation materials.
2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
3. For insulation with factory-applied jackets on above-ambient surfaces, secure laps with outward-clinched staples at 6 inches o.c.
4. For insulation with factory-applied jackets on below-ambient surfaces, do not staple longitudinal tabs. Instead, secure tabs with additional adhesive, as recommended by insulation material manufacturer, and seal with vapor-barrier mastic and flashing sealant.

B. Insulation Installation on Pipe Flanges:

1. Install preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with mineral-fiber blanket insulation.
4. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch, and seal joints with flashing sealant.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install preformed sections of same material as that of straight segments of pipe insulation when available.
2. When preformed insulation elbows and fittings are not available, install mitered sections of pipe insulation, to a thickness equal to adjoining pipe insulation. Secure insulation materials with wire or bands.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed sections of same material as that of straight segments of pipe insulation when available.
2. When preformed sections are not available, install mitered sections of pipe insulation to valve body.
3. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
4. Install insulation to flanges as specified for flange insulation application.

3.8 FIELD-APPLIED JACKET INSTALLATION

A. Where glass-cloth jackets are indicated, install directly over bare insulation or insulation with factory-applied jackets.

1. Draw jacket smooth and tight to surface with 2-inch overlap at seams and joints.
2. Embed glass cloth between two 0.062-inch- thick coats of lagging adhesive.
3. Completely encapsulate insulation with coating, leaving no exposed insulation.

B. Where FSK jackets are indicated, install as follows:

1. Draw jacket material smooth and tight.
2. Install lap or joint strips with same material as jacket.
3. Secure jacket to insulation with manufacturer's recommended adhesive.
4. Install jacket with 1-1/2-inch laps at longitudinal seams and 3-inch- wide joint strips at end joints.
5. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-barrier mastic.

C. Where PVC jackets are indicated and for horizontal applications, install with 1-inch overlap at longitudinal seams and end joints. Seal with manufacturer's recommended adhesive.

1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.

D. Where metal jackets are indicated, install with 2-inch overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless steel bands 12 inches o.c. and at end joints.

E. Where PVDC jackets are indicated, install as follows:

1. Apply three separate wraps of filament tape per insulation section to secure pipe insulation to pipe prior to installation of PVDC jacket.
2. Wrap factory-presized jackets around individual pipe insulation sections, with one end overlapping the previously installed sheet. Install presized jacket with an approximate overlap at butt joint of 2 inches over the previous section. Adhere lap seal using adhesive or SSL, and then apply 1-1/4 circumferences of appropriate PVDC tape around overlapped butt joint.
3. Continuous jacket can be spiral-wrapped around a length of pipe insulation. Apply adhesive or PVDC tape at overlapped spiral edge. When electing to use adhesives, refer to manufacturer's written instructions for application of adhesives along this spiral edge to maintain a permanent bond.
4. Jacket can be wrapped in cigarette fashion along length of roll for insulation systems with an outer circumference of 33-1/2 inches or less. The 33-1/2-inch-circumference limit allows for 2-inch- overlap seal. Using the length of roll allows for longer sections of jacket to be installed at one time. Use adhesive on the lap

seal. Visually inspect lap seal for "fishmouthing," and use PVDC tape along lap seal to secure joint.

5. Repair holes or tears in PVDC jacket by placing PVDC tape over the hole or tear and wrapping a minimum of 1-1/4 circumferences to avoid damage to tape edges.

3.9 FINISHES

A. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating on exterior insulation.

3.10 PIPING INSULATION SCHEDULE, GENERAL

A. Insulation conductivity and thickness per pipe size shall comply with schedules in this Section or with requirements of authorities having jurisdiction, whichever is more stringent.

B. Acceptable preformed pipe and tubular insulation materials and thicknesses are identified for each piping system and pipe size range. If more than one material is listed for a piping system, selection from materials listed is Contractor's option.

3.11 MINIMUM PIPE INSULATION THICKNESS (in inches)

FLUID OPERATING TEMPERATURE RANGE AND USAGE (°F)	INSULATION CONDUCTIVITY		INCHES OR *R*-VALUE	NOMINAL PIPE OR TUBE SIZE (inches)				
	Conductivity Btu × in/(h × ft^2 × °F)[b]	Mean Rating Temperature (°F)		< 1	1 to < 1 1/2	1 1/2 to < 4	4 to < 8	> 8
				Minimum insulation thickness (inches)				
> 350	0.32–0.34	250	Inches	4.5	5.0	5.0	5.0	5.0
			R-value	R-32	R-36	R-34	R-26	R-21
251–350	0.29–0.32	200	Inches	3.0	4.0	4.5	4.5	4.5
			R-value	R-20	R-29	R-32	R-24	R-20
201–250	0.27–0.30	150	Inches	2.5	2.5	2.5	3.0	3.0
			R-value	R-17	R-17	R-17	R-15	R-13
141–200	0.25–0.29	125	Inches	1.5	1.5	2.0	2.0	2.0
			R-value	R-9	R-9	R-11	R-10	R-9
105–140	0.21–0.28	100	Inches	1.0	1.0	1.5	1.5	1.5
			R-value	R-5	R-9	R-8	R-8	R-7
40–60	0.21–0.27	75	Inches	0.5	0.5	1.0	1.0	1.0
			R-value	R-2	R-2	R-5	R-5	R-4
< 40	0.20–0.26	50	Inches	0.5	1.0	1.0	1.0	1.5
			R-value	R-6	R-9	R-9	R-8	R-7

3.12 INDOOR PIPING INSULATION SCHEDULE

A. Condensate and Equipment Drain Water below 60 Deg F (16 Deg C):

1. Flexible Elastomeric.
2. Mineral-Fiber, Preformed Pipe Insulation, Type I.

B. Steam and Steam Condensate, Boiler Blowdown, Vents, Drains, and Safety Relief Vents:

1. Mineral-Fiber, Preformed Pipe Insulation, Type I.

C. Refrigerant Suction and Hot-Gas Piping:

1. Flexible Elastomeric.

D. Refrigerant Suction and Hot-Gas Flexible Tubing:

1. Flexible Elastomeric.

E. Refrigerant Liquid Piping:

1. Flexible Elastomeric.

F. Domestic Cold Water:

1. Mineral-Fiber, Preformed Pipe Insulation, Type I.

3.13 OUTDOOR, ABOVEGROUND PIPING INSULATION SCHEDULE

A. Refrigerant Suction and Hot-Gas Piping:

1. Flexible Elastomeric.

B. Refrigerant Suction and Hot-Gas Flexible Tubing:

1. Flexible Elastomeric.

C. Refrigerant Liquid Piping:

1. Flexible Elastomeric.

3.14 INDOOR, FIELD-APPLIED JACKET SCHEDULE

A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

B. If more than one material is listed, selection from materials listed is Contractor's option.

C. Piping, Concealed:

1. None.

D. Piping, Exposed:

1. PVC 30 mils thick.

3.15 OUTDOOR, FIELD-APPLIED JACKET SCHEDULE

A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

B. If more than one material is listed, selection from materials listed is Contractor's option.

C. Piping, Concealed:

1. PVC 30 mils thick.

D. Piping, Exposed:

1. PVC: 30 mils thick.

END OF SECTION 230719

SECTION 230800 - COMMISSIONING OF HVAC SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. The requirements of this section are supplementary to the General Commissioning Requirements for the project and do not negate or supersede the commissioning requirements specified elsewhere.

B. This section defines the commissioning responsibilities of the Division 23 Contractor (referred to herein as either "MC" or "the Contractor") and all other subcontractors or factory-authorized service representatives responsible for the systems to be commissioned. The responsibilities of other parties, including the Commissioning Agent (CxA), Owner, and Design Team (A/E) are referenced for clarification purposes only.

C. The final list of Systems to be Commissioned will be included in the Commissioning Plan provided by the CxA.

D. Related Requirements:

1. Section 019113 "General Commissioning Requirements" describes the overall commissioning process and responsibilities for which this contract is responsible.

E. Abbreviations: The following are common abbreviations used in the Specifications. For additional definitions refer to Section 019113.

1. A/E: Architects and Engineers
2. Cx: Commissioning
3. CxA: Commissioning Authority
4. Cx Plan: Commissioning Plan Document
5. CC: Controls Contractor
6. CM: Construction Manager
7. EC: Electrical Contractor
8. FT: Functional Performance Test
9. MC: Mechanical Contractor
10. PFI: Pre-Functional Inspection
11. TAB: Test and Balance Contractor

1.2 INFORMATIONAL SUBMITTALS

A. Prefunctional Checklists

1. Submit according to the procedures defined in the Commissioning Plan and as agreed at the commissioning scoping meeting.

B. Startup and Manufacturer Test Reports

1. Obtain copies of all startup reports as well as any test reports prepared by factory authorized service representatives as required by the specification section for each commissioned system. Promptly provide copies of reports to the CxA, as requested.

C. Requests for Clarification

1. The CxA may request supplemental written clarification for items which are not clearly indicated in equipment submittal documentation. Where such requests are made, the MC shall provide written responses to the CxA within 5 business days. Examples of such requests may include, but are not limited to, clarification of equipment operating sequences, performance data, startup requirements, selected options or accessories, etc.

PART 2 - PRODUCTS (NOT APPLICABLE)

PART 3 - EXECUTION

3.1 MEETINGS

A. Attend commissioning meetings as described in the General Commissioning Requirements.

B. Commissioning meetings may be scheduled separately from regular construction progress meetings, at the discretion of the CM and CxA.

3.2 COORDINATION AND SCHEDULING

A. MC shall coordinate schedule for prefunctional checklists and equipment startup with CxA.

B. CxA shall review and approve prefunctional checklists and equipment startup reports prior to scheduling functional testing.

3.3 PREFUNCTIONAL CHECKLISTS

A. Blank copies of the required checklists will be provided by the CxA for use by the MC.

B. Completed copies of checklists shall be submitted to the CxA according to the procedures defined in the Commissioning Plan and as agreed at the commissioning scoping meeting.

C. Where checklists require sign-off by multiple parties (e.g. checking of electrical connections by the EC on equipment provided by the MC) each party shall complete their respective portions of the checklist and shall organize all documentation into a single, comprehensive checklist record. Responsible parties shall be indicated by the CxA on each checklist.

D. The MC shall submit any requests for direction on completion of checklists in writing to the CM and CxA.

3.4 FUNCTIONAL PERFORMANCE TESTING

A. The objective of functional performance testing is to demonstrate that each commissioned system is installed and operating in accordance with the documented design intent. Functional testing shall commence only after all prefunctional inspections, manufacturer testing and startup activities are complete.

B. The detailed functional testing requirements for each commissioned system will be established in the Commissioning Plan and the Functional Testing Procedures to be developed by the CxA.

C. Before test procedures are written, the CxA shall obtain all requested documentation related to the intended functional performance of the commissioned systems. This includes submittal documentation, change orders, requests for information, design clarifications, and updated controls system programming information (points lists, control sequences, etc).

D. MC shall provide assistance to the CxA by reviewing the procedures and responding to questions and concerns posed by the CxA.

E. General testing requirements:

1. Certify that HVAC systems, subsystems, and equipment have been installed, calibrated, and started and are operating in accordance with the Contract Documents and approved Shop Drawings and submittals.
2. Certify that HVAC instrumentation and control systems have been completed and calibrated, that they are operating in accordance with the Contract Documents and approved Shop Drawings and submittals, and that pretest set points have been recorded.
3. Set systems, subsystems, and equipment into operating mode to be tested in accordance with approved test procedures (e.g., normal shutdown, normal auto

position, normal manual position, unoccupied cycle, emergency power, and alarm conditions).

4. Measure capacities and effectiveness of systems, assemblies, subsystems, equipment, and components, including operational and control functions to verify compliance with acceptance criteria.
5. Test systems, assemblies, subsystems, equipment, and components operating modes, interlocks, control responses, and responses to abnormal or emergency conditions, and response in accordance with commissioning and acceptance test criteria.

3.5 SEASONAL TESTING

A. Where seasonal tests are specified, scheduled, or otherwise required by the CxA, the MC shall provide qualified personnel to assist with execution of tests. Where required, the MC shall also secure the services of factory-authorized personnel who are fully capable of executing the required tests.

3.6 MANUFACTURER'S FIELD SERVICE

A. Where required in these specifications, the MC shall retain the services of a factory-authorized representative, vendor's representative, or third-party testing service to carry out equipment startup and testing services (hereby referred to as "Manufacturer's Field Service").

B. The MC shall ensure that the contract for Manufacturer's Field Service contains sufficient time, in addition to normal startup activities, for the representative to assist the commissioning team in completing functional performance tests. The scope and schedule of testing will be directed by the CxA. This requirement applies to service contracts for each of the commissioned system identified in these specifications.

C. It shall be the responsibility of the Contractor to specifically request and secure all Manufacturer's Field Services necessary for the startup and commissioning activities specified in the contract documents. Where the standard Manufacturer's Field Service proposed by a vendor or third party service representative may otherwise be insufficient, the necessary services shall be secured during the equipment procurement process.

D. Following correction of deficiencies, the MC shall arrange for Manufacturer's Field Service required to re-test previously deficient systems, as directed by the CxA.

3.7 DEFICIENCIES, NON-CONFORMANCE AND APPROVAL OF TESTS

A. MC shall be responsible for responding to deficiencies or items of non-conformance related to the system.

B. Where deficiencies are identified during the commissioning process, the MC shall issue a written response.

C. Deficiencies shall be corrected in a timely manner. Once corrections are made, notify the CxA that the system(s) are ready for re-inspection and/or re-testing.

D. Items which are not corrected, require multiple inspections by the CxA to resolve, or which result in scheduling delays may result in back charges to the responsible party. Refer to the section entitled "Documentation, Non-Conformance and Approval of Tests" in section 019113 for additional information on deficiency resolution.

E. Upon successful completion of testing for each system, the CxA will document the results of testing in the functional testing record. A copy of the test record shall be included in the commissioning documentation to be provided to the Owner upon completion of commissioning.

3.8 OWNER TRAINING

A. Training shall be provided by the MC in coordination with the Owner, CM and CxA. Adequacy of training shall be verified by the CxA, though the CxA may opt not attend all portions of training. For detailed training requirements, refer to section 019113 "General Commissioning Requirements" as well as the requirements contained within the individual equipment specifications.

3.9 PERSONNEL

A. Provide qualified technicians, instrumentation, tools and equipment during the startup, functional testing, and seasonal testing of the commissioned systems. Ensure the availability of at least one individual on site during commissioning tests.

END OF SECTION 230800

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SECTION 232113 - HYDRONIC PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Copper tube and fittings.
2. Steel pipe and fittings.
3. Plastic pipe and fittings.
4. Joining materials.
5. Transition fittings.
6. Dielectric fittings.

1.2 ACTION SUBMITTALS

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

1. Pipe and tube.
2. Fittings.
3. Joining materials.
4. Transition fittings.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Piping layout, or BIM model, drawn to scale, showing the items described in this Section, and coordinated with all building trades.

B. Qualification Data: For Installer.

C. Welding certificates.

D. Field quality-control reports.

1.4 QUALITY ASSURANCE

A. Installer Qualifications:

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

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

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

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

1.5 WARRANTY

A. PP-R Manufacturer's Warranty: Manufacturer agrees to repair or replace PP-R pipe and fittings that fail in materials or workmanship within 10 years from date of Substantial Completion.

1. Warranty is to cover labor and material costs of repairing and/or replacing defective materials and repairing any incidental damage caused by failure of the piping system due to defects in materials or manufacturing.
2. Warranty is to be in effect only upon submission by the Contractor to the manufacturer of valid pressure/leak documentation indicating that the system was tested and passed the manufacturer's pressure/leak test.

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. Domestic Cold Water/Makeup-Water Piping: 150 psig at 150 deg F.
2. Condensate-Drain Piping: 180 deg F.
3. Blowdown-Drain Piping: 200 deg F.
4. Air-Vent Piping: 200 deg F.
5. Safety-Valve-Inlet and -Outlet Piping: Equal to the pressure of the piping system to which it is attached.

2.2 COPPER TUBE AND FITTINGS

A. Drawn-Temper Copper Tube: ASTM B88, Type L.

B. DWV Copper Tube: ASTM B306, Type DWV.

C. Wrought-Copper, Solder-Joint Fittings: ASME B16.22, pressure fittings.

D. Bronze Flanges: ASME B16.24, Class 150, with solder-joint ends.

E. Wrought Copper Unions: ASME B16.22.

F. Grooved, Mechanical-Joint, Copper Tube Appurtenances:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Anvil International.
   b. Victaulic Company.
2. Grooved-End Copper Fittings: ASTM B75, copper tube or ASTM B584, bronze castings.
3. Grooved-End-Tube Couplings: To fit copper-tube dimensions; rigid pattern unless otherwise indicated; gasketed fitting EPDM-rubber gasket rated for minimum 230 deg F for use with ferrous housing, and steel bolts and nuts; 300 psigminimum CWP pressure rating.

G. Copper-Tube, Pressure-Seal-Joint Fittings:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Elkhart Products Corporation.
   b. NIBCO INC.
   c. Viega LLC.
2. Fittings: Cast-brass, cast-bronze, or wrought-copper with EPDM O-ring seal in each end.
3. Minimum 200-psig working-pressure rating at 250 deg F.

2.3 STEEL PIPE AND FITTINGS

A. Steel Pipe: ASTM A53/A53M, black steel with plain ends; welded and seamless, Grade B, and wall thickness as indicated in "Piping Applications" Article.

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

C. Malleable-Iron Threaded Fittings: ASME B16.3, Classes 150 and 300 as indicated in "Piping Applications" Article.

D. Malleable-Iron Unions: ASME B16.39; Classes 150, 250, and 300 as indicated in "Piping Applications" Article.

E. Cast-Iron Pipe Flanges and Flanged Fittings: ASME B16.1, Classes 25, 125, and 250; raised ground face, and bolt holes spot faced as indicated in "Piping Applications" Article.

F. Wrought-Steel Fittings: ASTM A234/A234M, wall thickness to match adjoining pipe.

G. Wrought Cast- and Forged-Steel Flanges and Flanged Fittings: ASME B16.5, including bolts, nuts, and gaskets of the following material group, end connections, and facings:

1. Material Group: 1.1.
2. End Connections: Butt welding.
3. Facings: Raised face.

H. Grooved Mechanical-Joint Fittings and Couplings:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Anvil International.
   b. Gustin Bacon Company.
   c. Victaulic Company.
2. Joint Fittings: ASTM A536, Grade 65-45-12 ductile iron; ASTM A47/A47M, Grade 32510 malleable iron; ASTM A53/A53M, Type F, E, or S, Grade B fabricated steel; or ASTM A106/A106M, Grade B steel fittings with grooves or shoulders constructed to accept grooved-end couplings; with nuts, bolts, locking pin, locking toggle, or lugs to secure grooved pipe and fittings.
3. Couplings: Ductile- or malleable-iron housing and EPDM gasket of central cavity pressure-responsive design; with nuts, bolts, locking pin, locking toggle, or lugs to secure grooved pipe and fittings.

I. Plain-End Mechanical-Joint Couplings:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Anvil International.
   b. Shurjoint-Apollo Piping Products USA Inc.
   c. Victaulic Company.
2. Housing: ASTM A536 Grade 65-45-12 segmented ductile iron or type 304 stainless steel.
3. Housing coating: None.
4. Gasket: EPDM.
5. Sealing Mechanism: Double-lip sealing system or carbon steel case-hardened jaws.
6. Bolts, hex nuts, washers, or lock bars based on manufacturer's design.
7. Minimum Pressure Rating: Equal to that of the joined pipes.

J. Steel Pressure-Seal Fittings:

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. Victaulic Company.
   b. Viega LLC.
2. Housing: Steel.
3. O-Rings and Pipe Stop: EPDM.
4. Tools: Manufacturer's special tool.
5. Minimum 300-psig working-pressure rating at 230 deg F.

K. Steel Pipe Nipples: ASTM A733, made of same materials and wall thicknesses as pipe in which they are installed.

2.4 PLASTIC PIPE AND FITTINGS

A. PVC Plastic Pipe: ASTM D1785, with wall thickness as indicated in "Piping Applications" Article.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Charlotte Pipe and Foundry Company.
   b. IPEX USA LLC.
   c. Spears Manufacturing Company.
2. PVC Plastic Pipe Fittings: Socket-type pipe fittings, ASTM D2466 for Schedule 40 pipe; ASTM D2467 for Schedule 80 pipe.

2.5 JOINING MATERIALS

A. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.

1. ASME B16.21, nonmetallic, flat, asbestos free, 1/8-inch maximum thickness unless otherwise indicated.
   a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
   b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.

B. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.

C. Solder Filler Metals: ASTM B32, lead-free alloys. Include water-flushable flux according to ASTM B813.

D. Brazing Filler Metals: AWS A5.8/A5.8M, BCuP Series, copper-phosphorus alloys for joining copper with copper; or BAg-1, silver alloy for joining copper with bronze or steel.

E. Welding Filler Metals: Comply with AWS D10.12M/D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

2.6 TRANSITION FITTINGS

A. Plastic-to-Metal Transition Fittings:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Charlotte Pipe and Foundry Company.
   b. IPEX USA LLC.
   c. Uponor.
   d. Viega LLC.
2. One-piece fitting with one threaded brass or copper insert and one solvent-cement-joint end of material and wall thickness to match plastic pipe material.

B. Plastic-to-Metal Transition Unions:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Charlotte Pipe and Foundry Company.
   b. IPEX USA LLC.
   c. NIBCO INC.
   d. Spears Manufacturing Company.
2. Brass or copper end, solvent-cement-joint end of material and wall thickness to match plastic pipe material, rubber gasket, and threaded union.

2.7 DIELECTRIC FITTINGS

A. General Requirements: Assembly of copper alloy and ferrous materials with separating nonconductive insulating material. Include end connections compatible with pipes to be joined.

B. Dielectric Unions:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. A.Y. McDonald Mfg. Co.
   b. Capitol Manufacturing Company.
   c. HART Industrial Unions, LLC.

d. Jomar Valve.
e. Zurn Industries, LLC.

2. Description:
   a. Standard: ASSE 1079.
   b. Pressure Rating: 125 psig minimum at 180 deg F.
   c. End Connections: Solder-joint copper alloy and threaded ferrous.

C. Dielectric Flanges:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Capitol Manufacturing Company.
   b. Matco-Norca.
   c. Zurn Industries, LLC.
2. Description:
   a. Standard: ASSE 1079.
   b. Factory-fabricated, bolted, companion-flange assembly.
   c. Pressure Rating: 125 psig minimum at 180 deg F.
   d. End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.

D. Dielectric-Flange Insulating Kits:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Advance Products & Systems, Inc.
   b. Calpico, Inc.
   c. Pipeline Seal and Insulator, Inc.
2. Description:
   a. Nonconducting materials for field assembly of companion flanges.
   b. Pressure Rating: 150 psig.
   c. Gasket: Neoprene or phenolic.
   d. Bolt Sleeves: Phenolic or polyethylene.
   e. Washers: Phenolic with steel backing washers.

E. Dielectric Nipples:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Elster Perfection Corporation.
   b. Precision Plumbing Products.
   c. Victaulic Company.
2. Description:
   a. Standard: IAPMO PS 66.

b. Electroplated steel nipple, complying with ASTM F1545.
c. Pressure Rating: 300 psig at 225 deg F.
d. End Connections: Male threaded or grooved.
e. Lining: Inert and noncorrosive, propylene.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS

A. Piping, aboveground, NPS 2.5 and smaller, shall be the following:

1. Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered pressure-seal joints.

B. Piping, aboveground, NPS 3 and larger, shall be any of the following:

1. Type L, drawn-temper copper tubing, wrought-copper fittings, and grooved joints.
2. Schedule 40 steel pipe; grooved, mechanical joint coupling and fittings; and grooved, mechanical joints.

C. Condensate-Drain Piping, Copper: Type DWV, drawn-temper copper tubing, wrought-copper fittings, and soldered joints in plenums and Schedule 40 PVC plastic pipe and fittings and solvent-welded joints in all other locations.

D. Blowdown-Drain Piping: Same materials and joining methods as for piping specified for the service in which blowdown drain is installed.

E. Air-Vent Piping:

1. Inlet: Same as service where installed with metal-to-plastic transition fittings for plastic piping systems according to piping manufacturer's written instructions.
2. Outlet: Type K, annealed-temper copper tubing with soldered or flared joints.

F. Safety-Valve-Inlet and -Outlet Piping for Hot-Water Piping: Same materials and joining methods as for piping specified for the service in which safety valve is installed with metal-to-plastic transition fittings for plastic piping systems according to piping manufacturer's written instructions.

3.2 INSTALLATION OF PIPING

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements are used to size pipe and

calculate friction loss, expansion, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

B. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.

C. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

D. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

E. Install piping to permit valve servicing.

F. Install piping at indicated slopes.

G. Install piping free of sags and bends.

H. Install fittings for changes in direction and branch connections.

I. Install piping to allow application of insulation.

J. Select system components with pressure rating equal to or greater than system operating pressure.

K. Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.

L. Install drains, consisting of a tee fitting, NPS 3/4 ball valve, and short NPS 3/4 threaded nipple with cap, at low points in piping system mains and elsewhere as required for system drainage.

M. Install piping at a uniform grade of 0.2 percent upward in direction of flow.

N. Reduce pipe sizes using eccentric reducer fitting installed with level side up.

O. Install branch connections to mains using tee fittings in main pipe, with the branch connected to the bottom of the main pipe. For up-feed risers, connect the branch to the top of the main pipe.

P. Install unions in piping, NPS 2 and smaller, adjacent to valves, at final connections of equipment, and elsewhere as indicated.

Q. Install flanges in piping, NPS 2-1/2 and larger, at final connections of equipment and elsewhere as indicated.

R. Install shutoff valve immediately upstream of each dielectric fitting.

S. Install sleeves for piping penetrations of walls, ceilings, and floors.

T. Install sleeve seals for piping penetrations of concrete walls and slabs.

U. Install escutcheons for piping penetrations of walls, ceilings, and floors.

3.3 JOINT CONSTRUCTION

A. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

C. Soldered Joints: Apply ASTM B813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B32.

D. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

E. Welded Joints: Construct joints according to AWS D10.12M/D10.12, using qualified processes and welding operators according to "Quality Assurance" Article.

F. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

G. Grooved Joints: Assemble joints with coupling and gasket, lubricant, and bolts. Cut or roll grooves in ends of pipe based on pipe and coupling manufacturer's written instructions for pipe wall thickness. Use grooved-end fittings and rigid, grooved-end-pipe couplings.

H. Plain-End Mechanical-Coupled Joints: Prepare, assemble, and test joints in accordance with manufacturer's written installation instructions.

I. Mechanically Formed, Copper-Tube-Outlet Joints: Use manufacturer-recommended tools and procedure, and brazed joints.

J. Pressure-Sealed Joints: Use manufacturer-recommended tools and procedure. Leave insertion marks on pipe after assembly.

3.4 INSTALLATION OF DIELECTRIC FITTINGS

A. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.

B. Dielectric Fittings for NPS 2 and Smaller: Use dielectric unions.

C. Dielectric Fittings for NPS 2-1/2 to NPS 4: Use dielectric flanges.

D. Dielectric Fittings for NPS 5 and Larger: Use dielectric flange kits.

3.5 INSTALLATION OF HANGERS AND SUPPORTS

A. Install hangers for copper tubing and steel piping, with maximum horizontal spacing and minimum rod diameters, to comply with MSS-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

B. Install hangers for plastic piping, with maximum horizontal spacing and minimum rod diameters, to comply with manufacturer's written instructions, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

C. Support horizontal piping within 12 inches of each fitting and coupling.

D. Support vertical runs of copper tubing and steel piping to comply with MSS-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

E. Support vertical runs of PP-R piping to comply with manufacturer's written instructions, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

3.6 TERMINAL EQUIPMENT CONNECTIONS

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

B. Install control valves in accessible locations close to connected equipment.

C. Install bypass piping with globe valve around control valve. If parallel control valves are installed, only one bypass is required.

D. Install ports for pressure gauges and thermometers at coil inlet and outlet connections.

3.7 FIELD QUALITY CONTROL

A. Prepare hydronic piping according to ASME B31.9 and as follows:

1. Leave joints, including welds, uninsulated and exposed for examination during test.
2. Provide temporary restraints for expansion joints that cannot sustain reactions due to test pressure. If temporary restraints are impractical, isolate expansion joints from testing.
3. Flush hydronic piping systems with clean water; then remove and clean or replace strainer screens.
4. Isolate equipment from piping. If a valve is used to isolate equipment, its closure shall be capable of sealing against test pressure without damage to valve. Install blinds in flanged joints to isolate equipment.
5. Install safety valve, set at a pressure no more than one-third higher than test pressure, to protect against damage by expanding liquid or other source of overpressure during test.

B. Perform the following tests on hydronic piping:

1. Use ambient temperature water as a testing medium unless there is risk of damage due to freezing. Another liquid that is safe for workers and compatible with piping may be used.
2. While filling system, use vents installed at high points of system to release air. Use drains installed at low points for complete draining of test liquid.
3. Isolate expansion tanks and determine that hydronic system is full of water.
4. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the system's working pressure. Test pressure shall not exceed maximum pressure for any vessel, pump, valve, or other component in system under test. Verify that stress due to pressure at bottom of vertical runs does not exceed 90 percent of specified minimum yield strength or 1.7 times the "SE" value in Appendix A in ASME B31.9, "Building Services Piping."
5. After hydrostatic test pressure has been applied for at least 10 minutes, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components, and repeat hydrostatic test until there are no leaks.
6. Prepare written report of testing.

C. Perform the following before operating the system:

1. Open manual valves fully.
2. Inspect pumps for proper rotation.
3. Set makeup pressure-reducing valves for required system pressure.
4. Inspect air vents at high points of system and determine if all are installed and operating freely (automatic type), or bleed air completely (manual type).
5. Set temperature controls so all coils are calling for full flow.
6. Inspect and set operating temperatures of hydronic equipment, such as boilers, chillers, cooling towers, to specified values.
7. Verify lubrication of motors and bearings.

END OF SECTION 232113

SECTION 232213 - STEAM AND CONDENSATE HEATING 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 and all Division 23 Sections.

1.2 SUMMARY

A. Section includes pipe and fittings for LP steam and condensate piping:

1. Steel pipe and fittings.
2. Joining materials.

1.3 ACTION SUBMITTALS

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

1. Steel pipe and fitting.
2. Joining material.

B. Shop Drawings:

1. Piping layout, drawn to scale, including locations of pipe anchors and alignment guides and expansion joints and loops.
2. Locations of and details for penetrations, including sleeves and sleeve seals for exterior walls, floors, basement, and foundation walls.
3. Locations of and details for penetration and firestopping for fire- and smoke-rated wall and floor and ceiling assemblies.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer.

B. Welding certificates.

C. Field quality-control reports.

1.5 QUALITY ASSURANCE

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

B. Pipe Welding: Qualify procedures and operators according to the following:

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

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Components and installation shall be capable of withstanding the following minimum working pressures and temperatures unless otherwise indicated:

1. LP Steam Piping: 5 psig.
2. Condensate Piping: 250 deg F.
3. Makeup-Water Piping: 80 psig at 150 deg F.
4. Blowdown-Drain Piping: Equal to pressure of the piping system to which it is attached.
5. Air-Vent and Vacuum-Breaker Piping: Equal to pressure of the piping system to which it is attached.
6. Safety-Valve-Inlet and -Outlet Piping: Equal to pressure of the piping system to which it is attached.

2.2 STEEL PIPE AND FITTINGS

A. Steel Pipe: ASTM A 53/A 53M, black steel, plain ends, welded and seamless, Grade B, and Schedule as indicated in piping applications articles.

B. Cast-Iron Threaded Fittings: ASME B16.4; Classes 125, 150, and 300 as indicated in piping applications articles.

C. Cast-Iron Threaded Flanges and Flanged Fittings: ASME B16.1, Classes 125 and 250 as indicated in piping applications articles; raised ground face, and bolt holes spot faced.

D. Wrought-Steel Fittings: ASTM A 234/A 234M, wall thickness to match adjoining pipe.

E. Wrought-Steel Flanges and Flanged Fittings: ASME B16.5, including bolts, nuts, and gaskets of the following material group, end connections, and facings:

1. Material Group: 1.1.
2. End Connections: Butt welding.
3. Facings: Raised face.

F. Steel Pipe Nipples: ASTM A 733, made of ASTM A 53/A 53M, black steel of same Type, Grade, and Schedule as pipe in which installed.

2.3 JOINING MATERIALS

A. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.

1. ASME B16.21, nonmetallic, flat, asbestos free, 1/8-inch maximum thickness unless otherwise indicated.
   a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
   b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.

B. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.

C. Welding Filler Metals: Comply with AWS D10.12M/D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

D. Welding Materials: Comply with Section II, Part C, of ASME Boiler and Pressure Vessel Code for welding materials appropriate for wall thickness and for chemical analysis of pipe being welded.

PART 3 - EXECUTION

3.1 LP STEAM PIPING APPLICATIONS

A. LP Steam Piping, NPS 2 and Smaller: Schedule 40, Type S, Grade B, steel pipe; Class 125 cast-iron fittings; and threaded joints.

B. LP Steam Piping, NPS 2-1/2 through NPS 12: Schedule 40, Type E, Grade B, steel pipe; Class 150 wrought-steel fittings, flanges, and flange fittings; and welded and flanged joints.

C. Condensate piping above grade, NPS 2 and smaller, shall be the following:

1. Schedule 80, Type S, Grade B, steel pipe; Class 125 cast-iron fittings; and threaded joints.

D. Condensate piping above grade, NPS 2-1/2 and larger, shall be the following:

1. Schedule 80, Type E, Grade B, steel pipe; Class 150 wrought-steel fittings, flanges, and flange fittings; and welded and flanged joints.

3.2 ANCILLARY PIPING APPLICATIONS

A. Blowdown-Drain Piping: Same materials and joining methods as for piping specified for the service in which blowdown drain is installed.

B. Vacuum-Breaker Piping: Outlet, same as service where installed.

C. Safety-Valve-Inlet and -Outlet Piping: Same materials and joining methods as for piping specified for the service in which safety valve is installed.

3.3 PIPING INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

B. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.

C. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless otherwise indicated.

D. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

E. Install piping to permit valve servicing.

F. Install piping free of sags and bends.

G. Install fittings for changes in direction and branch connections.

H. Install piping to allow application of insulation.

I. Select system components with pressure rating equal to or greater than system operating pressure.

J. Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.

K. Install drains, consisting of a tee fitting, NPS ¾ full port-ball valve, and short NPS ¾ threaded nipple with cap, at low points in piping system mains and elsewhere as required for system drainage.

L. Install steam supply piping at a minimum uniform grade of 0.2 percent downward in direction of steam flow.

M. Install condensate return piping at a minimum uniform grade of 0.4 percent downward in direction of condensate flow.

N. Reduce pipe sizes using eccentric reducer fitting installed with level side down.

O. Install branch connections to mains using tee fittings in main pipe, with the branch connected to top of main pipe.

P. Install valves according to the following Sections or other Sections as needed:

1. Section 232216 “Steam and Condensate Heating Piping Specialties.”

Q. Install unions in piping, NPS 2 and smaller, adjacent to valves, at final connections of equipment, and elsewhere as indicated.

R. Install flanges in piping, NPS 2-1/2 and larger, at final connections of equipment and elsewhere as indicated.

S. Install shutoff valve immediately upstream of each dielectric fitting.

T. Install strainers on supply side of control valves, pressure-reducing valves, traps, and elsewhere as indicated. Install NPS ¾ nipple and full port ball valve in blowdown connection of strainers NPS 2 and larger. Match size of strainer blow-off connection for strainers smaller than NPS 2.

U. Comply with requirements in Section 230516 "Expansion Fittings and Loops for HVAC Piping" for installation of expansion loops, expansion joints, anchors, and pipe alignment guides.

V. Comply with requirements in Section 230553 "Identification for HVAC Piping and Equipment" for identifying piping.

W. Install drip legs at low points and natural drainage points such as ends of mains, bottoms of risers, and ahead of pressure regulators, and control valves.

1. On straight runs with no natural drainage points, install drip legs at intervals not exceeding 300 feet.
2. Size drip legs same size as main. In steam mains NPS 6 and larger, drip leg size can be reduced, but to no less than NPS 4.

X. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."

Y. Install sleeve seals for piping penetrations of concrete walls and slabs.

Z. Install escutcheons for piping penetrations of walls, ceilings, and floors.

3.4 STEAM AND CONDENSATE PIPING SPECIALTIES INSTALLATION

A. Comply with requirements in Section 232216 "Steam and Condensate Heating Piping Specialties" for installation requirements for strainers, flash tanks, special-duty valves, steam traps, thermostatic air vents and vacuum breakers, and steam and condensate meters.

3.5 INSTALLATION OF HANGERS AND SUPPORTS

A. Comply with requirements in Section 230529 "Hangers and Supports for HVAC Piping and Equipment" for installation of hangers, supports, and anchor devices.

B. Install the following pipe attachments:

1. Adjustable steel clevis hangers for individual horizontal piping less than 20 feet long.
2. Adjustable roller hangers and spring hangers for individual horizontal piping 20 feet or longer.
3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet or longer, supported on a trapeze.
4. Spring hangers to support vertical runs.

C. Install hangers for steel steam supply piping and steel steam condensate piping, with maximum horizontal spacing and minimum rod diameters, to comply with MSS-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

D. Support horizontal piping within 12 inches of each fitting.

E. Support vertical runs of steel steam supply piping and steel steam condensate piping to comply with MSS-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

3.6 PIPE JOINT CONSTRUCTION

A. Ream ends of pipes and remove burrs. Bevel plain ends of steel pipe.

B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

C. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

D. Welded Joints: Construct joints according to AWS D10.12M/D10.12, using qualified processes and welding operators according to "Quality Assurance" Article.

E. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

3.7 TERMINAL EQUIPMENT CONNECTIONS

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

B. Install traps and control valves in accessible locations close to connected equipment.

C. Install bypass piping with globe valve around control valve. If parallel control valves are installed, only one bypass is required.

D. Install vacuum breakers downstream from control valve, close to coil inlet connection.

E. Install a drip leg at coil outlet.

3.8 FIELD QUALITY CONTROL

A. Prepare steam and condensate piping according to ASME B31.9, "Building Services Piping", and as follows:

1. Leave joints, including welds, uninsulated and exposed for examination during test.
2. Provide temporary restraints for expansion joints that cannot sustain reactions due to test pressure. If temporary restraints are impractical, isolate expansion joints from testing.
3. Flush system with clean water. Clean strainers.
4. Isolate equipment from piping. If a valve is used to isolate equipment, its closure shall be capable of sealing against test pressure without damage to valve. Install blinds in flanged joints to isolate equipment.

B. Perform the following tests and inspections:

1. Use ambient temperature water as a testing medium unless there is risk of damage due to freezing. Another liquid that is safe for workers and compatible with piping may be used.
2. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the working pressure. Test pressure shall not exceed maximum pressure for any vessel, pump, valve, or other component in system under test. Verify that stress due to pressure at bottom of vertical runs does not exceed 90 percent of specified minimum yield strength.
3. After hydrostatic test pressure has been applied for at least 10 minutes, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components, and repeat hydrostatic test until there are no leaks.

C. Prepare test and inspection reports.

END OF SECTION 232213

SECTION 232216 - STEAM AND CONDENSATE HEATING PIPING SPECIALTIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes the following piping specialties for steam and condensate piping:

1. Strainers.
2. Stop-check valves.
3. Safety valves.
4. Steam traps.
5. Thermostatic air vents and vacuum breakers.
6. Flexible connectors.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Strainer.
2. Valve.
3. Steam trap.
4. Air vent and vacuum breaker.
5. Connector.

1.3 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For valves, safety valves, pressure-reducing valves, steam traps, air vents, vacuum breakers, and meters to include in emergency, operation, and maintenance manuals.

1.4 QUALITY ASSURANCE

A. Pipe Welding: Qualify procedures and operators according to the following:

1. ASME Compliance: Safety valves and pressure vessels shall bear the appropriate ASME label. Fabricate and stamp flash tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Components and installation shall be capable of withstanding the following minimum working pressures and temperatures unless otherwise indicated:

1. LP Steam Piping: 5 psig.
2. Condensate Piping: 250 deg F.
3. Makeup-Water Piping: 80 psig at 150 deg F.
4. Blowdown-Drain Piping: Equal to pressure of the piping system to which it is attached.
5. Air-Vent and Vacuum-Breaker Piping: Equal to pressure of the piping system to which it is attached.
6. Safety-Valve-Inlet and -Outlet Piping: Equal to pressure of the piping system to which it is attached.

2.2 STRAINERS

A. Y-Pattern Strainers:

1. Body: ASTM A126, Class B cast iron, with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for strainers NPS 2 and smaller; flanged ends for strainers NPS 2-1/2 and larger.
3. Strainer Screen: Stainless-steel, 40-mesh strainer or perforated stainless-steel basket.
4. Tapped blowoff plug.
5. CWP Rating: 250-psig working steam pressure.

2.3 STOP-CHECK VALVES

A. Stop-Check 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; a Crane brand
   b. Jenkins Valves
2. Body and Bonnet: Malleable iron.
3. End Connections: Flanged.
4. Disc: Cylindrical with removable liner and machined seat.

5. Stem: Brass alloy.
6. Operator: Outside screw and yoke with cast-iron handwheel.
7. Packing: PTFE-impregnated packing with two-piece packing gland assembly.
8. Pressure Class: 250.

2.4 STEAM SAFETY VALVES

A. Bronze Steam Safety Valves: ASME labeled.

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. WATTS
   b. Spirax Sarco, Inc.
   c. Armstrong International, Inc.
2. Disc Material: Forged copper alloy.
3. End Connections: Threaded inlet and outlet.
4. Spring: Fully enclosed steel spring with adjustable pressure range and positive shutoff; factory set and sealed.
5. Pressure Class: 250.
6. Drip-Pan Elbow: Cast iron and having threaded inlet and outlet, with threads complying with ASME B1.20.1.
7. Size and Capacity: As required for equipment according to ASME Boiler and Pressure Vessel Code.

B. Cast-Iron Steam Safety Valves: ASME labeled.

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. WATTS
   b. Spirax Sarco, Inc.
   c. Armstrong International, Inc.
2. Disc Material: Forged copper alloy with bronze nozzle.
3. End Connections: Raised-face flanged inlet and threaded or flanged outlet connections.
4. Spring: Fully enclosed cadmium-plated steel spring with adjustable pressure range and positive shutoff, factory set and sealed.
5. Pressure Class: 250.
6. Drip-Pan Elbow: Cast iron and having threaded inlet, outlet, and drain, with threads complying with ASME B1.20.1.

7. Exhaust Head: Cast iron and having threaded inlet and drain, with threads complying with ASME B1.20.1.
8. Size and Capacity: As required for equipment according to ASME Boiler and Pressure Vessel Code.

2.5 STEAM TRAPS

A. Float and Thermostatic Steam Traps:

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. Spirax Sarco, Inc.
   b. Armstrong International, Inc.
   c. Hoffman Specialty
2. Body and Bolted Cap: ASTM A126 cast iron.
3. End Connections: Threaded.
4. Float Mechanism: Replaceable, stainless steel.
5. Head and Seat: Hardened stainless steel.
6. Trap Type: Balanced pressure.
7. Thermostatic Bellows: Stainless steel.
8. Thermostatic air vent capable of withstanding 45 deg F of superheat and resisting water hammer without sustaining damage.
9. Vacuum Breaker: Thermostatic with phosphor bronze bellows, and stainless-steel cage, valve, and seat.
10. Maximum Operating Pressure: 125 psig.

2.6 THERMOSTATIC AIR VENTS AND VACUUM BREAKERS

A. Thermostatic Air Vents:

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. Spirax Sarco, Inc.
   b. Armstrong International, Inc.
   c. Hoffman Specialty
2. Body: Cast iron, bronze, or stainless steel.
3. End Connections: Threaded.
4. Float, Valve, and Seat: Stainless steel.
5. Thermostatic Element: Phosphor bronze bellows in a stainless-steel cage.
6. Pressure Rating: 250 psig.

7. Maximum Temperature Rating: 450 deg F.

B. Vacuum Breakers:

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. Spirax Sarco, Inc.
   b. Armstrong International, Inc.
   c. Hoffman Specialty
2. Body: Brass, or stainless steel.
3. End Connections: Threaded.
4. Sealing Ball, Retainer, Spring, and Screen: Stainless steel.
5. O-Ring Seal: Ethylene propylene rubber.
6. Pressure Rating: 200 psig.
7. Maximum Temperature Rating: 450 deg F.

PART 3 - EXECUTION

3.1 VALVE APPLICATIONS

A. Install shutoff duty valves at branch connections to steam supply mains, at steam supply connections to equipment, and at the outlet of steam traps.

B. Install safety valves on pressure-reducing stations and elsewhere as required by ASME Boiler and Pressure Vessel Code. Install safety-valve discharge piping, without valves, to nearest floor drain or as indicated on Drawings. Comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1, for installation requirements.

3.2 PIPING INSTALLATION

A. Install piping to permit valve servicing.

B. Install drains, consisting of a tee fitting, NPS ¾ full-port ball valve, and short NPS ¾ threaded nipple with cap, at low points in piping system mains and elsewhere as required for system drainage.

C. Install unions in piping, NPS 2 and smaller, adjacent to valves, at final connections of equipment and elsewhere as indicated.

D. Install flanges in piping, NPS 2-1/2 and larger, at final connections of equipment and elsewhere as indicated.

E. Install shutoff valve immediately upstream of each dielectric fitting.

F. Install strainers on supply side of control valves, pressure-reducing valves, traps, and elsewhere as indicated. Install NPS 3/4 nipple and full-port ball valve in blowdown connection of strainers NPS 2 and larger. Match size of strainer blow-off connection for strainers smaller than NPS 2.

3.3 STEAM-TRAP INSTALLATION

A. Install steam traps in accessible locations as close as possible to connected equipment.

B. Install full-port ball valve, strainer, and union upstream from trap; install union, check valve, and full-port ball valve downstream from trap unless otherwise indicated.

3.4 SAFETY VALVE INSTALLATION

A. Install safety valves according to ASME B31.9, "Building Services Piping."

B. Pipe safety-valve discharge without valves to atmosphere outside the building.

C. Install drip-pan elbow fitting adjacent to safety valve and pipe drain connection to nearest floor drain.

D. Install exhaust head with drain to waste, on vents equal to or larger than NPS 2-1/2.

3.5 TERMINAL EQUIPMENT CONNECTIONS

A. Install traps and control valves in accessible locations close to connected equipment.

B. Install vacuum breakers downstream from control valve, close to coil inlet connection.

END OF SECTION 232216

SECTION 232300 - REFRIGERANT PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Copper tube and fittings.
2. Valves and specialties.
3. Refrigerants.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of valve, refrigerant piping, and piping specialty.

1. Include pressure drop, based on manufacturer's test data, for the following:
   a. Thermostatic expansion valves.
   b. Solenoid valves.
   c. Hot-gas bypass valves.
   d. Filter dryers.
   e. Strainers.
   f. Pressure-regulating valves.

B. Shop Drawings:

1. Show layout of refrigerant piping and specialties, including pipe, tube, and fitting sizes; flow capacities; valve arrangements and locations; slopes of horizontal runs; oil traps; double risers; wall and floor penetrations; and equipment connection details.
2. Show piping size and piping layout, including oil traps, double risers, specialties, and pipe and tube sizes to accommodate, as a minimum, equipment provided, elevation difference between compressor and evaporator, and length of piping to ensure proper
3. operation and compliance with warranties of connected equipment.
4. Show interface and spatial relationships between piping and equipment.
5. Shop Drawing Scale: 1/4 inch equals 1 foot.

1.3 INFORMATIONAL SUBMITTALS

A. Welding certificates.

B. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For refrigerant valves and piping specialties to include in maintenance manuals.

1.5 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to 2010 ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."

B. Comply with ASHRAE 15, "Safety Code for Refrigeration Systems."

C. Comply with ASME B31.5, "Refrigeration Piping and Heat Transfer Components."

1.6 PRODUCT STORAGE AND HANDLING

A. Store piping with end caps in place to ensure that piping interior and exterior are clean when installed.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Line Test Pressure for Refrigerant R-32:

1. Suction Lines for Air-Conditioning Applications: 300 psig.
2. Suction Lines for Heat-Pump Applications: 535 psig.

2.2 COPPER TUBE AND FITTINGS

A. Copper Tube: ASTM B 88, Type K or L ASTM B 280, Type ACR.

B. Wrought-Copper Fittings, Brazed-Joint: ASME B16.50.

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

D. Brazing Filler Metals: AWS A5.8/A5.8M.

E. Flexible Connectors:

1. Body: Tin-bronze bellows with woven, flexible, tinned-bronze-wire-reinforced protective jacket.
2. End Connections: Socket ends.
3. Offset Performance: Capable of minimum 3/4-inch misalignment in minimum 7-inch- long assembly.
4. Working Pressure Rating: Factory test at minimum 500 psig.
5. Maximum Operating Temperature: 250 deg F.

F. Copper-Tube, Pressure-Seal-Joint Fittings for Refrigerant Piping:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Danfoss Inc.
   b. Mueller Streamline Inc.
   c. Nibco Inc.
   d. Parker Hannifin Corp.
2. Fittings: UL 207 Listed.
3. Fitting Body: Refrigerant-grade copper in accordance with ASTM B75 or ASTM B743.
4. O-Rings: HNBR or Neoprene for R410a or R32 refrigerant only.
5. Tools: Manufacturer's approved special tools.
6. Maximum Rated Pressure (MRP): 700 psig.
7. Continuous Operating Temperature: 250 deg F.
8. O-Ring Temperature Rating: Minus 40 to 284 deg F.
9. Minimum Burst Pressure in accordance with UL 207: 2100 psig.
10. Vacuum Pressure Capability: 200 microns.
11. Complies with UL 109 for vibration resistance.
12. Approved for the following oils: POE, PVE, PAO, AB, and mineral oil.
13. Approved Tubing Materials: Copper-to-copper connections.
14. Compatible with the following copper tubing:
    a. Tubing tolerance must conform to ASTM B280, ASTM B88, or ASTM B743.
       1) Hard Drawn Copper, 1/4 to 1-3/8 inch: Type ACR, M, L, K.
       2) Soft (Annealed) Copper 1/4 to 1-3/8 inch: Type ACR, L, K.
15. Standards Compliance:
    a. UL 207 Listed, approved for field and factory installations, SA#7511, SDTW(7).
    b. International Mechanical Code (IMC) 2021, 2018, 2015, 2012, 2009, 2006 per ICC-ES, PMG-1440.
    c. ASHRAE 15, ANSI 15, ASME B31.5, ANSI 31.5, ASTM B75, ASTM B88, ASTM B743, ASTM B280, EN 12735-1.
    d. SAE Threaded Fittings: Conform to SAE J513 and SAE J533.

e. Compatible ODM Fittings: Material conforms to C12200 copper in accordance with ASTM B280.

2.3 VALVES AND SPECIALTIES

A. Diaphragm Packless Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Danfoss Inc.
   b. Henry Technologies Inc.; The Henry Group.
   c. Parker Hannifin Corp.
   d. Paul Mueller Company.
2. Body and Bonnet: Forged brass or cast bronze; globe design with straight-through or angle pattern.
3. Diaphragm: Phosphor bronze and stainless steel with stainless-steel spring.
4. Operator: Rising stem and hand wheel.
5. Seat: Nylon.
6. End Connections: Socket, union, or flanged.
7. Working Pressure Rating: 500 psig.
8. Maximum Operating Temperature: 275 deg F.

B. Packed-Angle Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Danfoss Inc.
   b. Henry Technologies Inc.; The Henry Group.
   c. Parker Hannifin Corp.
   d. Paul Mueller Company.
2. Body and Bonnet: Forged brass or cast bronze.
3. Packing: Molded stem, back seating, and replaceable under pressure.
4. Operator: Rising stem.
5. Seat: Nonrotating, self-aligning polytetrafluoroethylene.
6. Seal Cap: Forged-brass or valox hex cap.
7. End Connections: Socket, union, threaded, or flanged.
8. Working Pressure Rating: 500 psig.
9. Maximum Operating Temperature: 275 deg F.

C. Check Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Apollo Valves; a part of Aalberts Integrated Piping Systems.
   b. Danfoss Inc.
   c. Emerson Climate Technologies; Emerson Electric Co.
   d. Parker Hannifin Corp.
   e. Paul Mueller Company.
2. Body: Ductile iron, forged brass, or cast bronze; globe pattern.
3. Bonnet: Bolted ductile iron, forged brass, or cast bronze; or brass hex plug.
4. Piston: Removable polytetrafluoroethylene seat.
5. Closing Spring: Stainless steel.
6. Manual Opening Stem: Seal cap, plated-steel stem, and graphite seal.
7. End Connections: Socket, union, threaded, or flanged.
8. Maximum Opening Pressure: 0.50 psig.
9. Working Pressure Rating: 500 psig.
10. Maximum Operating Temperature: 275 deg F.

D. Service Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Danfoss Inc.
   b. Emerson Climate Technologies; Emerson Electric Co.
   c. Parker Hannifin Corp.
   d. Paul Mueller Company.
   e. RectorSeal HVAC; a CSW Industrials Company.
2. Body: Forged brass with brass cap including key end to remove core.
3. Core: Removable ball-type check valve with stainless-steel spring.
4. Seat: Polytetrafluoroethylene.
5. End Connections: Copper spring.
6. Working Pressure Rating: 500 psig.

E. Refrigerant Locking Caps:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. C & D Valve, LLC.
   b. JB Industries.
   c. RectorSeal HVAC; a CSW Industrials Company.
2. Description: Locking-type, tamper-resistant, threaded caps to protect refrigerant charging ports from unauthorized refrigerant access and leakage.
3. Material: Brass, with protective shroud or sleeve.

4. Refrigerant Identification: Color-coded, refrigerant specific or Universal design.
5. Special Tool: For installing and unlocking.

F. Solenoid Valves: Comply with AHRI 760 and UL 429; listed and labeled by a National Recognized Testing Laboratory (NRTL).

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Danfoss Inc.
   b. Emerson Climate Technologies; Emerson Electric Co.
   c. Henry Technologies Inc.; The Henry Group.
   d. Parker Hannifin Corp.
   e. Paul Mueller Company.
2. Body and Bonnet: Plated steel.
3. Solenoid Tube, Plunger, Closing Spring, and Seat Orifice: Stainless steel.
4. Seat: Polytetrafluoroethylene.
5. End Connections: Threaded.
6. Electrical: Molded, watertight coil in NEMA 250 enclosure of type required by location with 1/2-inch conduit adapter, and ac coil.
7. Working Pressure Rating: 400 psig.
8. Maximum Operating Temperature: 240 deg F.

G. Safety Relief Valves: Comply with 2010 ASME Boiler and Pressure Vessel Code; listed and labeled by an NRTL.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Danfoss Inc.
   b. Henry Technologies Inc.; The Henry Group.
   c. Parker Hannifin Corp.
   d. Paul Mueller Company.
2. Body and Bonnet: Ductile iron and steel, with neoprene O-ring seal.
3. Piston, Closing Spring, and Seat Insert: Stainless steel.
4. Seat: Polytetrafluoroethylene.
5. End Connections: Threaded.
6. Working Pressure Rating: 400 psig.
7. Maximum Operating Temperature: 240 deg F.

H. Thermostatic Expansion Valves: Comply with AHRI 750.

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

b. Emerson Climate Technologies; Emerson Electric Co.
c. Henry Technologies Inc.; The Henry Group.
d. Paul Mueller Company.

2. Body, Bonnet, and Seal Cap: Forged brass or steel.
3. Diaphragm, Piston, Closing Spring, and Seat Insert: Stainless steel.
4. Packing and Gaskets: Non-asbestos.
5. Capillary and Bulb: Copper tubing filled with refrigerant charge.
6. Suction Temperature: 40 deg F.
7. Superheat: Adjustable.
8. Reverse-flow option (for heat-pump applications).
9. End Connections: Socket, flare, or threaded union.
10. Working Pressure Rating: 700 psig.

I. Hot-Gas Bypass Valves: Comply with UL 429; listed and labeled by an NRTL.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Danfoss Inc.
   b. Henry Technologies Inc.; The Henry Group.
   c. Parker Hannifin Corp.
2. Body, Bonnet, and Seal Cap: Ductile iron or steel.
3. Diaphragm, Piston, Closing Spring, and Seat Insert: Stainless steel.
4. Packing and Gaskets: Non-asbestos.
5. Solenoid Tube, Plunger, Closing Spring, and Seat Orifice: Stainless steel.
6. Seat: Polytetrafluoroethylene.
7. Equalizer: Internal or External.
8. Electrical: Molded, watertight coil in NEMA 250 enclosure of type required by location with 1/2-inch conduit.
9. End Connections: Socket.
10. Throttling Range: Maximum 5 psig.
11. Working Pressure Rating: 500 psig.
12. Maximum Operating Temperature: 240 deg F.

J. Straight-Type Strainers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Danfoss Inc.
   b. Henry Technologies Inc.; The Henry Group.
   c. Parker Hannifin Corp.
2. Body: Welded steel with corrosion-resistant coating.
3. Screen: 100-mesh stainless steel.

4. End Connections: Socket or flare.
5. Working Pressure Rating: 500 psig.
6. Maximum Operating Temperature: 275 deg F.

K. Angle-Type Strainers:
   a. Danfoss, Inc.
   b. Henry Technologies Inc.; The Henry Group.
   c. Parker Hannifin Corporation.

2. Body: Forged brass or cast bronze.
3. Drain Plug: Brass hex plug.
4. Screen: 100-mesh monel.
5. End Connections: Socket or flare.
6. Working Pressure Rating: 500 psig.
7. Maximum Operating Temperature: 275 deg F.

L. Moisture/Liquid Indicators:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Danfoss Inc.
   b. Emerson Climate Technologies; Emerson Electric Co.
   c. Henry Technologies Inc.; The Henry Group.
   d. Parker Hannifin Corp.

2. Body: Forged brass.
3. Window: Replaceable, clear, fused glass window with indicating element protected by filter screen.
4. Indicator: Color coded to show moisture content in parts per million (ppm).
5. Minimum Moisture Indicator Sensitivity: Indicate moisture above 60 ppm.
6. End Connections: Socket or flare.
7. Working Pressure Rating: 500 psig.
8. Maximum Operating Temperature: 240 deg F.

M. Replaceable-Core Filter Dryers: Comply with AHRI 730.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Danfoss Inc.
   b. Emerson Climate Technologies; Emerson Electric Co.
   c. Henry Technologies Inc.; The Henry Group.
   d. Parker Hannifin Corp.

2. Body and Cover: Painted-steel shell with ductile-iron cover, stainless-steel screws, and neoprene gaskets.

3. Filter Media: 10 micron, pleated with integral end rings; stainless-steel support.
4. Desiccant Media: Activated charcoal.
5. Designed for reverse flow (for heat-pump applications).
6. End Connections: Socket.
7. Access Ports: NPS 1/4 connections at entering and leaving sides for pressure differential measurement.
8. Maximum Pressure Loss: 2 psig.
9. Working Pressure Rating: 500 psig.
10. Maximum Operating Temperature: 240 deg F.

N. Permanent Filter Dryers: Comply with AHRI 730.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Danfoss Inc.
   b. Emerson Climate Technologies; Emerson Electric Co.
   c. Henry Technologies Inc.; The Henry Group.
   d. Parker Hannifin Corp.
2. Body and Cover: Painted-steel shell.
3. Filter Media: 10 micron, pleated with integral end rings; stainless-steel support.
4. Desiccant Media: Activated charcoal.
5. Designed for reverse flow (for heat-pump applications).
6. End Connections: Socket.
7. Access Ports: NPS 1/4 connections at entering and leaving sides for pressure differential measurement.
8. Maximum Pressure Loss: 2 psig.
9. Working Pressure Rating: 500 psig.
10. Maximum Operating Temperature: 240 deg F.

O. Mufflers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Danfoss Inc.
   b. Emerson Climate Technologies; Emerson Electric Co.
   c. Henry Technologies Inc.; The Henry Group.
2. Body: Welded steel with corrosion-resistant coating.
3. End Connections: Socket or flare.
4. Working Pressure Rating: 500 psig.
5. Maximum Operating Temperature: 275 deg F.

P. Receivers: Comply with AHRI 495.

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. Henry Technologies Inc.; The Henry Group.
2. Comply with 2010 ASME Boiler and Pressure Vessel Code; listed and labeled by an NRTL.
3. Comply with UL 207; listed and labeled by an NRTL.
4. Body: Welded steel with corrosion-resistant coating.
5. Tappings: Inlet, outlet, liquid level indicator, and safety relief valve.
6. End Connections: Socket or threaded.
7. Working Pressure Rating: 500 psig.
8. Maximum Operating Temperature: 275 deg F.

Q. Liquid Accumulators: Comply with AHRI 495.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Emerson Climate Technologies; Emerson Electric Co.
   b. Henry Technologies Inc.; The Henry Group.
   c. Parker Hannifin Corp.
2. Body: Welded steel with corrosion-resistant coating.
3. End Connections: Socket or threaded.
4. Working Pressure Rating: 500 psig.
5. Maximum Operating Temperature: 275 deg F.

2.4 REFRIGERANTS

A. ASHRAE 34, R-32: Difluoromethane.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Arkema Inc.
   b. DuPont Fluorochemicals Div.
   c. Genetron Refrigerants; Honeywell International Inc.
   d. Mexichem Fluor Inc.

B. ASHRAE 34, R-134a: Tetrafluoroethane.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Arkema Inc.
   b. DuPont Fluorochemicals Div.

c. Genetron Refrigerants; Honeywell International Inc.
d. Mexichem Fluor Inc.

C. ASHRAE 34, R-407C: Difluoromethane/Pentafluoroethane/1,1,1,2-Tetrafluoroethane.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Arkema Inc.
b. DuPont Fluorochemicals Div.
c. Genetron Refrigerants; Honeywell International Inc.
d. Mexichem Fluor Inc.

D. ASHRAE 34, R-410A: Pentafluoroethane/Difluoromethane.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Arkema Inc.
b. DuPont Fluorochemicals Div.
c. Genetron Refrigerants; Honeywell International Inc.
d. Mexichem Fluor Inc.

E. ASHRAE 34, R-454B: Hydrofluoroolefin.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Arkema Inc.
b. DuPont Fluorochemicals Div.
c. Genetron Refrigerants; Honeywell International Inc.
d. Mexichem Fluor Inc.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS FOR REFRIGERANT R-32

A. Suction Lines NPS 4 and Smaller for Conventional Air-Conditioning Applications: Copper, Type ACR, drawn-temper tubing and wrought-copper fittings with soldered joints.

B. Hot-Gas and Liquid Lines, and Suction Lines for Heat-Pump Applications:

1. Copper, Type ACR, annealed- or drawn-temper tubing and wrought-copper fittings with brazed joints.

C. Safety-Relief-Valve Discharge Piping:

3.2 PIPING APPLICATIONS FOR REFRIGERANT R-134a

A. Suction Lines NPS 4 and Smaller for Conventional Air-Conditioning Applications: Copper, Type ACR, drawn-temper tubing and wrought-copper fittings with brazed joints.

B. Hot-Gas and Liquid Lines, and Suction Lines for Heat-Pump Applications:

1. Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with brazed joints.

C. Safety-Relief-Valve Discharge Piping, Copper: Copper, Type ACR, drawn-temper tubing and wrought-copper fittings with soldered joints.

3.3 PIPING APPLICATIONS FOR REFRIGERANT R-407C

A. Suction Lines NPS 4 and Smaller for Conventional Air-Conditioning Applications: Copper, Type ACR, drawn-temper tubing and wrought-copper fittings with brazed joints.

B. Hot-Gas and Liquid Lines, and Suction Lines for Heat-Pump Applications:

1. Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with brazed joints.

C. Safety-Relief-Valve Discharge Piping, Copper: Copper, Type ACR, drawn-temper tubing and wrought-copper fittings with soldered joints.

3.4 PIPING APPLICATIONS FOR REFRIGERANT R-410A

A. Suction Lines NPS 4 and Smaller for Conventional Air-Conditioning Applications: Copper, Type ACR, drawn-temper tubing and wrought-copper fittings with soldered joints.

B. Hot-Gas and Liquid Lines, and Suction Lines for Heat-Pump Applications:

1. Copper, Type ACR, annealed- or drawn-temper tubing and wrought-copper fittings with brazed joints.

C. Safety-Relief-Valve Discharge Piping:

1. Copper, Type ACR, annealed- or drawn-temper tubing and wrought-copper fittings with brazed joints.

3.5 PIPING APPLICATIONS FOR REFRIGERANT R-454B

A. Suction Lines NPS 4 and Smaller for Conventional Air-Conditioning Applications: Copper, Type ACR, drawn-temper tubing and wrought-copper fittings with soldered joints.

B. Hot-Gas and Liquid Lines, and Suction Lines for Heat-Pump Applications:

1. Copper, Type ACR, annealed- or drawn-temper tubing and wrought-copper fittings with brazed joints.

C. Safety-Relief-Valve Discharge Piping:

1. Copper, Type ACR, annealed- or drawn-temper tubing and wrought-copper fittings with brazed joints.

3.6 VALVE AND SPECIALTY APPLICATIONS

A. Install diaphragm packless valves in suction and discharge lines of compressor.

B. Install service valves for gauge taps at inlet and outlet of hot-gas bypass valves and strainers if they are not an integral part of valves and strainers.

C. Install a check valve at the compressor discharge and a liquid accumulator at the compressor suction connection.

D. Except as otherwise indicated, install diaphragm packless valves on inlet and outlet side of filter dryers.

E. Install a full-size, three-valve bypass around filter dryers.

F. Install solenoid valves upstream from each expansion valve and hot-gas bypass valve. Install solenoid valves in horizontal lines with coil at top.

G. Install thermostatic expansion valves as close as possible to distributors on evaporators.

1. Install valve so diaphragm case is warmer than bulb.
2. Secure bulb to clean, straight, horizontal section of suction line using two bulb straps. Do not mount bulb in a trap or at bottom of the line.
3. If external equalizer lines are required, make connection where it will reflect suction-line pressure at bulb location.

H. Install safety relief valves where required by 2010 ASME Boiler and Pressure Vessel Code. Pipe safety-relief-valve discharge line to outside according to ASHRAE 15.

I. Install moisture/liquid indicators in liquid line at the inlet of the thermostatic expansion valve or at the inlet of the evaporator coil capillary tube.

J. Install strainers upstream from and adjacent to the following unless they are furnished as an integral assembly for the device being protected:

1. Solenoid valves.
2. Thermostatic expansion valves.
3. Hot-gas bypass valves.
4. Compressor.

K. Install filter dryers in liquid line between compressor and thermostatic expansion valve, and in the suction line at the compressor.

L. Install receivers sized to accommodate pump-down charge.

M. Install flexible connectors at compressors.

N. Provide refrigerant locking caps on refrigerant charging ports that are located outdoors unless otherwise protected from unauthorized access by a means acceptable to the authority having jurisdiction.

3.7 INSTALLATION OF PIPING, GENERAL

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems; indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Shop Drawings.

B. Install refrigerant piping according to ASHRAE 15.

C. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.

D. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

F. Install piping adjacent to machines to allow service and maintenance.

G. Install piping free of sags and bends.

H. Install fittings for changes in direction and branch connections.

I. Select system components with pressure rating equal to or greater than system operating pressure.

J. Install piping as short and direct as possible, with a minimum number of joints, elbows, and fittings.

K. Arrange piping to allow inspection and service of refrigeration equipment. Install valves and specialties in accessible locations to allow for service and inspection. Install access doors or panels if valves or equipment requiring maintenance is concealed behind finished surfaces.

L. Protective steel shield plates shall cover the area of the tube plus the area extending not less than 2 inches (51 mm) beyond both sides of the tube.

M. Install shield plates where tubing is installed in studs, joist, rafters, or similar member spaces located less than $1^{1}/_{4}$ inches (32 mm) from the nearest edge of the member.

N. Shield plates shall be of steel material having a thickness of not less than 0.0575 inch (1.46 mm) (No. 16 gage).

O. Install refrigerant piping in protective conduit where installed below ground.

P. Install refrigerant piping in rigid or flexible conduit in locations where exposed to mechanical injury.

Q. Slope refrigerant piping as follows:

1. Install horizontal hot-gas discharge piping with a uniform slope downward away from compressor.
2. Install horizontal suction lines with a uniform slope downward to compressor.
3. Install traps and double risers to entrain oil in vertical runs.
4. Liquid lines may be installed level.

R. When brazing or soldering, remove solenoid-valve coils and sight glasses; also remove valve stems, seats, and packing, and accessible internal parts of refrigerant specialties. Do not apply heat near expansion-valve bulb.

S. Before installation of steel refrigerant piping, clean pipe and fittings using the following procedures:

1. Shot blast the interior of piping.
2. Remove coarse particles of dirt and dust by drawing a clean, lintless cloth through tubing by means of a wire or electrician's tape.
3. Draw a clean, lintless cloth saturated with trichloroethylene through the tube or pipe. Continue this procedure until cloth is not discolored by dirt.
4. Draw a clean, lintless cloth, saturated with compressor oil, squeezed dry, through the tube or pipe to remove remaining lint. Inspect tube or pipe visually for remaining dirt and lint.
5. Finally, draw a clean, dry, lintless cloth through the tube or pipe.
6. Safety-relief-valve discharge piping is not required to be cleaned but is required to be open to allow unrestricted flow.

T. Install piping with adequate clearance between pipe and adjacent walls and hangers or between pipes for insulation installation.

U. Identify refrigerant piping and valves according to Section 230553 "Identification for HVAC Piping and Equipment."

V. Install sleeves for piping penetrations of walls, ceilings, and floors.

W. Install sleeve seals for piping penetrations of concrete walls and slabs.

X. Install escutcheons for piping penetrations of walls, ceilings, and floors.

3.8 PIPE JOINT CONSTRUCTION

A. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

C. Fill pipe and fittings with an inert gas (nitrogen or carbon dioxide), during brazing or welding, to prevent scale formation.

D. Soldered Joints: Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook."

E. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," Chapter "Pipe and Tube."

1. Use Type BCuP (copper-phosphorus) alloy for joining copper socket fittings with copper pipe.
2. Use Type BAg (cadmium-free silver) alloy for joining copper with bronze or steel.

F. Threaded Joints: Thread steel pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and to restore full ID. Join pipe fittings and valves as follows:

1. Apply appropriate tape or thread compound to external pipe threads unless dry-seal threading is specified.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

G. Steel pipe can be threaded, but threaded joints must be seal brazed or seal welded.

H. Welded Joints: Construct joints according to AWS D10.12M/D10.12.

I. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

J. Copper Pressure-Seal Fittings: Join copper tubing and fittings with tools and installation procedure defined by fitting manufacturer.

1. Training: Installation by manufacturer-trained installers.
2. Installation:
   a. Install fittings following installation steps in accordance with manufacturer's written installation instructions.
   b. Examination: Upon delivery to the Project site, examine copper tubing and fittings for debris, defects, incise marks (manufacturer's engraving on tube), holes, and cracks.
   c. If any brazing is required, follow manufacturer's brazing guidelines. Not following guidelines will damage the internal O-ring, likely resulting in leaks.
   d. Do not crimp fittings over flared style tubing (ODF). The flare can be cut off and the fitting crimped to the tube if there is a minimum of 2 inches of tube remaining.
3. Installation general locations:
   a. Follow manufacturer's requirement on spacing and fitting location.

3.9 INSTALLATION OF HANGERS AND SUPPORTS

A. Install the following pipe attachments:

1. Adjustable steel clevis hangers for individual horizontal runs less than 20 feet long.
2. Roller hangers and spring hangers for individual horizontal runs 20 feet or longer.

3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet or longer, supported on a trapeze.
4. Spring hangers to support vertical runs.
5. Copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.

B. Install hangers for copper tubing, with maximum horizontal spacing and minimum rod diameters, to comply with MSS-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

C. Support horizontal piping within 12 inches of each fitting.

D. Support vertical runs of copper tubing to comply with MSS-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

3.10 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Comply with ASME B31.5, Chapter VI.
2. Test refrigerant piping, specialties, and receivers. Isolate compressor, condenser, evaporator, and safety devices from test pressure if they are not rated above the test pressure.
3. Test high- and low-pressure side piping of each system separately at not less than the pressures indicated in "Performance Requirements" Article.
    a. Fill system with nitrogen to the required test pressure.
    b. System shall maintain test pressure at the manifold gage throughout duration of test.
    c. Test joints and fittings with electronic leak detector or by brushing a small amount of soap and glycerin solution over joints.
    d. Remake leaking joints using new materials, and retest until satisfactory results are achieved.

B. Prepare test and inspection reports.

3.11 SYSTEM CHARGING

A. Charge system using the following procedures:

1. Install core in filter dryers after leak test but before evacuation.
2. Evacuate entire refrigerant system with a vacuum pump to 500 micrometers. If vacuum holds for 12 hours, system is ready for charging.
3. Break vacuum with refrigerant gas, allowing pressure to build up to 2 psig.

4. Charge system with a new filter-dryer core in charging line.

3.12 ADJUSTING

A. Adjust thermostatic expansion valve to obtain proper evaporator superheat.

B. Adjust high- and low-pressure switch settings to avoid short cycling in response to fluctuating suction pressure.

C. Adjust set-point temperature of air-conditioning or chilled-water controllers to the system design temperature.

D. Perform the following adjustments before operating the refrigeration system, according to manufacturer's written instructions:

1. Open shutoff valves in condenser water circuit.
2. Verify that compressor oil level is correct.
3. Open compressor suction and discharge valves.
4. Open refrigerant valves except bypass valves that are used for other purposes.
5. Check open compressor-motor alignment and verify lubrication for motors and bearings.

E. Replace core of replaceable filter dryer after system has been adjusted and after design flow rates and pressures are established.

END OF SECTION 232300

SECTION 233113 - METAL DUCTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Single-wall rectangular ducts and fittings.
2. Double-wall rectangular ducts and fittings.
3. Single-wall round ducts and fittings.
4. Double-wall round ducts and fittings.
5. Sheet metal materials.
6. Sealants and gaskets.
7. Hangers and supports.

1.2 ACTION SUBMITTALS

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

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

B. Shop Drawings:

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

12. Hangers and supports, including methods for duct and building attachment and vibration isolation.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: A single set of plans or BIM model, drawn to scale, showing the items described in this Section, and coordinated with all building trades.

1.4 QUALITY ASSURANCE

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Delegated Duct Design: Duct construction, including sheet metal thicknesses, seam and joint construction, reinforcements, and hangers and supports, comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and with performance requirements and design criteria indicated in "Duct Schedule" Article.

B. Structural Performance: Duct hangers and supports are to withstand the effects of gravity loads and stresses within limits and under conditions described in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible".

C. Wind Performance: Ducts are to withstand the effects of wind determined in accordance with to ASCE/SEI 7.

D. Airstream Surfaces: Surfaces in contact with airstream comply with requirements in ASHRAE 62.1.

E. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment," and Section 7 - "Construction and System Startup."

F. ASHRAE/IES Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6.4.4 - "HVAC System Construction and Insulation."

G. Duct Dimensions: Unless otherwise indicated, all duct dimensions indicated on Drawings are inside clear dimensions and do not include insulation or duct wall thickness.

2.2 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.

1. Construct ducts of galvanized sheet steel unless otherwise indicated.
2. For ducts exposed to weather, construct of stainless steel indicated by manufacturer to be suitable for outdoor installation.
3. For ducts serving or exposed to natatoriums, construct of aluminum indicated by manufacturer to be suitable for natatorium installation.

B. Transverse Joints: Fabricate joints in accordance with 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."

1. For ducts with longest side less than 36 inches, select joint types in accordance with Figure 2-1.
2. For ducts with longest side 36 inches or greater, use flange joint connector Type T-22, T-24, T-24A, T-25a, or T-25b. Factory-fabricated flanged duct connection system may be used if submitted and approved by engineer of record.

C. Longitudinal Seams: Select seam types and fabricate in accordance with 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 in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Ch. 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."

2.3 DOUBLE-WALL RECTANGULAR DUCTS AND FITTINGS

A. Source Limitations: Obtain double-wall rectangular ducts and fittings from single manufacturer.

B. Rectangular Ducts: Fabricate ducts with indicated dimensions for clear internal dimensions of the inner duct.

C. Outer Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class unless otherwise indicated.

1. For ducts exposed to weather, construct outer duct of aluminum indicated by manufacturer to be suitable for outdoor installation.

D. Transverse Joints: Select joint types and fabricate in accordance with 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."

1. For ducts with longest side less than 36 inches, select joint types in accordance with Figure 2-1.
2. For ducts with longest side 36 inches or greater, use flange joint connector Type T-22, T-24, T-24A, T-25a, or T-25b. Factory-fabricated flanged duct connection system may be used if submitted and approved by engineer of record.
3. Provide weather tight clips at all joints.

E. Longitudinal Seams: Select seam types and fabricate in accordance with 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." Provide weather tight clips at all joints.

F. Inner Duct: Solid galvanized sheet steel. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class unless otherwise indicated.

G. Interstitial Insulation, 2″ Foam.

1. R-12 insulation.

H. Double-wall assembly shall be tested and complies with UL-723 and ASTM E84.

2.4 SINGLE-WALL ROUND DUCTS AND FITTINGS

A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Ch. 3, "Round, Oval, and Flexible Duct," based on indicated static-pressure class unless otherwise indicated.

1. Construct ducts of galvanized sheet steel unless otherwise indicated.
2. For ducts exposed to weather, construct of stainless steel indicated by manufacturer to be suitable for outdoor installation.
3. For ducts serving or exposed to natatoriums, construct of aluminum indicated by manufacturer to be suitable for natatorium installation.

4. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Linx Industries; a DMI company (formerly Lindab).
   b. MKT Metal Manufacturing.
   c. SEMCO, LLC; part of FlaktGroup.
   d. Sheet Metal Connectors, Inc.
   e. Spiral Manufacturing Co., Inc.

B. Source Limitations: Obtain single-wall round ducts and fittings from single manufacturer.

C. 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).

D. Transverse Joints: Select joint types and fabricate in accordance with 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.

E. Longitudinal Seams: Select seam types and fabricate in accordance with 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.

F. Tees and Laterals: Select types and fabricate in accordance with 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."

2.5 DOUBLE-WALL ROUND DUCTS AND FITTINGS

A. Source Limitations: Obtain double-wall round ducts and fittings from single manufacturer.

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) of the inner duct.

C. Outer Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Ch. 3, "Round, Oval, and Flexible Duct," based on static-pressure class unless otherwise indicated.
   1. For ducts exposed to weather, construct outer duct of aluminum indicated by manufacturer to be suitable for outdoor installation.
   2. Transverse Joints: Select joint types and fabricate in accordance with 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."
      a. Transverse Joints in Ducts Larger Than 60 Inches in Diameter: Flanged.
      b. Provide weather tight clips at all joints.
   3. Longitudinal Seams: Select seam types and fabricate in accordance with 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."
      a. Fabricate round ducts larger than 90 inches in diameter with butt-welded longitudinal seams.
      b. Fabricate flat-oval ducts larger than 72 inches in width (major dimension) with butt-welded longitudinal seams.
      c. Provide weather tight clips at all joints.
   4. Tees and Laterals: Select types and fabricate in accordance with 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."

D. Inner Duct: Solid galvanized sheet steel. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Ch. 3, "Round, Oval, and Flexible Duct," based on static-pressure class unless otherwise indicated.

A. Interstitial Insulation, 2" Foam.

1. R-12 insulation.

B. Double-wall assembly shall be tested and complies with UL-723 and ASTM E84.

2.6 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 are to be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

B. Galvanized Sheet Steel: Comply with ASTM A653/A653M.

1. Galvanized Coating Designation: G90.
2. Finishes for Surfaces Exposed to View: Mill phosphatized.

C. Stainless Steel Sheets: Comply with ASTM A480/A480M, Type 304 or 316, as indicated in "Duct Schedule" Article; cold rolled, annealed, sheet. Exposed surface finish is to be No. 2B, No. 2D, No. 3, or No. 4 as indicated in "Duct Schedule" Article.

D. Aluminum Sheets: Comply with ASTM B209 Alloy 3003, H14 temper; with mill finish for concealed ducts, and standard, one-side bright finish for duct surfaces exposed to view.

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.

2.7 SEALANT AND GASKETS

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

B. 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. Maximum Static-Pressure Class: 10-inch wg, positive or negative.
9. Service: Indoor or outdoor.
10. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.

C. Flanged Joint Sealant: Comply with ASTM C920.

1. General: Single-component, acid-curing, silicone, elastomeric.
2. Type: S.
3. Grade: NS.
4. Class: 25.
5. Use: O.

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

E. Round Duct Joint O-Ring Seals:

1. Seal is to provide maximum leakage class of 3 cfm/100 sq. ft. at 1-inch wg and is to be rated for10-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.

2.8 HANGERS AND SUPPORTS

A. Hanger Rods for Noncorrosive Environments: Galvanized-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 A603.

E. Steel Cables for Stainless Steel Ducts: Stainless steel complying with ASTM A492.

F. Steel Cable End Connections: Galvanized-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 in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" unless otherwise indicated.

C. Install ducts in maximum practical lengths with fewest possible joints.

D. Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections.

E. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.

F. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.

G. Install ducts with a clearance of 1 inch, plus allowance for insulation thickness.

H. Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.

I. 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.

J. Install fire, combination fire/smoke, and smoke dampers where indicated on Drawings and as required by code, and by local authorities having jurisdiction.

K. Install heating coils, cooling coils, air filters, dampers, and all other duct-mounted accessories in air ducts where indicated on Drawings.

L. Protect duct interiors from moisture, construction debris and dust, and other foreign materials both before and after installation. Comply with SMACNA's "IAQ Guidelines for Occupied Buildings Under Construction," Appendix G, "Duct Cleanliness for New Construction Guidelines."

M. Elbows: Use long-radius elbows wherever they fit.

1. Fabricate 90-degree rectangular mitered elbows to include turning vanes.
2. Fabricate 90-degree round elbows with a minimum of three segments for 12 inches and smaller and a minimum of five segments for 14 inches and larger.

N. Branch Connections: Use lateral or conical branch connections.

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 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 DUCTWORK EXPOSED TO WEATHER

A. All external joints are to have secure watertight mechanical connections. Seal all openings to provide weatherproof construction.

B. Construct ductwork to resist external loads of wind, snow, ice, and other effects of weather. Provide necessary supporting structures.

C. Double Wall:

1. Ductwork complies with requirements in "Double-Wall Rectangular Ducts and Fittings" or "Double-Wall Round Ducts and Fittings" Article.
2. Ductwork outer wall is to be aluminum indicated by manufacturer to be suitable for outdoor installation.
3. Provide interstitial insulation.

3.4 DUCT SEALING

A. Seal ducts for duct static-pressure, seal classes, and leakage classes specified in "Duct Schedule" Article in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

3.5 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. Coordinate with Section 230548 "Vibration and Seismic Controls for HVAC."

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.

3.6 DUCTWORK CONNECTIONS

A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

3.7 PAINTING

A. Paint interior of metal ducts that are visible through registers and grilles and that do not have duct liner. Apply one coat of flat, black, latex paint over a compatible galvanized-steel primer.

3.8 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Leakage Tests:

1. Comply with SMACNA's "HVAC Air Duct Leakage Test Manual." Submit a test report for each test.
2. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.
3. Testing of each duct section is to be performed with access doors, coils, filters, dampers, and other duct-mounted devices in place as designed. No devices are to be removed or blanked off so as to reduce or prevent additional leakage.
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 Cleanliness Tests:

1. Visually inspect duct system to ensure that no visible contaminants are present.
2. Test sections of metal duct system, chosen randomly by Owner, for cleanliness in accordance with "Description of Method 3 - NADCA Vacuum Test" in NADCA ACR, "Assessment, Cleaning and Restoration of HVAC Systems."
   a. Acceptable Cleanliness Level: Net weight of debris collected on the filter media is to not exceed 0.75 mg/100 sq. cm.

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

E. Prepare test and inspection reports.

3.9 DUCT CLEANING

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

B. Use duct cleaning methodology as indicated in NADCA ACR.

C. Use service openings for entry and inspection.

1. Provide openings with access panels appropriate for duct static-pressure and leakage class at dampers, coils, and any other locations where required for inspection and cleaning access. Provide insulated panels for insulated or lined duct. Patch insulation and liner as recommended by duct liner manufacturer. Comply with Section 233300 "Air Duct Accessories" for access panels and doors.
2. Disconnect and reconnect flexible ducts as needed for cleaning and inspection.
3. Remove and reinstall ceiling to gain access during the cleaning process.

D. Particulate Collection and Odor Control:

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

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

1. Air outlets and inlets (registers, grilles, and diffusers).

2. Supply, return, and exhaust fans including fan housings, plenums (except ceiling supply and return plenums), scrolls, blades or vanes, shafts, baffles, dampers, and drive assemblies.
3. Air-handling unit internal surfaces and components including mixing box, coil section, air wash systems, spray eliminators, condensate drain pans, humidifiers and dehumidifiers, filters and filter sections, and condensate collectors and drains.
4. Coils and related components.
5. Return-air ducts, dampers, actuators, and turning vanes except in ceiling plenums and mechanical equipment rooms.
6. Supply-air ducts, dampers, actuators, and turning vanes.
7. Dedicated exhaust and ventilation components and makeup air systems.

F. Mechanical Cleaning Methodology:

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

3.10 DUCT SCHEDULE

A. Fabricate ducts with galvanized sheet steel except as otherwise indicated and as follows:

1. Fabricate all ducts to achieve SMACNA pressure class, seal class, and leakage class as indicated below.

B. Supply Ducts:

1. Ducts Connected to Fan Coil Units, Furnaces, Heat Pumps, and Terminal Units:
   a. Pressure Class: Positive 2-inch wg.
   b. Minimum SMACNA Seal Class: B.

2. Ducts Connected to Constant-Volume Air-Handling Units:
   a. Pressure Class: Positive 3-inch wg.
   b. Minimum SMACNA Seal Class: A.

3. Ducts Connected to Equipment Not Listed Above:
   a. Pressure Class: Positive 2-inch wg.
   b. Minimum SMACNA Seal Class: A.

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: B.

2. Ducts Connected to Air-Handling Units:
   a. Pressure Class: Positive or negative 2-inch wg.
   b. Minimum SMACNA Seal Class: B.

3. Ducts Connected to Equipment Not Listed above:
   a. Pressure Class: Positive or negative 2-inch wg.
   b. Minimum SMACNA Seal Class: A.

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: A if negative pressure, and A if positive pressure.

2. Ducts Connected to Air-Handling Units:
   a. Pressure Class: Positive or negative 2-inch wg.
   b. Minimum SMACNA Seal Class: A if negative pressure, and A if positive pressure.

3. Ducts Connected to Equipment Not Listed above:
   a. Pressure Class: Positive or negative 3-inch wg.
   b. Minimum SMACNA Seal Class: B if negative pressure; A if positive pressure.

E. Exposed to Weather/Exterior Supply and Return/Exhaust Ducts:

1. Ducts Connected to all equipment:
    a. Pressure Class: Positive or negative 3-inch wg.
    b. Minimum SMACNA Seal Class: A.
    c. Double-wall construction complying with requirements in "Double-Wall Rectangular Ducts and Fittings" or "Double-Wall Round Ducts and Fittings" Article.
    d. Ductwork outer wall is to be aluminum indicated by manufacturer to be suitable for outdoor installation.

F. Intermediate Reinforcement:

1. Galvanized-Steel Ducts: Galvanized steel.

2. Stainless Steel Ducts:
    a. Exposed to Airstream: Match duct material.
    b. Not Exposed to Airstream: Match duct material.

3. Aluminum Ducts: Aluminum.

G. Elbow Configuration:

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

2. Rectangular Duct - Requirements for All Velocities: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."
   a. Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
   b. Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.
   c. Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."

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

H. 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: Conical 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

1.1 SUMMARY

A. Section Includes:

1. Backdraft and pressure relief dampers.
2. Manual volume dampers.
3. Fire dampers.
4. Smoke dampers.
5. Combination fire and smoke dampers.
6. Flange connectors.
7. Duct silencers.
8. Turning vanes.
9. Remote damper operators.
10. Duct-mounted access doors.
11. Flexible connectors.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. For duct silencers, include pressure drop, dynamic insertion loss, and self-generated noise data. Include breakout noise calculations for high-transmission-loss casings.

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

1. Detail duct accessories' fabrication and installation in ducts and other construction. Include dimensions, weights, loads, and required clearances; and method of field assembly into duct systems and other construction. Include the following:
   a. Special fittings.
   b. Manual volume damper installations.
   c. Control-damper installations.
   d. Fire-damper, smoke-damper, combination fire- and smoke-damper, ceiling, and corridor-damper installations, including sleeves; and duct-mounted access doors and remote damper operators.

e. Include diagrams for power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plans, or BIM model, drawn to scale, on which ceiling-mounted access panels and access doors required for access to duct accessories are shown and coordinated with each other, using input from installers of the items involved.

B. Source quality-control reports.

1.4 CLOSEOUT SUBMITTALS

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

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. Fusible Links: Furnish quantity equal to 10 percent of amount installed.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Comply with NFPA 90A and NFPA 90B.

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

2.2 BACKDRAFT AND PRESSURE RELIEF DAMPERS

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

1. American Warming and Ventilating; a Mestek Architectural Group company.

2. Cesco Products; a division of MESTEK, Inc.
3. Greenheck Fan Corporation.
4. Nailor Industries Inc.
5. Pottorff.
6. Ruskin Company.
7. Safe Air - Dowco Products.
8. United Enertech.
9. Vent Products Co., Inc.

B. Description: Gravity balanced.

C. Performance:

1. Maximum Air Velocity: 1250 fpm.
2. Maximum System Pressure: 2 inches wg.
3. AMCA Certification: Test and rate in accordance with AMCA 511.
4. Leakage:
   a. Class I: Leakage shall not exceed 4 cfm/sq. ft. against 1-inch wg differential static pressure.

D. Construction:

1. Frame:
   a. Hat shaped.
   b. 16-gauge- thick, galvanized sheet steel, with welded or mechanically attached corners and mounting flange.
2. Blades:
   a. Multiple single-piece blades.
   b. Off-center pivoted, maximum 6-inch width, 16-gauge- thick, with sealed edges.
3. Blade Action: Parallel.

E. Blade Seals: Neoprene, mechanically locked.

F. Blade Axles:

1. Material: Galvanized steel.
2. Diameter: 0.20 inch.

G. Tie Bars and Brackets: Galvanized steel.

H. Return Spring: Adjustable tension.

I. Bearings: Steel ball Brass sleeve or synthetic pivot bushings.

J. Accessories:

1. Adjustment device to permit setting for varying differential static pressure.
2. Counterweights and spring-assist kits for vertical airflow installations.
3. Chain pulls.
4. Screen Mounting:
   a. Front mounted in sleeve.
      1) Sleeve Thickness: 20 gauge minimum.
      2) Sleeve Length: 6 inches minimum.
5. Screen Material: Aluminum.
6. Screen Type: Bird.
7. 90-degree stops.

2.3 MANUAL VOLUME DAMPERS

A. Standard, Steel, Manual Volume Dampers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Air Balance; a division of MESTEK, Inc.
   b. Aire Technologies, Inc.; a DMI company.
   c. Greenheck Fan Corporation.
   d. Lloyd Industries, Inc.
   e. McGill AirFlow LLC.
   f. Nailor Industries Inc.
   g. Ruskin Company.
2. Performance:
   a. Leakage Rating Class III: Leakage not exceeding 40 cfm/sq. ft. against 1-inch wg differential static pressure.
3. Construction:
   a. Linkage out of airstream.
   b. Suitable for horizontal or vertical airflow applications.
4. Frames:
   a. Hat-shaped, 16-gauge- thick, galvanized sheet steel.
   b. Mitered and welded corners.
   c. Flanges for attaching to walls and flangeless frames for installing in ducts.
5. Blades:
   a. Multiple or single blade.
   b. Parallel- or opposed-blade design.
   c. Stiffen damper blades for stability.

d. Galvanized steel; 16 gauge thick.

6. Blade Axles: Galvanized steel.
7. Bearings:
   a. Oil-impregnated stainless steel sleeve.
   b. Dampers mounted with vertical blades to have thrust bearing at each end of every blade.
8. Tie Bars and Brackets: Galvanized steel.
9. Locking device with offset handle to hold damper blades in a fixed position without vibration.

B. Standard, Aluminum, Manual Volume Dampers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. American Warming and Ventilating; a Mestek Architectural Group company.
   b. Arrow United Industries.
   c. Cesco Products; a division of MESTEK, Inc.
   d. McGill AirFlow LLC.
   e. Nailor Industries Inc.
   f. Pottorff.
   g. Ruskin Company.
   h. Safe Air - Dowco Products.
   i. United Enertech.
   j. Vent Products Co., Inc.
2. Performance:
   a. Leakage Rating Class III: Leakage not exceeding 40 cfm/sq. ft. against 1-inch wg differential static pressure.
3. Construction:
   a. Linkage out of airstream.
   b. Suitable for horizontal or vertical airflow applications.
4. Frames:
   a. Hat-shaped, 0.10-inch- thick, aluminum sheet channels.
   b. Flanges for attaching to walls and flangeless frames for installing in ducts.
5. Blades:
   a. Multiple or single blade.
   b. Parallel- or opposed-blade design.
   c. Stiffen damper blades for stability.
   d. Roll-Formed Aluminum Blades: 0.10-inch- thick aluminum sheet.
   e. Extruded-Aluminum Blades: 0.050-inch- thick extruded aluminum.

6. Blade Axles: Galvanized steel.
7. Bearings:
   a. Oil-impregnated bronze Molded synthetic Stainless steel sleeve.
   b. Dampers mounted with vertical blades to have thrust bearing at each end of every blade.
8. Tie Bars and Brackets: Aluminum.
9. Locking device with offset handle to hold damper blades in a fixed position without vibration.

C. Low-Leakage, Steel, Manual Volume Dampers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Air Balance; a division of MESTEK, Inc.
   b. American Warming and Ventilating; a Mestek Architectural Group company.
   c. Arrow United Industries.
   d. Cesco Products; a division of MESTEK, Inc.
   e. Greenheck Fan Corporation.
   f. McGill AirFlow LLC.
   g. Nailor Industries Inc.
   h. Pottorff.
   i. Ruskin Company.
   j. Safe Air – Dowco Products.
   k. United Enertech.
   l. Vent Products Co., Inc.
2. Performance:
   a. AMCA Certification: Test and rate in accordance with AMCA 511.
   b. Leakage:
      1) Class I: Leakage shall not exceed 4 cfm/sq. ft. against 1-inch wg differential static pressure.
3. Construction:
   a. Linkage: Out of airstream.
   b. Suitable for horizontal or vertical airflow applications.
4. Frames:
   a. Hat, U, or angle shaped.
   b. Thickness: 16-gauge galvanized sheet steel.
   c. Mitered and welded corners.
   d. Flanges for attaching to walls and flangeless frames for installing in ducts.
5. Blades:
   a. Multiple or single blade.

b. Parallel- or opposed-blade design.
c. Stiffen damper blades for stability.
d. Galvanized, roll-formed steel; 16 gauge thick.

6. Blade Edging Seals:
   a. Closed-cell neoprene.
   b. Inflatable seal blade edging or replaceable rubber seals.
7. Blade Jamb Seals: Neoprene.
8. Blade Axles: Galvanized steel.
9. Bearings:
   a. Oil-impregnated stainless steel sleeve.
   b. Dampers mounted with vertical blades to have thrust bearing at each end of every blade.
10. Tie Bars and Brackets: Galvanized steel.
11. Locking device with offset handle to hold damper blades in a fixed position without vibration.

D. Low-Leakage, Aluminum, Manual Volume Dampers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Air Balance; a division of MESTEK, Inc.
   b. American Warming and Ventilating; a Mestek Architectural Group company.
   c. Arrow United Industries.
   d. Cesco Products; a division of MESTEK, Inc.
   e. McGill AirFlow LLC.
   f. Nailor Industries Inc.
   g. Pottorff.
   h. Ruskin Company.
   i. Safe Air - Dowco Products.
   j. United Enertech.
   k. Vent Products Co., Inc.
2. Performance:
   a. Leakage:
      1) Class I: Leakage shall not exceed 4 cfm/sq. ft. against 1-inch wg differential static pressure.
3. Construction:
   a. Linkage out of airstream.
   b. Suitable for horizontal or vertical airflow applications.
4. Frames:

a. Hat, U, or angle shaped.
b. Thickness: 0.08-inch aluminum sheet channels.
c. Flanges for attaching to walls and flangeless frames for installing in ducts.

5. Blades:
   a. Multiple or single blade.
   b. Parallel- or opposed-blade design.
   c. Roll-Formed Aluminum Blades:0.072-inch thick aluminum sheet.
   d. Extruded-Aluminum Blades: 0.050-inch- thick extruded aluminum.
6. Blade Edging Seals:
   a. Closed-cell neoprene.
   b. Inflatable seal blade edging or replaceable rubber seals.
7. Blade Jamb Seals: Neoprene.
8. Blade Axles: Nonferrous metal.
9. Bearings:
   a. Molded synthetic Stainless steel sleeve.
   b. Dampers mounted with vertical blades to have thrust bearings at each end of every blade.
10. Tie Bars and Brackets: Aluminum.
11. Locking device with offset handle to hold damper blades in a fixed position without vibration.

E. Jackshaft:

1. Material: Galvanized-steel pipe rotating within pipe-bearing assembly mounted on supports at each mullion and at each end of multiple-damper assemblies.
2. Length and Number of Mountings: As required to connect linkage of each damper in multiple-damper assembly.

F. Damper Hardware:

1. Zinc-plated, die-cast core with dial and handle, made of 3/32-inch- thick zinc-plated steel, and a 3/4-inch hexagon locking nut.
2. Include center hole to suit damper operating-rod size.
3. Include elevated platform for insulated duct mounting.

2.4 FIRE DAMPERS

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

1. Air Balance; a division of MESTEK, Inc.

2. Arrow United Industries.
3. Cesco Products; a division of MESTEK, Inc.
4. Greenheck Fan Corporation.
5. NCA Manufacturing, Inc.
6. Pottorff.
7. Ruskin Company.
8. Safe Air - Dowco Products.
9. United Enertech.
10. Vent Products Co., Inc.

B. Type: dynamic; rated and labeled in accordance with UL 555 by an NRTL.

C. Closing rating in ducts up to 4-inch wg static pressure class and minimum 2000 fpm velocity.

D. Fire Rating: 1-1/2 hours.

E. Frame: Curtain type with blades outside airstream except when located behind grille where blades may be inside airstream; fabricated with roll-formed galvanized steel; with mitered and interlocking corners; gauge in accordance with UL listing.

F. Mounting Sleeve: Factory- or field-installed, galvanized sheet steel; gauge in accordance with UL listing.

G. Mounting Orientation: Vertical or horizontal as indicated.

H. Blades: Roll-formed galvanized sheet steel, interlocking. Material gauge is to be in accordance with UL listing.

I. Horizontal Dampers: Include blade lock and stainless steel closure spring.

J. Heat-Responsive Device:

1. Replaceable, 165 deg F rated, fusible links.

2.5 SMOKE DAMPERS

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

1. Air Balance; a division of MESTEK, Inc.
2. Arrow United Industries.
3. Cesco Products; a division of MESTEK, Inc.
4. Greenheck Fan Corporation.

5. Pottorff.
6. Ruskin Company.
7. Safe Air - Dowco Products.
8. United Enertech.

B. General Requirements:

1. Label to indicate conformance to UL 555 and UL 555S by an NRTL.
2. Label to indicate conformance to NFPA 80 and NFPA 90A by an NRTL.
3. Unless otherwise indicated, use parallel-blade configuration.
4. Factory or field assemble multiple damper sections to provide a single damper assembly of size required by the application.
5. Factory install damper actuator by damper manufacturer as integral part of damper assembly. Coordinate actuator location, mounting, and electrical requirements with damper manufacturer.

C. Performance:
1. Leakage:
   a. Class I: Leakage shall not exceed 4 cfm/sq. ft. against 1-inch wg differential static pressure.
2. Pressure Drop: 0.05 inch wg at 1500 fpm across a 24-by-24-inch damper when tested in accordance with AMCA 500-D, Figure 5.3.
3. Velocity: Up to 3000 fpm.
4. Temperature: Minus 25 to plus 180 deg F.
5. Pressure Rating: Damper close-off pressure equal to fan shutoff pressure with a maximum blade deflection of 1/200 of blade length.

D. Construction:

1. Suitable for horizontal or vertical airflow applications.
2. Linkage out of airstream.
3. Frame:
   a. Hat shaped.
   b. Galvanized sheet steel, with welded or mechanically attached corners and mounting flange.
   c. Gauge in accordance with UL listing.
4. Blades:
   a. Roll-formed, horizontal, airfoil, galvanized sheet steel.
   b. Maximum width and gauge in accordance with UL listing.
5. Blade Edging Seals:
   a. Silicone rubber.

6. Blade Jamb Seal: Flexible stainless steel, compression type.
7. Blade Axles: 1/2-inch diameter; galvanized steel; blade-linkage hardware of zinc-plated steel and brass; ends sealed against blade bearings. Linkage is to be mounted out of airstream.
8. Bearings:
    a. Oil-impregnated stainless steel sleeve.

E. Mounting Sleeve: Factory-installed, galvanized sheet steel; length to suit wall or floor application; gauge in accordance with UL listing.

F. Damper Actuator - Electric:

1. Electric - 120 V ac.
2. UL 873, plenum rated.
3. Designed to operate in smoke-control systems complying with UL 555S requirements.
4. Two position with fail-safe spring return.
    a. Sufficient motor torque and spring torque to drive damper fully open and fully closed with adequate force to achieve required damper seal.
    b. Maximum 15-second full-stroke closure.
    c. Minimum 90-degree drive rotation.
5. Clockwise or counterclockwise drive rotation as required for application.
6. Environmental Operating Range:
    a. Temperature: Minus 40 to plus 130 deg F.
    b. Humidity: 5 to 95 percent relative humidity noncondensing.
7. Environmental Enclosure: NEMA 2.
8. Actuator to be factory mounted and provided with single-point wiring connection.

G. Controllers, Electrical Devices, and Wiring:

1. Electrical Connection: 115 V, single phase, 60 Hz.

H. Accessories:

1. Auxiliary switches for signaling or position indication.
2. Test and reset switches, damper mounted.
3. Smoke Detector: Integral, factory wired for single-point connection.

2.6 COMBINATION FIRE AND SMOKE DAMPERS

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

1. Air Balance; a division of MESTEK, Inc.
2. Arrow United Industries.
3. Cesco Products; a division of MESTEK, Inc.
4. Greenheck Fan Corporation.
5. Pottorff.
6. Ruskin Company.
7. Safe Air - Dowco Products.
8. United Enertech.

B. General Requirements:

1. Label to indicate conformance to UL 555 and UL 555S by an NRTL.
2. Label to indicate conformance to NFPA 80 and NFPA 90A by an NRTL.
3. Unless otherwise indicated, use parallel-blade configuration.

C. Closing rating in ducts up to 4-inch wg static pressure class and minimum 2000 fpm velocity.

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

E. Performance:
1. Leakage:
   a. Class IA: Leakage shall not exceed 3 cfm/sq. ft. against 1-inch wg differential static pressure.
   b. Class I: Leakage shall not exceed 4 cfm/sq. ft. against 1-inch wg differential static pressure.
   c. Class II: Leakage shall not exceed 10 cfm/sq. ft. against 1-inch wg differential static pressure.
2. Pressure Drop: 0.05 in. wg at 1500 fpm across a 24-by-24-inch damper when tested in accordance with AMCA 500-D, Figure 5.3.
3. Velocity: Up to 3000 fpm.
4. Temperature: Minus 25 to plus 180 deg F.
5. Pressure Rating: Damper close-off pressure equal to fan shutoff pressure with a maximum blade deflection of 1/200 of blade length.

F. Construction:

1. Suitable or horizontal or vertical airflow applications.
2. Linkage out of airstream.

3. Frame:
    a. Hat shaped.
    b. Galvanized sheet steel, with welded or mechanically attached corners and mounting flange.
    c. Gauge is to be in accordance with UL listing.
4. Blades:
    a. Roll-formed, horizontal, airfoil, galvanized sheet steel.
    b. Maximum width and gauge in accordance with UL listing.
5. Blade Edging Seals:
    a. Silicone rubber.
6. Blade Jamb Seal: Flexible stainless steel, compression type.
7. Blade Axles: 1/2-inch- diameter; galvanized steel; blade-linkage hardware of zinc-plated steel and brass; ends sealed against blade bearings. Linkage mounted out of airstream.
8. Bearings:
    a. Oil-impregnated stainless steel sleeve.

G. Mounting Sleeve:

1. Factory installed, galvanized sheet steel.
2. Length to suit wall or floor application.
3. Gauge in accordance with UL listing.

H. Heat-Responsive Device:

1. Replaceable, 165 deg F rated, fusible links.

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

J. Damper Actuator - Electric:

1. Electric - 120 V ac.
2. UL 873, plenum rated.
3. Designed to operate in smoke-control systems complying with UL 555S requirements.
4. Two position with fail-safe spring return.
    a. Sufficient motor torque and spring torque to drive damper fully open and fully closed with adequate force to achieve required damper seal.
    b. Maximum 15-second full-stroke closure.
    c. Minimum 90-degree drive rotation.
5. Clockwise or counterclockwise drive rotation as required for application.

6. Environmental Operating Range:
   a. Temperature: Minus 40 to plus 130 deg F.
   b. Humidity: 5 to 95 percent relative humidity noncondensing.
7. Environmental Enclosure: NEMA 2.
8. Actuator to be factory mounted and provided with single-point wiring connection.

K. Controllers, Electrical Devices, and Wiring:

1. Electrical Connection: 115 V, single phase, 60 Hz.

L. Accessories:

1. Auxiliary switches for signaling or position indication.
2. Test and reset switches, damper mounted.
3. Smoke Detector: Integral, factory wired for single-point connection.

2.7 FLANGE CONNECTORS

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

1. Ductmate Industries, Inc.
2. DynAir; a Carlisle Company.
3. Elgen Manufacturing.

B. Description: Add-on or roll-formed, factory fabricated, slide-on transverse flange connectors, gaskets, and components.

C. Material: Galvanized steel.

D. Gauge and Shape: Match connecting ductwork.

2.8 DUCT SILENCERS

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

1. FläktGroup.
2. Flexmaster U.S.A., Inc.
3. McGill AirFlow LLC.
4. Pottorff.
5. Ruskin Company.

B. General Requirements:

1. Factory fabricated.
2. Fire-Performance Characteristics: Adhesives, sealants, packing materials, and accessory materials shall have flame-spread index not exceeding 25 and smoke-developed index not exceeding 50 when tested in accordance with ASTM E84.
3. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
4. Bearing AMCA's Certified Ratings Seal for prefabricated silencer sound and air performance.

C. Shape:

1. Rectangular straight with splitters or baffles.
2. Round straight with center bodies or pods.
3. Rectangular elbow with splitters or baffles.
4. Round elbow with center bodies or pods.
5. Rectangular transitional with splitters or baffles.

D. Rectangular Silencer Outer Casing: ASTM A653/A653M, G90, galvanized sheet steel, 0.034 inch thick.

E. Round Silencer Outer Casing: ASTM A653/A653M, G90, galvanized sheet steel.

1. Sheet Metal Thickness for Units up to 24 Inches in Diameter: 22 gauge thick.
2. Sheet Metal Thickness for Units 26 through 40 Inches in Diameter: 20 gauge thick.
3. Sheet Metal Thickness for Units 42 through 52 Inches in Diameter: 18 gauge thick.
4. Sheet Metal Thickness for Units 54 through 60 Inches in Diameter: 16 gauge thick.

F. Inner Casing and Baffles: ASTM A653/A653M, G90 galvanized sheet metal, 22 gauge thick, and with 1/8-inch- diameter perforations.

G. Special Construction:

1. Suitable for outdoor use.
2. High transmission loss.

H. Connection Sizes: Match connecting ductwork unless otherwise indicated.

I. Principal Sound-Absorbing Mechanism:

1. Controlled impedance membranes and broadly tuned resonators without absorptive media.
2. Dissipative type with fill material.
   a. Fill Material: Inert and vermin-proof fibrous material, packed under not less than 15 percent compression.
   b. Erosion Barrier: Polymer bag enclosing fill, heat-sealed before assembly.
3. Lining: Fiberglas cloth.

J. Fabricate silencers to form rigid units that will not pulsate, vibrate, rattle, or otherwise react to system pressure variations. Do not use mechanical fasteners for unit assemblies.

1. Joints: Lock formed and sealed or flanged connections.
2. Suspended Units: Factory-installed suspension hooks or lugs attached to frame in quantities and spaced to prevent deflection or distortion.
3. Reinforcement: Cross or trapeze angles for rigid suspension.

K. Source Quality Control:

1. Test in accordance with ASTM E477.
2. Record acoustic ratings, including dynamic insertion loss and generated-noise power levels with an airflow of at least 2000 fpm face velocity.
3. Leak Test: Test units for airtightness at 200 percent of associated fan static pressure or 6-inch wg static pressure, whichever is greater.

2.9 TURNING VANES

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

1. Aero-Dyne Sound Control Co.
2. Duro Dyne Inc.
3. DynAir; a Carlisle Company.
4. Elgen Manufacturing.

B. Manufactured Turning Vanes for Metal Ducts: Fabricate curved blades of galvanized sheet steel; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.

1. Acoustic Turning Vanes: Fabricate airfoil-shaped aluminum extrusions with perforated faces and fibrous-glass fill.

C. Manufactured Turning Vanes for Nonmetal Ducts: Fabricate curved blades of resin-bonded fiberglass with acrylic polymer coating; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.

D. General Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."

E. Vane Construction:

1. Single wall for ducts up to 48 inches wide and double wall for larger dimensions.

2.10 REMOTE DAMPER OPERATORS

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

1. DynAir; a Carlisle Company.
2. METALAIRE, Inc.
3. United Enertech.

B. Description: Cable system designed for remote manual damper adjustment.

C. Tubing: Aluminum.

D. Cable: Steel.

E. Wall-Box Mounting: Recessed.

F. Wall-Box Cover-Plate Material: Stainless steel.

2.11 DUCT-MOUNTED ACCESS DOORS

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

1. Aire Technologies.
2. Arrow United Industries.
3. Cesco Products; a division of MESTEK, Inc.
4. Duro Dyne Inc.
5. McGill AirFlow LLC.
6. Ruskin Company.
7. United Enertech.

B. Duct-Mounted Access Doors: Fabricate access panels in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figure 7-2 (7-2M), "Duct Access Doors and Panels," and Figure 7-3, "Access Doors - Round Duct."

1. Door:
   a. Double wall, rectangular.
   b. Galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class.
   c. 24-gauge- thick galvanized steel door panel.
   d. Vision panel.
   e. Hinges and Latches: 1-by-1-inch butt or piano hinge and cam latches.
   f. Fabricate doors airtight and suitable for duct pressure class.
2. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.
   a. 24-gauge- thick galvanized steel or 0.032-inch- thick aluminum Insert value frame.
3. Number of Hinges and Locks:
   a. Access Doors Less Than 12 Inches Square: No hinges and two sash locks.
   b. Access Doors up to 18 Inches Square: Two hinges and two sash locks.
   c. Access Doors up to 24 by 48 Inches: Continuous and two compression latches with outside and inside handles.
   d. Access Doors Larger Than 24 by 48 Inches: Continuous and two compression latches with outside and inside handles.

2.12 DUCT ACCESS PANEL ASSEMBLIES

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

1. CL WARD & Family Inc.
2. Ductmate Industries, Inc.
3. Flame Gard, Inc.

B. Access panels used in cooking applications:

1. Labeled compliant to NFPA 96 for grease duct access doors.
2. Labeled in accordance with UL 1978 by an NRTL.

C. Panel and Frame: Minimum thickness 16-gauge carbon steel.

D. Fasteners: Carbon steel. Panel fasteners shall not penetrate duct wall.

E. Gasket: Comply with NFPA 96, grease-tight, high-temperature ceramic fiber, rated for minimum 2000 deg F.

F. Minimum Pressure Rating: 10 inches wg positive or negative.

2.13 FLEXIBLE CONNECTORS

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

1. Ductmate Industries, Inc.
2. Duro Dyne Inc.
3. DynAir; a Carlisle Company.
4. Elgen Manufacturing.

B. Fire-Performance Characteristics: Adhesives, sealants, fabric materials, and accessory materials shall have flame-spread index not exceeding 25 and smoke-developed index not exceeding 50 when tested in accordance with ASTM E84.

C. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

D. Materials: Flame-retardant or noncombustible fabrics.

E. Coatings and Adhesives: Comply with UL 181, Class 1.

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

1. Minimum Weight: 26 oz./sq. yd..
2. Tensile Strength: 480 lbf/inch in the warp and 360 lbf/inch in the filling.
3. Service Temperature: Minus 40 to plus 200 deg F.

G. Outdoor System, Flexible Connector Fabric: Glass fabric double coated with weatherproof, synthetic rubber resistant to UV rays and ozone.

1. Minimum Weight: 24 oz./sq. yd..
2. Tensile Strength: 530 lbf/inch in the warp and 440 lbf/inch in the filling.
3. Service Temperature: Minus 50 to plus 250 deg F.

2.14 DUCT ACCESSORY HARDWARE

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

1. CL WARD & Family Inc.
2. Ductmate Industries, Inc.
3. Duro Dyne Inc.
4. Elgen Manufacturing.
5. United Enertech.

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

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

2.15 MATERIALS

A. Galvanized Sheet Steel: Comply with ASTM A653/A653M.

1. Galvanized Coating Designation: G90.
2. Exposed-Surface Finish: Mill phosphatized.

B. Stainless Steel Sheets: Comply with ASTM A480/A480M, Type 304, and having a No. 2 finish for concealed ducts and finish for exposed ducts.

C. Aluminum Sheets: Comply with ASTM B209, Alloy 3003, Temper H14; with mill finish for concealed ducts and standard, one-side bright finish for exposed ducts.

D. Extruded Aluminum: Comply with ASTM B221, Alloy 6063, Temper T6.

E. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless steel ducts.

F. 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.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install duct accessories in accordance with applicable details in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for metal ducts and in NAIMA AH116 for fibrous-glass ducts.

B. Install duct accessories of materials suited to duct materials; use galvanized-steel accessories in galvanized-steel and fibrous-glass ducts, stainless steel accessories in stainless steel ducts, and aluminum accessories in aluminum ducts.

C. Install backdraft dampers at inlet of exhaust fans or exhaust ducts as close as possible to exhaust fan unless otherwise indicated.

D. Where multiple damper sections are necessary to achieve required dimensions, provide reinforcement to fully support damper assembly when fully closed at full system design static pressure.

E. Install volume dampers at points on supply, return, and exhaust systems where branches extend from larger ducts. Where dampers are installed in ducts having duct liner, install dampers with hat channels of same depth as liner, and terminate liner with nosing at hat channel.

1. Install steel volume dampers in steel ducts.
2. Install aluminum volume dampers in aluminum ducts.

F. Set dampers to fully open position before testing, adjusting, and balancing.

G. Install test holes at fan inlets and outlets and elsewhere as indicated and as needed for testing and balancing.

H. Install fire and smoke dampers in accordance with UL listing.

I. Connect ducts to duct silencers with flexible duct connectors.

J. Install duct access doors on sides of ducts to allow for inspecting, adjusting, and maintaining accessories and equipment at the following locations:

1. On both sides of duct coils.
2. Upstream from duct filters.
3. At outdoor-air intakes and mixed-air plenums.
4. At drain pans and seals.
5. Downstream from manual volume dampers, control dampers, backdraft dampers, and equipment.
6. Adjacent to and close enough to fire or smoke dampers, to reset or reinstall fusible links. Access doors for access to fire or smoke dampers having fusible links shall be pressure relief access doors and shall be outward operation for access doors installed upstream from dampers and inward operation for access doors installed downstream from dampers.
7. At each change in direction and at maximum 50-ft. spacing.
8. Upstream from turning vanes.

9. Upstream or downstream from duct silencers.
10. For grease ducts, install at locations and spacing as required by NFPA 96.
11. Control devices requiring inspection.
12. Elsewhere as indicated.

K. Install access doors with swing against duct static pressure.

L. Access Door Sizes:

1. One-Hand or Inspection Access: 8 by 5 inches.
2. Two-Hand Access: 12 by 6 inches.
3. Head and Hand Access: 18 by 10 inches.
4. Head and Shoulders Access: 21 by 14 inches.
5. Body Access: 25 by 14 inches.
6. Body plus Ladder Access: 25 by 17 inches.

M. Install flexible connectors to connect ducts to equipment.

N. For fans developing static pressures of 5 inches wg and more, cover flexible connectors with loaded vinyl sheet held in place with metal straps.

O. Install duct test holes where required for testing and balancing purposes.

P. Install thrust limits at centerline of thrust, symmetrical on both sides of equipment. Attach thrust limits at centerline of thrust and adjust to a maximum of 1/4-inch movement during start and stop of fans.

3.2 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Operate dampers to verify full range of movement.
2. Inspect locations of access doors, and verify that size and location of access doors are adequate to perform required operation.
3. Operate fire, smoke, and combination fire and smoke dampers to verify full range of movement and that proper heat-response device is installed.
4. Inspect turning vanes for proper and secure installation, and verify that vanes do not move or rattle.
5. Operate remote damper operators to verify full range of movement of operator and damper.

END OF SECTION 233300

SECTION 233346 - FLEXIBLE DUCTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Non-insulated flexible ducts.
2. Insulated flexible ducts.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For flexible ducts.

1. Include plans showing locations and mounting and attachment details.

1.3 INFORMATIONAL SUBMITTALS

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

PART 2 - PRODUCTS

2.1 ASSEMBLY DESCRIPTION

A. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems," and with NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."

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

C. Comply with the Air Diffusion Council's "ADC Flexible Air Duct Test Code FD 72-R1."

D. Comply with ASTM E96/E96M, "Test Methods for Water Vapor Transmission of Materials."

2.2 INSULATED FLEXIBLE DUCTS

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

1. Flexmaster U.S.A., Inc.
2. McGill AirFlow LLC.
3. Ward Industries; a brand of Hart & Cooley, Inc.

B. Insulated, Flexible Duct: UL 181, Class 1, two-ply vinyl film supported by helically wound, spring-steel wire; fibrous-glass insulation; polyethylene vapor-barrier film.

1. Pressure Rating: 10-inch wg positive and 1.0-inch wg negative.
2. Maximum Air Velocity: 4000 fpm.
3. Temperature Range: Minus 10 to plus 160 deg F.
4. Insulation R-Value: R6.

2.3 FLEXIBLE DUCT CONNECTORS

A. Clamps: Stainless-steel band with cadmium-plated hex screw to tighten band with a worm-gear action in sizes 3 through 18 inches, to suit duct size.

PART 3 - EXECUTION

3.1 INSTALLATION

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

B. Install in indoor applications only. Flexible ductwork should not be exposed to UV lighting.

C. Connect terminal units to supply ducts with maximum 12-inch lengths of flexible duct. Do not use flexible ducts to change directions.

D. Connect diffusers or light troffer boots to ducts with maximum 60-inch lengths of flexible duct clamped or strapped in place.

E. Connect flexible ducts to metal ducts with adhesive plus sheet metal screws.

F. Install duct test holes where required for testing and balancing purposes.

G. Installation:

1. Install ducts fully extended.
2. Do not bend ducts across sharp corners.
3. Bends of flexible ducting shall not exceed a minimum of one duct diameter.
4. Avoid contact with metal fixtures, water lines, pipes, or conduits.
5. Install flexible ducts in a direct line, without sags, twists, or turns.

H. Supporting Flexible Ducts:

1. Suspend flexible ducts with bands 1-1/2 inches wide or wider and spaced a maximum of 48 inches apart. Maximum centerline sag between supports shall not exceed 1/2 inch per 12 inches.
2. Install extra supports at bends placed approximately one duct diameter from center line of the bend.
3. Ducts may rest on ceiling joists or truss supports. Spacing between supports shall not exceed the maximum spacing per manufacturer's written installation instructions.
4. Vertically installed ducts shall be stabilized by support straps at a maximum of 72 inches o.c.

END OF SECTION 233346

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SECTION 233423 - HVAC POWER VENTILATORS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Centrifugal ventilators - roof downblast.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

   1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes for fans.
   2. Rated capacities, operating characteristics, and furnished specialties and accessories.
   3. Certified fan performance curves with system operating conditions indicated.
   4. Certified fan sound-power ratings.
   5. Motor ratings and electrical characteristics, plus motor and electrical accessories.
   6. Material thickness and finishes, including color charts.
   7. Dampers, including housings, linkages, and operators.
   8. Prefabricated roof curbs.
   9. Fan speed controllers.

B. Shop Drawings:

   1. Include plans, elevations, sections, and attachment 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. Include diagrams for power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans, reflected ceiling plans, and other details, or BIM model, drawn to scale, showing the items described in this Section and coordinated with all building trades.

B. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For HVAC power ventilators to include in normal and emergency operation, and maintenance manuals.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

2.2 CENTRIFUGAL VENTILATORS - ROOF DOWNBLAST

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

1. Greenheck Fan Corporation.
2. Loren Cook Company.
3. PennBarry.

B. Housing: Downblast; removable spun-aluminum dome top and outlet baffle; square, one-piece aluminum base with venturi inlet cone.

C. Fan Wheels: Aluminum hub and wheel with backward-inclined blades.

D. Accessories:

1. Variable-Frequency Motor Controller: Solid-state control to reduce speed from 100 to less than 25 percent.
2. Disconnect Switch: Nonfusible type, with thermal-overload protection mounted inside fan housing, factory wired through an internal aluminum conduit.
3. Bird Screens: Removable, 1/2-inch mesh, aluminum or brass wire.
4. Motorized Dampers: Parallel-blade dampers mounted in curb base with electric actuator; wired to close when fan stops.
5. Mounting Pedestal: Galvanized steel with removable access panel.

E. Prefabricated Roof Curb Adapter: Galvanized steel; mitered and welded corners; Size as required to suit existing roof curb and fan base.

1. Configuration: Self-flashing without a cant strip, with mounting flange.
2. Hinged sub-base to provide access to damper.
3. Metal Liner: Galvanized steel.
4. Mounting Pedestal: Galvanized steel with removable access panel.

2.3 SOURCE QUALITY CONTROL

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.

B. AMCA Certification: Fans shall comply with AMCA 11 and bear the AMCA-Certified Ratings Seal.

C. Fan Sound Ratings: Comply with AMCA 311, and label fans with the AMCA-Certified Ratings Seal. Sound ratings shall comply with AMCA 301. The fans shall be tested according to AMCA 300.

D. Fan Performance Ratings: Comply with AMCA 211 and label fans with AMCA-Certified Rating Seal. The fans shall be tested for air performance - flow rate, fan pressure, power, fan efficiency, air density, speed of rotation, and fan efficiency - according to AMCA 210/ASHRAE 51.

E. Operating Limits: Classify according to AMCA 99.

F. UL Standards: Power ventilators shall comply with UL 705. Power ventilators for use for restaurant kitchen exhaust shall also comply with UL 762.

PART 3 - EXECUTION

3.1 INSTALLATION OF HVAC POWER VENTILATORS

A. Install power ventilators level and plumb.

B. Secure roof-mounted fans to roof curbs with zinc-plated hardware.

C. Install units with clearances for service and maintenance.

D. Install and secure roof mounted units in accordance with local wind loading requirements.

3.2 DUCTWORK CONNECTIONS

A. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors.

3.3 ELECTRICAL CONNECTIONS

A. Install electrical devices furnished by manufacturer, but not factory mounted, according to NFPA 70 and NECA 1.

1. Nameplate shall be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least 1/2 inch high.

3.4 CONTROL CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

3.5 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

B. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

C. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

D. Perform tests and inspections.

E. Tests and Inspections:

1. Verify that shipping, blocking, and bracing are removed.
2. Verify that unit is secure on mountings and supporting devices and that connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
3. Verify that there is adequate maintenance and access space.
4. Verify that cleaning and adjusting are complete.
5. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align and adjust belts, and install belt guards.
6. Adjust damper linkages for proper damper operation.
7. Verify lubrication for bearings and other moving parts.
8. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.
9. Disable automatic temperature-control operators, energize motor and adjust fan to indicated rpm, and measure and record motor voltage and amperage.
10. Shut unit down and reconnect automatic temperature-control operators.
11. Remove and replace malfunctioning units and retest as specified above.

F. Test and adjust controls and safeties. Controls and equipment will be considered defective if they do not pass tests and inspections.

G. Prepare test and inspection reports.

3.6 ADJUSTING

A. Adjust damper linkages for proper damper operation.

B. Replace fan and motor pulleys as required to achieve design airflow.

C. Lubricate bearings.

3.7 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain centrifugal fans.

END OF SECTION 233423

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SECTION 233713.13 - AIR DIFFUSERS

PART 1 - GENERAL

1.1 ACTION SUBMITTALS

A. Product Data: For each type of product.

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 Schedule: Indicate drawing designation, room location, quantity, model number, size, and accessories furnished.

B. Samples: For each exposed product and for each color and texture specified. Actual size of smallest diffuser indicated.

C. Samples for Initial Selection: For diffusers with factory-applied color finishes. Actual size of smallest diffuser indicated.

D. Samples for Verification: For diffusers, in manufacturer's standard sizes to verify color selected. Actual size of smallest diffuser indicated.

1.2 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling pl

B. ans, 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.

C. Source quality-control reports.

PART 2 - PRODUCTS

2.1 Refer to schedules on drawings.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas where diffusers are 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 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 determ

C. ination of final location.

D. Install diffusers 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 to air patterns indicated, or as directed, before starting air balancing.

END OF SECTION 233713.13

SECTION 233713.23 - REGISTERS AND GRILLES

PART 1 - GENERAL

1.1 ACTION SUBMITTALS

A. Product Data: For each type of product.

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. Register and Grille Schedule: Indicate drawing designation, room location, quantity, model number, size, and accessories furnished.

B. Samples: For each exposed product and for each color and texture specified. Smallest size register and grille indicated.

C. Samples for Initial Selection: For registers and grilles with factory-applied color finishes. Smallest size register and grille indicated.

D. Samples for Verification: For registers and grilles, in manufacturer's standard sizes to verify color selected. Smallest size register and grille indicated.

1.2 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling pl

B. ans, 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.

C. Source quality-control reports.

PART 2 - PRODUCTS

2.1 Refer to schedules on drawings.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas where registers and grilles are 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 registers and grilles level and plumb.

B. Outlets and Inlets Locations: 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 in

C. stallation, notify Architect for a determinatio

D. n of final location.

E. Install 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 registers and grilles to air patterns indicated, or as directed, before starting air balancing.

END OF SECTION 233713.23

SECTION 237416.11 - PACKAGED, ROOFTOP AIR-CONDITIONING UNITS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes packaged, rooftop air-conditioning units (RTUs) with the following components:

1. Casings.
2. Fans, drives, and motors.
3. Coils.
4. Refrigerant circuit components.
5. Air filtration.
6. Dampers.
7. Electrical power connections.
8. Controls.
9. Accessories.

1.2 DEFINITIONS

A. RTU: Rooftop unit. As used in this Section, this abbreviation means packaged, rooftop air-conditioning units. This abbreviation is used regardless of whether the unit is mounted on the roof or on a concrete base on ground.

1.3 ACTION SUBMITTALS

A. Product Data: For each RTU.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes.
2. Include rated capacities, dimensions, required clearances, characteristics, and furnished specialties and accessories.
3. Include unit dimensions and weight.
4. Include cabinet material, metal thickness, finishes, insulation, and accessories.
5. Fans:

    a. Include certified fan-performance curves with system operating conditions indicated.
    b. Include certified fan-sound power ratings.

c. Include fan construction and accessories.
d. Include motor ratings, electrical characteristics, and motor accessories.

6. Include certified coil-performance ratings with system operating conditions indicated.
7. Include filters with performance characteristics.
8. Include dampers, including housings, linkages, and operators.

B. Shop Drawings: For each packaged, rooftop air-conditioning unit.

1. Include plans, elevations, sections, and mounting 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. Include diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans and other details, or BIM model, drawn to scale, showing the items described in this Section, and coordinated with all building trades.

B. Sample Warranty: For manufacturer's warranty.

C. System startup reports.

D. Field quality-control reports.

E. UL certification for A2L Refrigerant Safeties.

1.5 CLOSEOUT SUBMITTALS

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

1.6 MAINTENANCE MATERIAL SUBMITTALS

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

1. Filters: One set of filters for each unit.
2. Gaskets: One set for each access door.

1.7 WARRANTY

A. Warranty: Manufacturer agrees to repair or replace components of packaged, rooftop air-conditioning unit that fail in materials or workmanship within specified warranty period.

1. Warranty Period: 1 years from date of Substantial Completion.
2. Warranty Period for Compressors: 5 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.

B. NFPA Compliance: Comply with NFPA 90A for design, fabrication, and installation of RTUs and components.

C. ASHRAE 62.1 Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

D. ASHRAE 15 Compliance: For refrigeration system safety.

E. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

F. UL Compliance: Comply with UL 1995.

2.2 MANUFACTURERS

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

1. AAON.
2. Daikin Applied.
3. Trane.

2.3 UNIT CASINGS

A. General Fabrication Requirements for Casings: Formed and reinforced double-wall insulated panels, fabricated to allow removal for access to internal parts and components, with joints between sections sealed.

B. Double-Wall Construction:

1. Outside Casing Wall: Galvanized steel, minimum 18 gauge thick with manufacturer's standard finish, with pitched roof panels and knockouts with grommet seals for electrical and piping connections and lifting lugs.
2. Inside Casing Wall: G90-coated galvanized steel, 0.034 inch thick.
3. Floor Plate: G90 galvanized steel, minimum 18 gauge thick.
4. Casing Insulation:

a. Materials: Injected polyurethane foam insulation.
b. Casing Panel R-Value: Minimum 7
c. Insulation Thickness: 1 inch.
d. Thermal Break: Provide continuity of insulation with no through-casing metal in casing walls, floors, or roof of unit.

C. Airstream Surfaces: Surfaces in contact with airstream shall comply with requirements in ASHRAE 62.1.

D. Static-Pressure Classifications:

1. For Unit Sections Upstream of Fans: Minus 3-inch wg.
2. For Unit Sections Downstream and Including Fans: 4-inch wg.

E. Panels and Doors:

1. Panels:

a. Fabrication: Formed and reinforced with same materials and insulation thickness as casing.
b. Fasteners: Two or more camlock type for panel lift-out operation. Arrangement shall allow panels to be opened against air-pressure differential.
c. Gasket: Neoprene, applied around entire perimeters of panel frames.
d. Size: Large enough to allow inspection and maintenance of air-handling unit's internal components.

2. Access Doors:

a. Hinges: A minimum of two ball-bearing hinges or stainless steel piano hinge and two wedge-lever-type latches, operable from inside and outside. Arrange doors to be opened against air-pressure differential.
b. Gasket: Neoprene, applied around entire perimeters of panel frames.
c. Size: Large enough to allow inspection and maintenance of air-handling unit's internal components.

3. Locations and Applications:

a. Fan Section: Doors and inspection and access panels.
b. Access Section: Doors.
c. Coil Section: Inspection and access panels.
d. Damper Section: Doors.
e. Filter Section: Doors large enough to allow periodic removal and installation of filters.
f. Mixing Section: Doors.

F. Condensate Drain Pans:

1. Location: Each type of cooling coil rotary heat exchanger.
2. Construction: Single-wall, stainless steel sheet.
3. Drain Connection:

a. Located at lowest point of pan and sized to prevent overflow. Terminate with threaded nipple on both ends of pan.
b. Minimum Connection Size: NPS 1.

4. Slope: Minimum 0.125-in./ft. slope in at least two planes to collect condensate from cooling coils (including coil piping connections, coil headers, and return bends) and from humidifiers and to direct water toward drain connection.
5. Length: Extend drain pan downstream from leaving face for distance to comply with ASHRAE 62.1.
6. Width: Entire width of water producing device.
7. Depth: A minimum of 2 inches deep.
8. Units with stacked coils shall have an intermediate drain pan to collect condensate from top coil.

2.4 FANS, DRIVES, AND MOTORS

A. Fan and Drive Assemblies: Statically and dynamically balanced and designed for continuous operation at maximum-rated fan speed and motor horsepower.

B. Supply-Air Fans: Centrifugal, rated according to AMCA 210; galvanized or painted steel; mounted on solid-steel shaft.

1. Shafts: With field-adjustable alignment.

    a. Turned, ground, and polished hot-rolled steel with keyway.

2. Shaft Bearings:

    a. Heavy-duty, self-aligning, pillow-block type with an L-50 rated life of minimum 100,000 hours according to ABMA 9.
    b. Shaft grounding ring factory installed.

3. Housings: Formed- and reinforced-steel panels to form curved scroll housings with shaped cutoff and spun-metal inlet bell.

    a. Bracing: Steel angle or channel supports for mounting and supporting fan scroll, wheel, motor, and accessories.

4. Centrifugal Fan Wheels: Inlet flange, backplate, and shallow blades with inlet and tip curved forward in direction of airflow and mechanically fastened to flange and backplate; steel or aluminum hub swaged to backplate and fastened to shaft with setscrews.
5. Mounting: For internal vibration isolation. Factory-mount fans with manufacturer's standard vibration isolation mounting devices having a minimum static deflection of 1 inch.
6. Shaft Lubrication Lines: Extended to a location outside the casing.

C. Drives, Direct: Factory-mounted, direct drive.

D. Condenser-Coil Fan: Variable-speed propeller, mounted on shaft of permanently lubricated multispeed ECM motors.

2.5 COILS

A. General Requirements for Coils:

1. Comply with AHRI 410.
2. Fabricate coils section to allow for removal and replacement of coil for maintenance and to allow in-place access for service and maintenance of coil(s).
3. Coils shall not act as structural component of unit.

B. Supply-Air Refrigerant Coil:

1. Tubes: Copper.
2. Fins: Aluminum Plate
3. Fin and Tube Joints: Mechanical bond.

4. Headers: Seamless-copper headers with brazed connections.
5. Frames: Galvanized steel.
6. Coatings: None.
7. Ratings: Designed, tested, and rated according to ASHRAE 33 and AHRI 410.

    a. Working Pressure: Minimum 300 psig.

C. Outdoor-Air Refrigerant Coil:

1. Tubes: Copper.
2. Fins: Aluminum Plate

3. Fin and Tube Joints: Mechanical bond.
4. Headers: Seamless-copper headers with brazed connections.
5. Frames: Galvanized steel.
6. Coatings: None.
7. Ratings: Designed, tested, and rated according to ASHRAE 33 and AHRI 410.

    a. Working Pressure: Minimum 300 psig.

D. Hot-Gas Reheat Refrigerant Coil:

1. Tubes: Copper.
2. Fins: Aluminum Plate

3. Fin and Tube Joints: Mechanical bond.
4. Headers: Seamless-copper headers with brazed connections.
5. Frames: Galvanized steel.
6. Coatings: None.
7. Ratings: Designed, tested, and rated according to ASHRAE 33 and AHRI 410.

    a. Working Pressure: Minimum 300 psig.

8. Suction-discharge bypass valve.

2.6 REFRIGERANT CIRCUIT COMPONENTS

A. Compressor: Hermetic, variable-speed scroll, mounted on vibration isolators; with internal overcurrent and high-temperature protection, internal pressure relief, and crankcase heater.

B. Refrigeration Specialties:

1. Refrigerant: R-454B or R32.

2. Expansion valve with replaceable thermostatic element.
3. Refrigerant filter/dryer.
4. Manual-reset high-pressure safety switch.
5. Automatic-reset low-pressure safety switch.
6. Liquid line sight glass.
7. Oil separator.
8. Minimum off-time relay.
9. Automatic-reset compressor motor thermal overload.
10. Brass service valves installed in compressor suction and liquid lines.
11. Low-ambient kit high-pressure sensor.
12. Hot-gas reheat solenoid valve modulating with a replaceable magnetic coil.
13. Hot-gas bypass solenoid valve with a replaceable magnetic coil.
14. Four-way reversing valve with a replaceable magnetic coil, thermostatic expansion valves with bypass check valves, and a suction line accumulator.

C. Refrigeration only controller.
1. DDC controller capable of running all components associated with the refrigerant circuit.

2.7 AIR FILTRATION

A. Panel Filters:

1. Description: Flat, non-pleated factory-fabricated, self-supported, disposable air filters with holding frames.
2. Filter Unit Class: UL 900.
3. Media: Interlaced glass, synthetic or cotton fibers coated with nonflammable adhesive and antimicrobial coating.
4. Filter-Media Frame: Beverage board with perforated metal retainer, or metal grid, on outlet side.
5. Pre-filter Rating: Merv 8
6. Post-filter Rating: Merv 13

2.8 DAMPERS

A. Outdoor-and Return-Air Dampers: Low-leakage, double-skin, airfoil-blade, galvanized-steel dampers with compressible jamb seals and extruded-vinyl blade edge seals with zinc-plated steel operating rods rotating in sintered bronze or nylon bearings mounted in a single galvanized-steel frame, and with operating rods connected with a common linkage. Leakage rate shall not exceed 4 cfm/sq. ft. at 1-inch wg and 8 cfm/sq. ft. at 4-inch wg.

B. Barometric relief dampers.

2.9 ELECTRICAL POWER CONNECTIONS

A. RTU shall have a single connection of power to unit with unit-mounted disconnect switch accessible from outside unit and control-circuit transformer with built-in overcurrent protection.

2.10 ACCESSORIES

A. Duplex, 115-V, ground-fault-interrupter outlet with 15-A overcurrent protection. Include transformer if required. Outlet shall be energized even if the unit main disconnect is open.

B. Return-air bypass damper.

C. Factory- or field-installed, demand-controlled ventilation.

D. Safeties:
1. Condensate overflow switch.
2. Phase-loss reversal protection.
3. High and low pressure control.
4. A2L Refrigerant leak detection and mitigation.

E. Coil guards of painted, galvanized-steel wire.

F. Hail guards of galvanized steel, painted to match casing.

G. Door switches to disable heating or reset set point when open.

H. Outdoor-air intake weather hood.

I. Service Lights and Switch: Factory installed in fan and coil sections with weatherproof cover. Factory wire lights to a single-point field connection.

2.11 MATERIALS

A. Steel:

1. ASTM A36/A36M for carbon structural steel.
2. ASTM A568/A568M for steel sheet.

B. Stainless Steel:

1. Manufacturer's standard grade for casing.
2. Manufacturer's standard type, ASTM A240/A240M for bare steel exposed to airstream or moisture.

C. Galvanized Steel: ASTM A653/A653M.

D. Aluminum: ASTM B209.

E. Corrosion-Resistant Coating: Coat with a corrosion-resistant coating capable of withstanding a 3000-hour salt-spray test according to ASTM B117.

1. Standards:

a. ASTM B117 for salt spray.
b. ASTM D2794 for minimum impact resistance of 100 in-lb.
c. ASTM B3359 for cross-hatch adhesion of 5B.

2. Application: Spray.
3. Thickness: 1 mil.
4. Gloss: Minimum gloss of 60 on a 60-degree meter.

2.12 SOURCE QUALITY CONTROL

A. AHRI Compliance:
1. Comply with AHRI 340/360 for testing and rating energy efficiencies for RTUs.
2. Comply with AHRI 270 for testing and rating sound performance for RTUs.
3. Comply with AHRI 1060 for testing and rating performance for air-to-air exchanger.

B. AMCA Compliance:

1. Comply with AMCA 11 and bear the AMCA-Certified Ratings Seal for air and sound performance according to AMCA 211 and AMCA 311.
2. Damper leakage tested according to AMCA 500-D.
3. Operating Limits: Classify according to AMCA 99.

PART 3 - EXECUTION

3.1 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.

3.2 INSTALLATION

A. Unit Support: Install unit level on structural steel supports. Coordinate wall penetrations and flashing with wall construction. Secure RTUs to structural support with anchor bolts.

3.3 PIPING CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where installing piping adjacent to RTU, allow space for service and maintenance.

C. Connect condensate drain pans using NPS 1-1/4, ASTM B88, Type M copper tubing. Extend to nearest equipment or roof drain. Construct deep trap at connection to drain pan and install cleanouts at changes in direction.

3.4 DUCT CONNECTIONS

A. Comply with duct installation requirements specified in other HVAC Sections. Drawings indicate general arrangement of ducts.

3.5 STARTUP SERVICE

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

1. Complete installation and startup checks according to manufacturer's written instructions.
2. Inspect for visible damage to unit casing.
3. Inspect for visible damage to compressor, coils, and fans.
4. Inspect internal insulation.
5. Verify that labels are clearly visible.
6. Verify that clearances have been provided for servicing.
7. Verify that controls are connected and operable.
8. Verify that filters are installed.

9. Clean condenser coil and inspect for construction debris.
10. Remove packing from vibration isolators.
11. Inspect operation of barometric relief dampers.
12. Verify lubrication on fan and motor bearings.
13. Inspect fan-wheel rotation for movement in correct direction without vibration and binding.
14. Adjust fan belts to proper alignment and tension.
15. 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.

16. Inspect and record performance of interlocks and protective devices; verify sequences.
17. Operate unit for an initial period as recommended or required by manufacturer.
18. Calibrate thermostats.
19. Adjust and inspect high-temperature limits.
20. Inspect outdoor-air dampers for proper stroke and interlock with return-air dampers.
21. Start refrigeration system and measure and record the following when ambient is a minimum of 15 deg F above return-air temperature:

    a. Coil leaving-air, dry- and wet-bulb temperatures.
    b. Coil entering-air, dry- and wet-bulb temperatures.
    c. Outdoor-air, dry-bulb temperature.
    d. Outdoor-air-coil, discharge-air, dry-bulb temperature.

22. Inspect controls for correct sequencing of heating, mixing dampers, refrigeration, and normal and emergency shutdown.
23. 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.

24. Simulate maximum cooling demand and inspect the following:

    a. Compressor refrigerant suction and hot-gas pressures.
    b. Short circuiting of air through condenser coil or from condenser fans to outdoor-air intake.

25. Verify operation of remote panel including pilot-light operation and failure modes. Inspect the following:

    a. High-temperature limit on gas-fired heat exchanger.
    b. Low-temperature safety operation.
    c. Filter high-pressure differential alarm.
    d. Economizer to minimum outdoor-air changeover.
    e. Relief-air fan operation.
    f. Smoke and firestat alarms.

26. After startup and performance testing and prior to Substantial Completion, replace existing filters with new filters.

3.6 CLEANING AND ADJUSTING

A. After completing system installation and testing, adjusting, and balancing RTUs and air-distribution systems, clean RTUs internally to remove foreign material and construction dirt and dust. Clean fan wheels, cabinets, dampers, coils, and filter housings, and install new, clean filters.

3.7 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. 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.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

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

D. Prepare test and inspection reports.

3.8 DEMONSTRATION

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

END OF SECTION 237416.11

SECTION 238126 – SPLIT-SYSTEM HEAT PUMP

PART 1 - GENERAL

1.1 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, and furnished specialties and accessories. Include performance data in terms of capacities, outlet velocities, static pressures, sound power characteristics, motor requirements, and electrical characteristics.

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

1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Wiring Diagrams: For power, signal, and control wiring.

1.2 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

B. Warranty: Sample of special warranty.

1.3 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For split-system air-conditioning units to include in emergency, operation, and maintenance manuals.

1.4 QUALITY ASSURANCE

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

B. ASHRAE Compliance:

1. Fabricate and label refrigeration system to comply with ASHRAE 15, "Safety Standard for Refrigeration Systems."

2. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 4 - "Outdoor Air Quality," Section 5 - "Systems and Equipment," Section 6 - " Procedures," and Section 7 - "Construction and System Start-up."

C. ASHRAE/IES Compliance: Applicable requirements in ASHRAE/IES 90.1.

1.5 COORDINATION

A. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.

1.6 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of split-system air-conditioning units that fail in materials or workmanship within specified warranty period.

1. Warranty Period:
   a. For Compressor: Five year(s) from date of Substantial Completion.
   b. For Parts: One year from date of Substantial Completion.
   c. For Labor: One year from date of Substantial Completion.

PART 2 - PRODUCTS

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

1. Daikin Applied.
2. Samsung
3. Hitachi.

2.2 INDOOR UNITS

A. Wall-Mounted, Evaporator-Fan Components:

1. Cabinet: Enameled steel with removable panels on front and ends in color selected by Architect, and discharge drain pans with drain connection.
2. Coil: Copper tube, with mechanically bonded aluminum fins and thermal-expansion valve. Comply with ARI 206/110.
3. Fan: Direct drive, centrifugal.
4. Fan Motors:

a. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
b. Multitapped, multispeed with internal thermal protection and permanent lubrication.
c. Enclosure Type: Totally enclosed, fan cooled.
d. NEMA Premium (TM) efficient motors as defined in NEMA MG 1.

5. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
6. Filter: Washable.
7. Variable-Frequency Controllers:
   a. Description: NEMA ICS 2, IGBT, PWM, VFC; listed and labeled as a complete unit and arranged to provide variable speed of an NEMA MG 1, Design B, three-phase induction motor by adjusting output voltage and frequency.
   b. Isolated control interface to allow controller to follow control signal over an 11:1 speed range.
   c. Internal Adjustability Capabilities:
      1) Minimum Speed: 5 to 25 percent of maximum rpm.
      2) Maximum Speed: 80 to 100 percent of maximum rpm.
      3) Acceleration: 2 seconds to a minimum of 22 seconds.
      4) Deceleration: 2 seconds to a minimum of 22 seconds.
      5) Current Limit: 50 percent to a minimum of 110 percent of maximum rating.
   d. Automatic Reset/Restart: Attempts three restarts after controller fault or on return of power after an interruption and before shutting down for manual reset or fault correction. Bidirectional autospeed search shall be capable of starting into rotating loads, spinning in either direction and returning motor to set speed in proper direction, without damage to controller, motor, or load.
   e. Power-Interruption Protection: Prevents motor from re-energizing after a power interruption until motor has stopped.
   f. Torque Boost: Automatically varies starting and continuous torque to at least 1.5 times the minimum torque to ensure high-starting torque and increased torque at slow speeds.
   g. Motor Temperature Compensation at Slow Speeds: Adjustable current fall-back, based on output frequency for temperature protection of self-cooled, fan-ventilated motors at slow speeds.
   h. Door-mounted, digital status lights shall indicate the following conditions:
      1) Power on.
      2) Run.
      3) Overvoltage.
      4) Line fault.
      5) Overcurrent.

6) External fault.

i. Panel-Mounted Operator Station: Start-stop and auto-manual selector switches with manual-speed-control potentiometer and elapsed-time meter.

j. Meters or digital readout devices and selector switch, mounted flush in controller door and connected, to indicate the following controller parameters:
   1) Output frequency (Hertz).
   2) Motor speed (rpm).
   3) Motor status (running, stop, fault).
   4) Motor current (amperes).
   5) Motor torque (percent).
   6) Fault or alarming status (code).
   7) Proportional-integral-derivative feedback signal (percent).
   8) DC-link voltage (volts dc).
   9) Set-point frequency (Hertz).
   10) Motor output voltage (volts).

k. Control Signal Interface:
   1) Electric Input Signal Interface: A minimum of two analog inputs (0 to 10 V or 0/4-20 mA) and six programmable digital inputs.
   2) Remote signal inputs capable of accepting any of the following speed-setting input signals from the control system:
      a) 0 to 10-V dc.
      b) 0-20 or 4-20 mA.
      c) Potentiometer using up/down digital inputs.
      d) Fixed frequencies using digital inputs.
      e) RS485.
      f) Keypad display for local hand operation.
   3) Output signal interface with a minimum of one analog output signal (0/4-20 mA), which can be programmed to any of the following:
      a) Output frequency (Hertz).
      b) Output current (load).
      c) DC-link voltage (volts dc).
      d) Motor torque (percent).
      e) Motor speed (rpm).
      f) Set-point frequency (Hertz).
   4) Remote indication interface with a minimum of two dry circuit relay outputs (120-V ac, 1 A) for remote indication of the following:
      a) Motor running.
      b) Set-point speed reached.
      c) Fault and warning indication (overtemperature or overcurrent).
      d) High- or low-speed limits reached.

8. Communications: RS485 interface allows VFC to be used with an external system within a multidrop LAN configuration. Interface shall allow all parameter settings of VFC to be programmed via BMS control. Provide capability for VFC to retain these settings within the nonvolatile memory.
9. Accessories:
    a. Devices shall be factory installed in controller enclosure unless otherwise indicated.
    b. Push-Button Stations, Pilot Lights, and Selector Switches: NEMA ICS 2, heavy-duty type.
    c. Standard Displays:

        1) Output frequency (Hertz).
        2) Set-point frequency (Hertz).
        3) Motor current (amperes).
        4) DC-link voltage (volts dc).
        5) Motor torque (percent).
        6) Motor speed (rpm).
        7) Motor output voltage (volts).

2.3 OUTDOOR UNITS:

A. Air-Cooled, Compressor-Condenser Components:

1. Casing: Steel, finished with baked enamel in color selected by Architect, with removable panels for access to controls, weep holes for water drainage, and mounting holes in base. Provide brass service valves, fittings, and gage ports on exterior of casing.

B. Cabinet: Steel, finished with baked enamel in color selected by Architect, with removable panels for access to controls, weep holes for water drainage, and mounting holes in base. Provide brass service valves, fittings, and gage ports on exterior of casing.

C. Coil: Copper tube, with mechanically bonded aluminum fins and liquid subcooler. Comply with ARI 206/110.

D. Refrigerant: R-32

E. Compressor: Compressor: Hermetically sealed with crankcase heater and mounted on vibration isolation device. Compressor motor shall have thermal- and current-sensitive overload devices, start capacitor, relay, and contactor.

    a. Compressor Type: Scroll.

F. Fan: Aluminum-propeller type, directly connected to motor.

G. Motor: Permanently lubricated, with integral thermal-overload protection.

H. Accessories: Front wind baffle, side wind baffle, and rear wind baffle.

2.4 ACCESSORIES

A. Mini Condensate Pump.

B. Equipment stand.

C. Snow hood.

D. Drain pan heater.

E. Interface adapter for BMS integration and monitoring.

F. Thermostat: Low voltage with subbase to control compressor and evaporator fan.

G. Thermostat: Wireless infrared functioning to remotely control compressor and evaporator fan, with the following features:

1. Compressor time delay.
2. 24-hour time control of system stop and start.
3. Liquid-crystal display indicating temperature, set-point temperature, time setting, operating mode, and fan speed.
4. Fan-speed selection including auto setting.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install units level and plumb.

B. Install evaporator-fan components using manufacturer's standard mounting devices securely fastened to building structure.

C. Install roof-mounted, compressor-condenser components on equipment supports. Anchor units to supports with removable, cadmium-plated fasteners.

3.2 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.

B. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

C. Tests and Inspections:

1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
2. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

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

E. Prepare test and inspection reports.

3.3 STARTUP SERVICE

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

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

3.4 DEMONSTRATION

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

END OF SECTION 238132

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SECTION 238216.122 – STEAM AIR COILS

PART 1 - GENERAL

1.1 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.

1.2 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans, sections, and other details, or BIM model, drawn to scale, showing the items described in this Section and coordinated with all building trades.

1.3 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For air coils to include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. ASHRAE 62.1 Compliance: Comply with applicable requirements in ASHRAE 62.1, Section 5, "Systems and Equipment," and Section 7, "Construction and Startup."

B. Performance Ratings: Tested and rated in accordance with AHRI 410 and ASHRAE 33.

2.2 STEAM AIR COILS

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

1. Capital Coil.
2. Daikin Applied.
3. Trane.

B. Description: Plate fin coils constructed of tubes mechanically expanded into continuous collars that are die-formed into plate fins and specially designed for thermal expansion and contraction of the tubes during coil operation.

C. Tubes:

1. Material: Copper.
2. Nominal Diameter: Minimum 5/8 inch
3. Nominal Wall Thickness: Minimum of 0.020 inch thick.

D. Fins:

1. Materials: Aluminum: 0.0075 inch thick.
2. Spacing: Maximum 6 fins per inch.
3. Collars: Full collars for accurate fin spacing and maximum tube contact while leaving no surface of tube exposed.

E. Headers:

1. Material: Copper

F. Casing:

1. Depth: Extend coil casing and tube sheets a minimum of 1/2 inch beyond face of fins on both entering and leaving sides.
2. Materials:
   a. Galvanized steel, G90 coating.

G. Nameplate: Aluminum or stainless steel nameplate with brass or stainless steel chain for each coil, with the following data engraved or embossed:

1. Manufacturer name, address, telephone number, and website address.
2. Manufacturer model number.
3. Serial number.
4. Manufacturing date.
5. Coil identification (indicated on Drawings).
6. Coil fin length.
7. Coil fin height.
8. Coil weight with fluid/without fluid.
9. Coil casing material and thickness.
10. Coil fin material and thickness.
11. Coil tube material and thickness.
12. Coil header material and thickness.

2.3 MATERIALS

A. Aluminum: ASTM B209.

B. Copper Tube: ASTM B75/B75M annealed temper or ASTM B280 drawn temper.

C. Copper Sheet: ASTM B152.

D. Galvanized Steel: ASTM A653/A653M.

E. Steel: Pipe Connections: ASTM A53/A53M.

2.4 SOURCE QUALITY CONTROL

A. Steam Coils: Factory tested to 300 psig.

B. Coils to display a tag with inspector's identification as proof of testing.

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 in accordance with 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 PIPING 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 steam piping with gate valve and union and steam condensate piping with union, strainer, trap, gate valve, and control valve to allow coils to be disconnected without draining piping.

END OF SECTION 238216.12

SECTION 238236 - FINNED-TUBE RADIATION HEATERS

PART 1 - GENERAL

1.1 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include rated capacities, operating characteristics, furnished specialties, and accessories.

B. 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. Include details and dimensions of custom-fabricated enclosures.
4. Indicate location and size of each field connection.
5. Indicate location and arrangement of piping valves and specialties.
6. Indicate location and arrangement of integral controls.
7. Include enclosure joints, corner pieces, access doors, and other accessories.
8. Include diagrams for power, signal, and control wiring.

C. Samples: For each exposed product and for each color and texture specified.

D. Color Samples for Initial Selection: For finned-tube radiation heaters with factory-applied color finishes.

E. Color Samples for Verification: For each type of exposed finish.

1.2 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans and other details, or BIM model, drawn to scale, showing the items described in this Section, and coordinated with all building.

B. Field quality-control reports.

PART 2 - PRODUCTS

2.1 STEAM FINNED-TUBE RADIATION HEATERS

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

1. Slant/Fin Corp.
2. Sterling HVAC Products; a Mestek company.
3. Zehnder-Rittling.

B. Performance Ratings: Rate finned-tube radiation heaters according to Hydronics Institute's "I=B=R Testing and Rating Standard for Finned-Tube (Commercial) Radiation."

C. Element Supports: Ball-bearing cradle type to permit longitudinal movement on enclosure brackets.

D. Front Panel: Minimum 0.0528-inch- Insert thickness thick steel.

E. Wall-Mounted Back Panel: Minimum 0.0329-inch- thick steel, full height, with full-length channel support for front panel without exposed fasteners.

F. Floor-Mounted Pedestals: Conceal insulated piping at maximum 36-inch spacing. Pedestal-mounted back panel shall be solid panel matching front panel. Provide stainless-steel escutcheon for floor openings at pedestals.

G. Support Brackets: Locate at maximum 36-inch spacing to support front panel and element.

H. Finish: Baked-enamel finish in manufacturer's standard color as selected by Architect.

I. Access Doors: Factory made, permanently hinged with tamper-resistant fastener, minimum size 6 by 7 inches, integral with enclosure.

J. Enclosure Color: Anodized finish, color as selected by architect from manufacturer’s standard colors.

K. Accessories:

1. Filler sections, corners, relay sections, and splice plates all matching the enclosure and grille finishes.
2. Thermostatic radiator valve.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas to receive finned-tube radiation heaters for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for hydronic-piping connections to verify actual locations before installation of finned-tube radiation heaters.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 FINNED-TUBE RADIATION HEATER INSTALLATION

A. Install units level and plumb.

B. Install enclosure continuously around corners, using outside and inside corner fittings.

C. Join sections with splice plates and filler pieces to provide continuous enclosure.

D. Install access doors for access to valves.

E. Install enclosure continuously from wall to wall.

F. Terminate enclosures with manufacturer's end caps except where enclosures are indicated to extend to adjoining walls.

G. Install valves within reach of access door provided in enclosure.

H. Install air-seal gasket between wall and recessed flanges or front cover of fully recessed unit.

I. Install piping within pedestals for freestanding units.

J. Install shutoff valve on inlet; install strainer, thermostatic radiator valve, steam trap, and shutoff valve on outlet.

K. Install piping adjacent to finned-tube radiation heaters to allow service and maintenance.

3.3 FIELD QUALITY CONTROL

A. Perform the following field tests and inspections:

1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
2. Operational Test: After electrical circuitry has been energized, start units to confirm proper operation.
3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

B. Units will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

END OF SECTION 238236

SECTION 238413 - ELECTRODE STEAM HUMIDIFIERS

PART 1 - GENERAL

1.1 ACTION SUBMITTALS

A. Product Data: For each type of product. Include rated capacities, operating characteristics, furnished specialties, and accessories.

1.2 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For humidifiers to include in operation and maintenance manuals.

1.3 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. Supply one replacement electrode cylinder with each self-contained humidifier.

1.4 QUALITY ASSURANCE

A. UL Listed.

B. ISO 9001-2008.

C. ANSI/NFPA 70 - National Electrical Code.

D. ARI 640, "Standard for Commercial and Industrial Humidifiers.

E. ASHRAE SSPC 135 BACnet

1.5 COORDINATION

A. Coordinate location and installation of humidifiers with distributer tubes/manifolds in ducts and plenums or occupied space. Revise locations and elevations to suit field conditions and to ensure proper humidifier operation.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Armstrong International, Inc.
2. Condair (Design Basis).
3. DRI-STEEM Humidifier Company.
4. Neptronic Inc.

B. Provide electrode humidifier generating mineral-free, sterile steam from a potable water supply. Packaged unit, wall mounted, atmospheric steam generation using an electrode steam cylinder[s]. Resistive element technology and boiler steam (pressure steam) technology not acceptable.

2.2 Unit[s] to be complete with:

A. Touchscreen controller with standard building automation:

1. Intuitive touchscreen control with color graphic user interface.
2. Standard building automation communication protocols BACnet IP, BACnet MSTP (Slave) and Modbus. Additional hardware required for building automation communication not acceptable.
3. Embedded web interface for easy configuration and remote monitoring from any computer with a web browser over a local area network (LAN) connection.
4. USB interface for new software/feature upload and download of operational information.
5. Single or dual channel analog signal acceptance, supporting both demand and transducer control. Ability to control setpoint from humidifier control when using transducer controls.

B. Packaged system with electrode cylinder technology:

1. Cylinder optimized for humidifier capacity and supply voltage. Cylinder shall be stainless steel and cleanable. Cylinder shall be serviceable and have high water sensor to prevent overfilling.
2. Durable powder coated steel cabinet with stainless steel base and zero side clearance requirement for minimal footprint.
3. Insulating air gap between plumbing and electrical compartment for increased electronic reliability.
4. Standard internal drain water tempering to ensure maximum 140° F drain water. External drain water cooler not acceptable.
5. Integral fill cup with minimum 1-inch air gap to prevent back siphoning.

6. Full cylinder indication and pre-notification of automatic shutdown at end of cylinder life.
7. Automatic pulse feature to clean any obstruction from the drain solenoid valve if required.
8. The humidifier shall have a drain pump which provides a quick drain cycle.
9. Factory built and wired disconnect switch.

C. Auto-Adaptive Control water management:

1. Advanced water management utilizing Proportional plus Integral AutoAdaptive Control system for optimal energy efficiency, water usage and cylinder life.
2. 98% thermal efficiency from startup until end of cylinder life.
3. Drains automatically optimized to water conditions to maximize cylinder and reduce water usage.
4. Modulating output between 0% and 100% of rated capacity.
5. Water level detection system shall be self-cleaning, self calibrating and equipped with a redundancy system, consisting of a high-resolution capacitive sensor and two fail-safe resistive sensors.
6. Humidifier shall operate under all types of water including tap, deionized and reverse osmosis water, with no additional parts.

D. Atmospheric Steam Panel Distribution Manifold:

1. Prefabricated steam dispersion grid assembly.
2. Designed for short absorption distance.
3. Suitable for atmospheric steam applications.
4. Extending the full width and height of duct or plenum.
5. Horizontal or Vertical header with multiple vertical or horizontal tubes designed for dry steam injection within short absorption distance.
6. Nozzles/metered orifices, spaced evenly along distribution tubes, provide dry and uniform steam distribution.
7. Distribution panel extending the full width and height of duct or plenum.
8. Headers and Distribution Tubes:

    a. Material: Stainless steel.
    b. Insulation: Insulated, minimum R-0.5.

9. Steam Separator: Separators/baffles, integral to the header, provide condensate-free steam to distribution tubes.

E. Accessories:

1. Humidity Sensor: Wall mounted humidistat.
2. Duct-mounted, high-limit humidity sensor.
3. Airflow switch prevents humidifier operation without airflow.

4. Steam and Condensate Hoses: For interconnection of humidifier to distributer tube(s)/manifold.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install humidifiers per manufacturers' instructions.

B. Install with required clearance for service and maintenance.

C. Seal all duct and plenum penetrations with flange.

D. Install humidifier assemblies in metal ducts and casings constructed according to SMACNA's "HVAC Duct Construction Standards, Metal and Flexible."

E. Install stainless-steel drain pan under each manifold mounted in duct.

1. Construct drain pans with connection for drain; insulated.
2. Connect to condensate trap and drainage piping.
3. Extend drain pan upstream and downstream from tube(s)/manifold a minimum distance recommended by manufacturer but not less than required by ASHRAE 62.1.

F. Install tube(s)/manifold supply piping pitched to drain condensate back to humidifier or as recommended by manufacturer.

G. Install all manufacturer-furnished accessories in accordance with manufacturer's written installation instructions.

3.2 PIPING CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

1. Install piping adjacent to humidifiers to allow service and maintenance.
2. Install shutoff valve, strainer, backflow preventer, and union in humidifier makeup line.

B. Install piping specialties furnished by manufacturer but not factory mounted.

C. Install piping from safety relief valves to nearest floor drain.

3.3 CONTROL CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring between control devices.

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. Prepare test and inspection reports.

3.5 DEMONSTRATION

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

END OF SECTION 238413

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SECTION 250923 - BUILDING AUTOMATION SYSTEM (BMS) FOR HVAC

PART 1 - GENERAL

1.1 CONTROL SYSTEM DESCRIPTION

A. Controls System shall be Web-based and accessible either directly connected and/or through the owners IP LAN network.

B. The BAS shall meet BACnet communication standards to ensure the system maintains “interoperability” to avoid proprietary arrangements that will make it difficult for the Owner to consider other BAS manufacturers in future projects.

C. BAS controllers shall be listed by BACnet Testing Laboratories (BTL) with appropriate classification.

D. Direct Digital Control (DDC) technology shall be used to facilitate the functions necessary for control of mechanical systems and equipment on this project.

1.2 CONNECTION TO EXISTING BMS SYSTEM

A. All new control equipment inclusive of digital controllers must communicate and integrate seamlessly with the existing BMS system by:
   1. Stark Tech

B. Connect all new controllers to the existing host computer and extend network, including software, as required for a fully integrated control system.

C. Modify and add programming in host computer as necessary to accept all new equipment, control points, sequence of operations, etc.

1.3 CODES AND STANDARDS

A. Codes and Standards: Meet requirements of all applicable standards and codes, except when more detailed or stringent requirements are indicated by the Contract Documents, including requirements of this Section.

   1. Underwriters Laboratories: Products shall be UL-916-PAZX listed.

   2. National Electrical Code - NFPA 70.

   3. Federal Communications Commission - Part J.

4. ASHRAE/ANSI 135-2012 (BACnet) - (System Level Devices) - Building Controllers shall conform to the listed version of the BACnet specification to improve interoperability with various building system manufacturers' control systems and devices.
5. ASHRAE/ANSI 135-2012 (BACnet) - (Unit Level Devices) - Unit Controllers shall conform to the listed version of the BACnet specification to improve interoperability with various building system manufacturers' control systems and devices.

1.4 SYSTEM PERFORMANCE

A. Performance Standards. The BAS system shall conform to the following:

1. Graphic Display. The system shall display a graphic with a minimum of 20 dynamic points. All current data shall be displayed within 10 seconds of the operator's request.
2. Graphic Refresh. The system shall update all dynamic points with current data within 10 seconds.
3. Object Command. The maximum time between the command of a binary object by the operator and the reaction by the device shall be 5 seconds. Analog objects shall start to adjust within 5 seconds.
4. Object Scan. All changes of state and change of analog values shall be transmitted over the high-speed network such that any data used or displayed at a controller or workstation will be current within the prior 10 seconds.
5. Alarm Response Time. The maximum time from when an object goes into alarm to when it is annunciated at the workstation shall not exceed 10 seconds.
6. Program Execution Frequency. Custom and standard applications shall be capable of running as often as once every 5 seconds. The Contractor shall be responsible for selecting execution times consistent with the mechanical process under control.
7. Programmable Controllers shall be able to execute DDC PID control loops at a selectable frequency from at least once every 5 seconds. The controller shall scan and update the process value and output generated by this calculation at this same frequency.
8. Reporting Accuracy. Table 1 lists minimum acceptable reporting accuracies for all values reported by the specified system.
   a. Table 1: Reporting Accuracy

Measured Variable	Reported Accuracy
Space Temperature	±0.5°C [±1°F]
Ducted Air	±1.0°C [±2°F]
Outside Air	±1.0°C [±2°F]
Water Temperature	±0.5°C [±1°F]
Delta –T	±0.15°C[±0.25°F]
Relative Humidity	±5% RH
Water Flow	±5% of full scale
Air Flow (terminal)	±10% of reading *Note 1
Air Flow (measuring stations)	±5% of reading
Air Pressure (ducts)	±25 Pa [±0.1 "W.G.]
Air Pressure (space)	±3 Pa [±0.01 "W.G.]
Water Pressure	±2% of full scale *Note 2
Electrical Power	5% of reading *Note 3
Carbon Monoxide (CO)	± 50 PPM
Carbon Dioxide (CO2)	± 50 PPM

Note 1: (10%-100% of scale) (cannot read accurately below 10%)
Note 2: for both absolute and differential pressure
Note 3: * not including utility supplied meters

1.5 SUBMITTAL REQUIREMENTS

A. A complete bill of materials of equipment to be used indicating quantities, manufacturers and model numbers.

B. A schedule of all control valves including the valve size, pressure drop, model number (including pattern and connections), flow, CV, body pressure rating, and location.

C. A schedule of all control dampers including damper size, pressure drop, manufacturer, and model number.

D. All manufacturers' technical cut sheets for major system components.

E. Proposed Building Automation System architectural diagram depicting various controller types, workstations, device locations, addresses, and communication cable requirements

F. Detailed termination drawings showing all required field and factory terminations, as well as terminal tie-ins to DDC controls by mechanical equipment manufacturers. Terminal numbers shall be clearly labeled.

G. Points list showing all system objects and the proposed English language object names.

H. Sequence of operation for each controlled mechanical system and terminal end devices.

I. BACnet Protocol Implementation Conformance Statement (PICS) for each BACnet system level device (i.e. Building Controller & Operator Workstations) type. This defines the points list for proper coordination of interoperability with other building systems if applicable for this project.

J. BAS Workstation and HMI interface screen graphics for all systems, showing system schematics, control and instrumentation points, monitoring data, setpoints with adjustments, and alarms. A

K. Additional information or data which is deemed necessary to determine compliance with the specifications or which is deemed valuable in documenting and understanding the system to be installed.

L. As-built drawings showing any and all modifications to the shop drawings that took place during the construction process.

1.6 WARRANTY REQUIREMENTS

A. Warrant all work as follows:

1. BAS system labor and materials shall be warranted free from defects for a period of twelve (12) months after final completion acceptance by the Owner. BAS failures during the warranty period shall be adjusted, repaired, or replaced at no charge to the Owner. The BAS manufacturer shall respond to the Owner's request for warranty service within 24 hours of the initiated call and will occur during normal business hours (8AM-5PM).

2. At the end of the final start-up/testing, if equipment and systems are operating satisfactorily to the Owner and Engineer, the Owner shall sign certificates certifying that the BAS is operational and has been tested and accepted in accordance with the terms of this specification. The date of Owner's acceptance shall be the start of the warranty period.

1.7 SYSTEM MAINTENANCE

A. Perform Building Automation System preventative maintenance and support for a period of 1 year (beginning the date of substantial completion).

1. Make a minimum of 2 complete Building Automation System inspections, in addition to normal warranty requirements. Inspections to include:

a. System Review – Review the BAS to correct programming errors, failed points, points in alarm, and points that have been overridden manually.
b. Seasonal Control Loop Tuning – Control loops are reviewed to reflect changing seasonal conditions and / or facility heating and cooling loads.
c. Sequence of operation verification – Systems all verified to be operating as designed and in automatic operation. Scheduling and setpoints are reviewed and modified.
d. Database back-up
e. Operator coaching

2. Technician shall review critical alarm log and advise of additional services that may be required.
3. Technician shall submit a written report after each inspection.

1.8 OWNERSHIP OF BAS MATERIAL

A. Project specific software and documantation shall become the owner's property upon project completion. This includes the following:
1. Operator Graphic files
2. As-built hardware design drawings
3. Operating & Maintenance Manuals
4. BAS System software database
5. Controller application programming databases
6. Application Specific Controller configuration files
7. Required Licensed software

PART 2 - PRODUCTS

2.1 MATERIALS

A. Use new products that the manufacturer is currently manufacturing and that have been installed in a minimum of 25 installations. Do not use this installation as a product test site unless explicitly approved in writing by the owner or the owner's representative. Spare parts shall be available for at least five years after completion of this contract.

2.2 METAL CONDUITS AND FITTINGS

A. Description: Metal raceway of circular cross section with manufacturer-fabricated fittings.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Allied Tube & Conduit; Atkore International.
   2. O-Z/Gedney; brand of Emerson Electric Co., Automation Solutions, Appleton Group.
   3. Republic Conduit; Nucor Corporation, Nucor Tubular Products.
   4. Western Tube; Zekelman Industries.
   5. Wheatland Tube; Zekelman Industries.

C. General Requirements for Metal Conduits and Fittings:
   1. Listed and labeled as defined in NFPA 70, by a nationally recognized testing laboratory, and marked for intended location and application.
   2. Comply with TIA-569-D.

D. GRC: Comply with ANSI C80.1 and UL 6.

E. IMC: Comply with ANSI C80.6 and UL 1242.

F. EMT: Comply with ANSI C80.3 and UL 797.

G. Fittings for Metal Conduit: Comply with NEMA FB 1 and UL 514B.
   1. Conduit Fittings for Hazardous (Classified) Locations: Comply with UL 1203 and NFPA 70.
   2. Fittings for EMT:
      a. Material: Steel.
      b. Type: Set screw.

H. Joint Compound for IMC or GRC: Approved, as defined in NFPA 70, by authorities having jurisdiction for use in conduit assemblies, and compounded for use to lubricate and protect threaded conduit joints from corrosion and to enhance their conductivity.

2.3 METAL WIREWAYS AND AUXILIARY GUTTERS

A. Description: Sheet metal trough of rectangular cross section fabricated to required size and shape, without holes or knockouts, and with hinged or removable covers.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Cooper B-line; brand of Eaton, Electrical Sector.
   2. Hoffman; brand of nVent Electrical plc.
   3. MonoSystems, Inc.
   4. Square D; Schneider Electric USA.

C. General Requirements for Metal Wireways and Auxiliary Gutters:

1. Comply with UL 870 and NEMA 250, Type 1 unless otherwise indicated, and sized according to NFPA 70.
2. Metal wireways installed outdoors shall be listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.
3. Comply with TIA-569-D.

D. Fittings and Accessories: Include covers, couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.

E. Wireway Covers: Screw-cover type unless otherwise indicated.

F. Finish: Manufacturer's standard enamel finish.

2.4 SURFACE METAL PATHWAYS

A. Description: Galvanized steel with snap-on covers, complying with UL 5.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. MonoSystems, Inc.
2. Panduit Corp.
3. Wiremold; Legrand North America, LLC.

C. Finish: Manufacturer's standard enamel finish in color selected by Architect.

D. Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.

2.5 HOOKS

A. Description: Prefabricated sheet metal cable supports for telecommunications cable.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. MonoSystems, Inc.
2. Panduit Corp.
3. Wiremold; Legrand North America, LLC.

C. Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.

D. Comply with TIA-569-D.

E. Galvanized steel.

F. J shape.

2.6 BOXES, ENCLOSURES, AND CABINETS

A. Description: Enclosures for communications.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. ABB, Electrification Business.
2. Adalet.
3. Appleton; Emerson Electric Co., Automation Solutions.
4. Crouse-Hinds; brand of Eaton, Electrical Sector.
5. Erickson Electrical Equipment Company.
6. O-Z/Gedney; brand of Emerson Electric Co., Automation Solutions, Appleton Group.

C. General Requirements for Boxes, Enclosures, and Cabinets:
1. Comply with TIA-569-D.
2. Boxes, enclosures, and cabinets installed in wet locations shall be listed and labeled as defined in NFPA 70, by an NRTL, and marked for use in wet locations.
3. Box extensions used to accommodate new building finishes shall be of same material as recessed box.
4. Device Box Dimensions: 4 inches square by 2-1/8 inches deep

D. Sheet Metal Outlet and Device Boxes: Comply with NEMA OS 1 and UL 514A.

E. Hinged-Cover Enclosures: Comply with UL 50 and NEMA 250, Type 1, with continuous-hinge cover with flush latch unless otherwise indicated.
1. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.
a. Finished inside with radio-frequency-resistant paint.
2. Interior Panels: Steel; all sides finished with manufacturer's standard enamel.

F. Cabinets:
1. NEMA 250, Type 1 galvanized-steel box with removable interior panel and removable front, finished inside and out with manufacturer's standard enamel.
2. Hinged door in front cover with flush latch and concealed hinge.
3. Key latch to match panelboards.
4. Metal barriers to separate wiring of different systems and voltage.

2.7 COMMUNICATION

A. A. Network communication protocol(s) used throughout entire DDC system shall be open to Owner and available to other companies for use in making future modifications to DDC system.

B. This project shall be comprised of a high speed Ethernet network utilizing BACnet/IP communications between System Controllers and Workstations. Each System Controller shall function as a BACnet Router to each unit controller providing a unique BACnet Device ID for all controllers within the system.

C. Communications between System Controllers and sub-networks of Custom Application Controllers and/or Application Specific Controllers shall meet the ASHRAE 135 Standard either via BACnet MS/TP or BACnet over Zigbee.

1. Wireless Equipment Level Controller Communication and Auxiliary Control Devices shall conform to:
    a. Each System Controller shall perform communications to a network of Custom Application and Application Specific Controllers on a certified, open standard wireless solution to enable integration with other suppliers using the same open standard.
    b. Each communication interface shall be ZigBee certified as a BACnet tunneling device as allowed by the BACnet Standard and defined by the Zigbee Alliance.
    c. Each System Controller shall function as a BACnet Router to each unit controller providing a unique BACnet Device ID for all controllers within the system.
    d. The controls wireless network shall be capable of similar performance to a wired, equally quantified network by responding to controls requests within 10% timing comparison to facilitate a similar user experience for facility managers and occupants.
    e. The controls wireless network shall be secured using Advanced Encryption Standard AES-128 (FIPS Pub 197) and HMAC (FIPS Pub 198). A Trust Center will create a randomly generated 128-bit network security key for each ZigBee network.
    f. IEEE 802.15.4 radios to minimize risk of interference and maximize battery life, reliability, and range.
    g. Indoor design range shall be a minimum of 200 feet (60 m); open range shall be 2,500 ft. (762 m) with less than 2% packet error rate to minimize the need for repeaters and optimize network reliability.
    h. To maintain robust communication, self-healing, redundant mesh networking and two-way communications shall be used to optimize the wireless network reliability.

i. Wireless communication shall be capable of many-to-one sensors per controller to support averaging, monitoring, and multiple zone applications.

j. Space/wall sensors shall be available with batteries with a typical life of 15 or more years to minimize maintenance costs or with power harvesting capabilities to minimize the need for batteries.

k. Space/wall sensors shall be available with temperature, relative humidity, occupancy, and CO_2 to support common HVAC controls applications.

l. Occupancy sensors shall have adequate range, sensing patterns, and number of sensors required for 100% coverage.

m. CO_2 sensors shall have a design life of 15 or more years, and include barometric pressure sensing and be self-calibrating to minimize maintenance expenses over the life of the sensor.

n. Certifications shall include FCC CFR47 - RADIO FREQUENCY DEVICES - Section 15.247 & Subpart E

D. ASHRAE 135 Protocol:

1. ASHRAE 135 communication protocol shall be sole and native protocol used throughout entire DDC system.
2. DDC system shall not require use of gateways except to integrate HVAC equipment and other building systems and equipment, not required to use ASHRAE 135 communication protocol.
3. If used, gateways shall connect to DDC system using ASHRAE 135 communication protocol and Project object properties and read/write services indicated by interoperability schedule.
4. Operator workstations, controllers and other network devices shall be tested and listed by BACnet Testing Laboratories.

2.8 OPERATOR INTERFACE

A. Operator Web Interface shall conform to following:

1. System Security

a. Each operator shall be required to login to the system with a user name and password in order to view, edit, add, or delete data.

b. User Profiles shall restrict the user to only the objects, applications, and system functions as assigned by the system administrator.

c. Each operator shall be allowed to change their user password.

d. The System Administrator shall be able to manage the security for all other users.

e. The system shall include pre-defined “roles” that allow a system administrator to quickly assign permissions to a user.

f. User logon/logoff attempts shall be recorded.

g. The system shall track and record all user log-in activity and all changes done at the enterprise level including who made the change, when, what was changed, pervious value and new value.

2. Customizable Navigation Tree
   a. The operator web interface shall include a fully customizable navigation tree that shall allow an operator to do the following:
      1) Move and edit any of the nodes of the tree.
      2) Move entire groups to any area of the tree
      3) Change the name of any node in the tree
      4) Create custom nodes for any page in the web interface including: graphics, data log views, schedules, and dashboards
      5) Support navigation from multi-building to single building view
      6) Ability to create folders and assign and change hierarchy of nodes of the tree

3. Standard Equipment Pages
   a. The operator web interface shall include standard pages for all major equipment.
   b. These pages shall allow an operator to obtain information relevant to the operation of the equipment, including:
      1) Animated Equipment Graphics for each major piece of equipment and floor plan in the System.
      2) Alarms relevant to the equipment or application without requiring a user to navigate to an alarm page and perform a filter.
      3) Data Logs for the equipment without requiring a user to navigate to a Data Log page and perform a filter.

4. System Graphics Package
   a. The operator web interface shall be graphically based and shall include at least one 3-D color graphic per piece of equipment, graphics for each hydronic system, and graphics that summarize conditions on each floor of each building included in this contract.
   b. Graphics Package shall include at a minimum:
      1) 3-D Color Site Map (for multiple building campus projects) or 3-D Building Rendering (for single building projects)
      2) 3-D Color Custom Floor Plans
         a) Floor Plan Graphics to show accurate ductwork of system
         b) Toggle Switch to turn ductwork on/off per each floor plan
         c) Indicate thermal comfort on floor plan graphics using colors to represent zone temperature relative to zone set point
      3) 3-D Color Hydronic System Graphics with Animations
         a) Example Animation: Pump Flashing when On
      4) 3-D Color Major Equipment Graphics with Animations

a) Example Animation: Fan Spinning when On

5. Manual Control and Override
   a. Point Control – There shall be a method for a user to view, override, and edit if applicable, the status of any object and property in the system. The point status shall be available by menu, on graphics or through custom programs.
   b. Temporary Overrides - The user shall be able to perform a temporary override wherever an override is allowed, automatically removing the override after a specified period of time.
6. Engineering Units
   a. Allow for selection of the desired engineering units (i.e. Inch pound or SI) in the system.
7. Scheduling
   a. A user shall be able to perform the following tasks utilizing the operator web interface:
   b. Create a new schedule, defining the default values, events and membership.
   c. Create exceptions to a schedule for any given day.
   d. Apply an exception that spans a single day or multiple days.
   e. View a schedule by day, week and month.
   f. Exception schedules and holidays shall be shown clearly on the calendar.
   g. Modify the schedule events, members and exceptions.
   h. Create schedules and exceptions for multiple buildings
   i. Apply emergency schedule to multiple buildings
   j. Drag and drop scheduling editing
   k. Global schedule and exceptions across multiple buildings
8. Data Logs
   a. Data Logs Definition.
      1) The operator web interface shall allow a user with the appropriate security permissions to define a Data Log for any data in the system.
   b. Data Log Viewer.
      1) The operator web interface shall allow Data Log data to be viewed and printed.
      2) The operator web interface shall allow a user to view Data Log data in a text-based format (time –stamp/value).
      3) The operator shall be able to view the data collected by a Data Log in a graphical chart in the operator web interface.
      4) Data Log viewing capabilities shall include the ability to show a minimum of five points on a chart.
      5) Each data point data line shall be displayed as a unique color.

6) Data points can be hidden on the display view by clicking on the point
7) The operator shall be able to specify the duration of historical data to view by scrolling, zooming, or selecting from a pull down list.
8) The system shall have a graphical trace display of the associated time stamp and value for any selected point along the x-axis.

c. Export Data Logs.
1) The Enterprise operator web interface shall allow a user to export Data Log data in CSV, xlsx or text format for use by other industry standard word processing and spreadsheet packages.

9. Alarm/Event Notification
a. An operator shall be notified of new alarms/events as they occur while navigating through any part of the system via an alarm icon.
b. The operator will have the option of selecting an audible alarm notification for all alarm classes they subscribe to.
c. The system operator will have the option of setting specific times and days that that they will receive alarm notifications.
d. Alarm/Event Log. The operator shall be able to view all logged system alarms/events from any operator web interface.
1) The operator shall be able to sort and filter alarms from events. Alarms shall be sorted in categories based on severity.
2) The alarm/event log shall include a comment field for each alarm/event that allows a user to add specific comments associated with any alarm.

10. User Change Log
a. The operator shall be able to view all logged user changes in the system from any operator web interface.
1) An operator shall be able to group user changes by: date, affected, date & affected, user, date & user, transaction type, date & transaction type, or sort only.
2) The operator will have the option of additional filtering capability of: date, transaction, type, user, affected, and details that can be used individually or in conjunction with other filters.

11. Reports
a. The operator web interface shall have a reporting package that allows the operator to select reports to run.
b. The operator web interface shall have the ability to schedule reports to run at specified intervals of time.
c. The Enterprise operator web interface shall have the ability to email schedule reports at specified intervals of time.

d. The following standard reports shall be available without requiring a user to manually design the report:
   1) All Points in Alarm Report: On demand report showing all current alarms.
   2) All Points in Override Report: On demand report showing all overrides in effect.
   3) Schedules Report: List of all weekly events for all schedules in selected buildings
   4) Space Comfort Analysis Report: List of spaces that meet selected criteria for potential comfort issues (temp variance, high, low, unoccupied)

12. Operator Web Interface must meet the following Agency Compliance:
    a. BACnet Testing Laboratory (BTL) Listed

2.9 MOBILE APP INTERFACE

A. Mobile App Operator Interface shall support the following Operating systems
   1. Apple iOS 6
   2. Apple iOS 7
   3. Apple iOS 8
   4. Android V2.3
   5. Android V4.3
   6. Android V4.4

B. The operator interface shall support system access on a mobile device via a mobile app to:
   1. Alarm log
   2. System Status
   3. Equipment status
   4. Space Status
   5. Standard Equipment graphics

C. The operator interface shall support actions on a mobile device via a mobile app to:
   1. Override set points
   2. Override occupancy
   3. Acknowledge Alarms
   4. Comment on Alarms

2.10 PROGRAMMING TOOLS

A. Custom Application Programming Tools to create, modify, and debug custom application programming, under license for a period of at least (1) year. The operator shall be able to create, edit, and download custom programs at the same time that all other system applications are operating. The system shall be fully operable while custom routines are edited, compiled, and downloaded. Upon expiration of software license the building owner may choose to renew the license at their discretion.

B. Custom Graphic Editor. The tools neceesary to create, modify, and debug custom graphics. The operator shall be able to create, edit, and download custom graphics at the same time that all other system applications are operating. The system shall be fully operable while custom graphics are edited, compiled, and downloaded.

2.11 BUILDING CONTROLLERS

A. There shall be one or more independent, standalone microprocessor based System Controllers to manage the global strategies described in Application and Control Software section.

B. The System Controller shall have sufficient memory to support its operating system, database, and programming requirements.

C. The operating system of the Controller shall manage the input and output communications signals to allow distributed controllers to share real and virtual point information and allow central monitoring and alarms.

D. All System Controllers shall have a real-time clock.

E. Data shall be shared between networked System Controllers.

F. The System Controller shall continually check the status of its processor and memory circuits. If an abnormal operation is detected, the controller shall:

1. Assume a predetermined failure mode.
2. Generate an alarm notification.
3. Create a retrievable file of the state of all applicable memory locations at the time of the failure.
4. Automatically reset the System Controller to return to a normal operating mode.

G. Environment. Controller hardware shall be suitable for the anticipated ambient conditions. Controller used in conditioned ambient shall be mounted in an enclosure, and shall be rated for operation at -40° C to 50° C [-40° F to 122° F].

H. Clock Synchronization.

1. All System Controllers shall be able to synchronize with a NTP server for automatic time synchronization.
2. All System Controllers shall be able to accept a BACnet time synchronization command for automatic time synchronization.
3. All System Controllers shall automatically adjust for daylight savings time if applicable.

I. Serviceability

1. Diagnostic LEDs for power, communications, and processor

J. Memory. The System Controller shall maintain all BIOS and programming information indefinitely without power to the System controller.

K. BACnet Test Labs (BTL) Listing. Each System Controller shall be listed as a Building Controller (B-BC) by the BACnet Test Labs with a minimum BACnet Protocol Revision of 14.

2.12 ADVANCED APPLICATION CONTROLLERS

A. Advance Application Controllers shall be used to control all equipment or applications of medium and high complexity, including but not limited to Air Handlers, Boiler Plants and Chiller Plants.

B. To meet the sequence of operation for each application, the Controller shall use programs by the controller manufacturer that are either factory loaded or downloaded with service tool to the Controller.

C. Stand-Alone Operation: In case of communications failure stand-alone operation shall use default values or last values for remote sensors read over the network such as outdoor air temperature.

D. Environment. Controller hardware shall be suitable for the anticipated ambient conditions.

E. Input/Output: The Controller shall have on board or through expansion module all I/O capable of performing all functionality needed for the application. Controls by the equipment manufacturer must supply the required I/O for the equipment.

F. Input/Output Expandability – For the application flexibility, the Controller shall be capable of expanding to a total of at least 100 hardware I/O terminations.

G. Serviceability – The Controller shall have the following in order to improve serviceability of the Controller.

1. Diagnostic LEDs for power/normal operation/status, BACnet communications, sensor bus communications, and binary outputs. All wiring connections shall be clearly labeled and made to be field removable.

2. To aid in service replacement, the Controller shall allow for setting its BACnet address via controller mounted rotary switches that correspond to the numerical value of the address. (DIP switch methodologies are not allowed). Setting of the address shall be accomplished without the need of a service tool or power applied to the controller.
3. Controller data shall be maintained through a power failure.

H. Transformer for the Controller must be rated at minimum of 115% of ASC power consumption, and shall be fused or current limiting type. 24 VAC, +/- 15% nominal, 50-60 Hz, 24 VA plus binary output loads for a maximum of 12 VA for each binary output.

I. Controller must meet the following Agency Compliance:
1. UL916 PAZX, Open Energy Management Equipment
2. UL94-5V, Flammability
3. FCC Part 15, Subpart B, Class B Limit
4. BACnet Testing Laboratory (BTL) Listed

2.13 APPLICATION-SPECIFIC CONTROLLERS

A. Application Specific Controllers (ASC) shall be microprocessor-based DDC controller, The controller shall use programs by the controller manufacturer that are either factory loaded or downloaded with service tool to the Controller.

B. Zone Controllers are controllers that operate equipment that control the space temperature of single zone. Examples are controllers for VAV, Fan coil, Blower Coils, Unit Ventilators, Heat Pumps, and Water Source Heat Pumps.

C. Stand-Alone Operation: In case of communications failure stand-alone operation shall use default values or last values for remote sensors read over the network such as outdoor air temperature.

D. Environment: Controller hardware shall be suitable for the anticipated ambient conditions.

E. Input/Output: The Controller shall have on board or through expansion module all I/O capable of performing all functionality needed for the application. Controls by the equipment manufacture must supply the required I/O for the equipment.

F. Input/Output Expandability – For the application flexibility, the Controller shall be capable of expanding to a total of at least 100 hardware I/O terminations.

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1. Diagnostic LEDs for power/normal operation/status, BACnet communications, sensor bus communications, and binary outputs. All wiring connections shall be clearly labeled and made to be field removable.
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3. Controller data shall be maintained through a power failure.

H. Transformer for the Controller must be rated at minimum of 115% of ASC power consumption, and shall be fused or current limiting type. 24 VAC, +/- 15% nominal, 50-60 Hz, 24 VA plus binary output loads for a maximum of 12 VA for each binary output.

I. Controller must meet the following Agency Compliance:

1. UL916 PAZX, Open Energy Management Equipment
2. UL94-5V, Flammability
3. FCC Part 15, Subpart B, Class B Limit
4. BACnet Testing Laboratory (BTL) Listed

2.14 FIELD HARDWARE/INSTRUMENTATION

A. Temperature Sensing Devices

1. Type & Accuracy. Temperature sensors shall be of the type and accuracy indicated for the application. Sensors shall have an accuracy rating within 1% of the intended use temperature range.
2. Outside Air Temperature Sensors. Outside air temperature sensors' accuracy shall be within +1degF in the range of -52degF to 152degF.
3. Room Temperature Sensors. Room temperature sensors shall have an accuracy of +0.36degF in the range of 32degF to 96degF.
4. Chilled Water and Condenser Water Sensors. Chilled water and condenser water sensors shall have an accuracy of +0.25degF in their range of application.
5. Hot Water Temperature Sensors. Hot water temperature sensors shall have an accuracy of +0.75degF over the range of their application.

B. Pressure Instruments

1. Differential Pressure and Pressure Sensors: Sensors shall have a 4-20 MA output proportional signal with provisions for field checking. Sensors shall withstand up to 150% of rated pressure, without damaging the device. Accuracy shall be within +2%

of full scale. Sensors shall be manufactured by Leeds & Northrup, Setra, Robertshaw, Dwyer Instruments, Rosemont, or be approved equal.

2. Pressure Switches: Pressure switches shall have a repetitive accuracy of +2% of range and withstand up to 150% of rated pressure. Sensors shall be diaphragm or bourdon tube design. Switch operation shall be adjustable over the operating pressure range. The switch shall have an application rated Form C, snap-acting, self-wiping contact of platinum alloy, silver alloy, or gold plating.

C. Flow Switches:

1. Flow switches shall have a repetitive accuracy of +1% of their operating range. Switch actuation shall be adjustable over the operating flow range. Switches shall have snap-acting Form C contacts rated for the specific electrical application.

D. Humidity Sensors:

1. Sensors shall have an accuracy of +2.5% over a range of 20% to 95% RH.

E. Current Sensing Relays

1. Relays shall monitor status of motor loads. Switch shall have self-wiping, snap-acting Form C contacts rated for the application. The setpoint of the contact operation shall be field adjustable.

F. Output Relays

1. Control relay contacts shall be rated for 150% of the loading application, with self-wiping, snap-acting Form C contacts, enclosed in dustproof enclosure. Relays shall have silver cadmium contacts with a minimum life span rating of one million operations. Relays shall be equipped with coil transient suppression devices.

G. Solid State Relays

1. Input/output isolation shall be greater than 10 billion ohms with a breakdown voltage of 15 V root mean square, or greater, at 60 Hz. The contact operating life shall be 10 million operations or greater. The ambient temperature range of SSRs shall be 20F-140F. Input impedance shall be greater than 500 ohms. Relays shall be rated for the application. Operating and release time shall be 10 milliseconds or less. Transient suppression as an integral part of the relays.

H. Valve and Damper Actuators

1. Electronic Direct-Coupled: Electronic direct-coupled actuation.

2. Actuator Mounting: The actuator shall be direct-coupled over the shaft, enabling it to be mounted directly to the damper shaft without the need for connecting linkage. The fastening clamp assemble shall be of a 'V' bolt design with associated 'V' shaped toothed cradle attaching to the shaft for maximum strength and eliminating slippage. Spring return actuators shall have a 'V' clamp assembly of sufficient size to be directly

mounted to an integral jackshaft of up to 1.05 inches when the damper is constructed in this manner. Single bolt or screw type fasteners are not acceptable

3. Electronic Overload Sensing: The actuator shall have electronic overload or digital rotation sensing circuitry to prevent damage to the actuator throughout the entire rotation of the actuator. Mechanical end switches or magnetic clutch to deactivate the actuator at the end of rotation are not acceptable.
4. Power Failure/Safety Applications: For power failure/safety applications, an internal mechanical spring return mechanism shall be built into the actuator housing. Non-mechanical forms of fail-safe operation are not acceptable.
5. Spring Return Actuators: All spring return actuators shall be capable of both clockwise or counterclockwise spring return operation by simply changing the mounting orientation.
6. Proportional Actuators: Proportional actuators shall accept a 0 to 10VDC or 0 to 20mA control input and provide a 2 to 10VDC or 4 to 20mA operating range. An actuator capable of accepting a pulse width modulating control signal and providing full proportional operation of the damper is acceptable. All actuators shall provide a 2 to 10VDC position feedback signal.
7. 24 Volts (AC/DC) actuators: All 24VAC/DC actuators shall operate on Class 2 wiring and shall not require more than 10VA for AC or more than 8 watts for DC applications. Actuators operating on 120VAC power shall not require more than 10VA. Actuators operating on 230VAC shall not require more than 11VA.
8. Non-Spring Return Actuators: All non-spring return actuators shall have an external manual gear release to allow manual positioning of the damper when the actuator is not powered. Spring return actuators with more than 60 in-lb torque shall have a manual crank for this purpose.
9. Modulating Actuators: All modulating actuators shall have an external, built-in switch to allow reversing direction of rotation.
10. Conduit Fitting & Pre-Wiring: Actuators shall be have a conduit fitting and a minimum 3ft electrical cable, and shall be pre-wired to eliminate the necessity of opening the actuator housing to make electrical connections.
11. U.L. Listing: Actuators shall be Underwriters Laboratories Standard 873 listed and Canadian Standards Association Class 4813 02 certified as meeting correct safety requirements and recognized industry standards.
12. Warranty: Actuators shall be designed for a minimum of 60,000 full stroke cycles at the actuator's rated torque and shall have a 2-year manufacturer's warranty, starting from the date of installation. Manufacturer shall be ISO9001 certified.
13. Controls valve actuator application fail-safe positions shall be as follows
    a. AHU coils: normally open

b. Boilers: normally open
c. Chiller evaporator: normally open
d. Cooling tower isolation: normally open
e. Chiller condenser: normally open
f. Terminal equipment heating: normally open
g. Terminal equipment cooling: normally closed
h. Two-pipe changeover valves: fail to heating

I. Control Valves: Factory fabricated U.S. forged and assembled electric control valves of type, body material, and pressure class indicated. Where type or body material is not indicated, make selection as determined by manufacturer for installation requirements and pressure class, based on maximum pressure and temperature in piping system. The valve size shall be in accordance with scheduled or specified maximum pressure drop across control valve. Except as otherwise indicated, valves shall mate and match material of connecting piping. Equip control valves with control valve motor actuators, with proper shutoff rating for each individual application.

1. Water Service Valves: Equal percentage characteristics with rangeability of 50 to 1, Class 150 at 250°F and maximum full flow pressure drop 5 psig. Globe type with replaceable plugs and seats of stainless steel or brass. Select operators to close valves against pump shutoff head.
2. Double Seated Valves: Balanced plug type, with caged type trim providing seating and guiding surfaces on “top and bottom” guided plugs.
3. Valve Trim and Stems: Polished stainless steel.
4. Packing: Spring-loaded teflon, self-adjusting.
5. Terminal Unit Control Valves: Unless indicated otherwise, modulating, electrically actuated (by 24VAC max) control ball valves shall control terminal units including, but not necessarily limited to, convectors, finned tube radiation, and fan coil units that are of integral motor type.

J. Pressure-Independent Control Valves:

1. Valves shall have stainless-steel stems and stuffing boxes with extended necks to clear the piping insulation. Valve bodies shall meet ASME B16.34 or ASME B16.15 pressure and temperature class ratings based on the design operating temperature and 150 percent of the system design operating pressure. Valve leakage shall meet FCI 70-2 Class IV leakage rating (0.01 percent of valve Kv). Valves shall be two-way pressure independent globe-style bodies.
   a. Bodies for valves 2 inches and smaller shall be brass or bronze, with union ends
   b. Bodies for valves 2 to 3 inches shall be of brass, bronze or iron.
   c. Bodies for valves 2.5 inches and larger shall have flanged-end connections.

d. Valve and actuator combination shall be normally open or normally closed as shown.

2. Two-Way Pressure Independent Globe Valve: The valve shall be two-way globe style with integrated differential pressure control regulator. Where indicated modulating proportional valve application shall utilize controller or actuator to match required control signal to complement controlled coil heat transfer characteristic for linear control. The valve shall have:
   a. Integrated pressure regulator; regulator to control pressure across control valve orifice.
   b. Regulator incorporating EPDM diaphragm, stainless steel spring and pressure control disc. Pressure control seat shall be brass construction with vulcanized EPDM.
   c. Counterbalance of supply pipe pressure to return pipe pressure across diaphragm to prevent diaphragm damage when control valve is closed
   d. User adjustable maximum flow within valve control range; Adjustment method shall indicate percentage of valve flow range and utilize spring locked method of adjustment.
   e. The ability to regulate internal control valve differential pressure to have 100% control valve authority.
   f. shall have linear flow characteristic.
   g. Back seated globe design to allow service of packing under pressure without leakage.
   h. Entering to leaving (P1-P3) pressure control across low flow ½'' valve in size from 2.3PSI - 60PSI.
   i. Entering to leaving (P1-P3) pressure control across valves ½'' - ¾'' in size from 5PSI - 60PSI.
   j. Entering to leaving (P1-P3) pressure control across valves 1'' - 1¼'' in size from 5PSI - 60PSI.
   k. Entering to leaving (P1-P3) pressure control across valves 1½'' - 10'' in size from 4PSI - 60PSI.
   l. Union connections for ½'' - 2'' valve size: ANSI flanged connections for 2.5'' - 10'' valve sizes
   m. Stainless steel internal trim with brass globe and seat.
   n. A Threaded actuator connection
   o. Flow requirements sized for nominal body selection no more than one size smaller to corresponding nominal pipe connection.
      1) ½'' bodies shall be utilized for ½'' and may be utilized for ¾'' pipe connection and flow less than 5 GPM.

2) ¾'' bodies may be utilized for ¾'' pipe and may be applied to 1'' pipe connection with flow less than 7.5 GPM.
3) 1'' bodies may be utilized for 1'' pipe and may be applied to 1¼'' pipe connection with flow less than 12 GPM.
4) 1¼'' bodies may be utilized for 1¼'' and may be applied to 1½'' pipe connection with flow less than 17.5 GPM.
5) 1½'' bodies may be utilized for 1½'' pipe and may be applied to 2'' pipe connection with flows less than 33 GPM.
6) Flows less than 55 GPM may use 2'' bodies.
7) Flows less than 85 GPM may use 2½'' bodies.
8) Flows less than 120 GPM may use 3'' bodies.
9) Flows less than 165 GPM may use 4'' bodies.
10) Flows less than 395 GPM may use 5'' bodies.
11) Flows less than 640 GPM may use 6'' bodies.
12) Flows less than 830 GPM may use 8'' bodies.
13) Flows less than 1230 GPM may use 10'' bodies.

K. Dampers: Automatic control low leakage, opposed blade dampers, with damper frames not less than formed 13-gauged galvanized steel and mounting holes for enclosed duct mounting. Damper blades not less than formed 16-gauged galvanized steel, with maximum blade width of 8-inch. Equip dampers with motors of proper rating of each application.

1. Secure blades to ½ inch diameter zinc-plated axles using zinc-plated hardware. Seal off against spring stainless steel blade bearings. Blade bearings to be Nylon with thrust bearings at each end of every blade. Construct blade linkage hardware of zinc-plated steel and brass. Submit leakage and flow characteristics plus size schedule for controlled dampers.

2. Operating Temperature Range: From –20° to 200°F (-29° to 93°C).

3. For low leakage application or opposed blade design (as selected by manufacturers sizing techniques) with inflatable steel blade edging or replaceable rubber seals, rated for leakage less than 4 cfm per square foot of damper area, AR differential pressure of 4-inch w.g. when damper is being held by torque 50 inch-pounds.

4. Outdoor air and exhaust air dampers shall be low leakage and thermally insulated.

L. Electromagnetic Flow Meters

1. complete with all installation hardware necessary to enable insertion and removal of the meter without system shutdown. The flow meter shall be hand-insertable up to 400 psi. For installations in non-metallic pipe, install grounding rings or probes. Materials of construction for wetted metal components shall be 316 SS. The flow meter shall average velocity readings from two sets of diametrically opposed electrodes. Each flow meter shall be individually wet calibrated against a primary volumetric standard that is accurate to within 0.1% and traceable to NIST*. A

certificate of calibration shall be provided with each flow meter. Accuracy shall be within ± 1% of rate from 2-20 ft/s. Overall turndown shall exceed 100:1. Output signals shall be completely isolated and shall consist of the following: (1) analog output; 4-20mA, 0-10V, or 0-5V jumper selectable, (1) scalable dry contact output for totalization, and (1) high resolution frequency output for use with peripheral devices such as an ONICON display module or Btu meter. Each flow meter shall be covered by the manufacturer's two-year warranty.

2. Optional Flow Display: D-100 Series Display Module for network interface and local/remote indication of flow rate and total.

M. Ultrasonic Flow Meters: Provide a clamp-on transit time ultrasonic flowmeter complete with matched transducers, self- aligning installation hardware and triaxial transducer cables and calibration certificate

1. Flowmeter shall consist of a processor / transmitter, matched pair of transducers and mounting hardware including pipe clamps and mounting bracket for the line size and material specified

a. Sensing Technology: Ultrasonic transit time velocity-measurement utilizing non-wetted transducers matched for the specific applications in terms of pipe size and pipe material

b. Enclosure: Wall mount, NEMA4X polycarbonate with clear shatterproof enclosure

c. Maximum Temperature Rating: 250 deg F

d. Meter shall have CE approval

e. Each flowmeter shall be covered by the manufacturer's two-year warranty

2. Operation and Configuration

a. Flow Range: Flow-measuring element and transmitter shall cover operating range of equipment or system served.

b. Accuracy: Flowmeter shall have calibrated outputs directly from the transmitter, throughout the operating range with plus or minus 1.0% of flow rate from 1 to 20 ft/sec velocity

c. Calibration: ach flow meter shall be individually calibrated against a N.I.S.T. traceable standard and receive a certificate of calibration. Each flow meter shall be factory programmed based on the application data specified at time of order.

d. Transmitter and Display: Operator interface consisting of five pushbuttons. Display shall visually indicate instantaneous flow rate and total fluid volume. Output signals shall be RS485 serial network protocol, BACnet MS/TP or

MODBUS RTU, native to the transmitter, two (2) programmable pulse outputs configured for totalizing pulse, flow direction or flow alarm indication and one (1) analog output signal.

e. Flow meter shall be capable of operating from 24V ac/dc or 120V ac mains power.

N. Airflow Measuring Devices: Provide one thermal airflow measuring device (AMD) for each location indicated on plans, schedules and/or control diagrams. Fan inlet measurement devices shall not be substituted for duct or plenum measurement devices indicated on the plans. Each AMD shall use the principal of thermal dispersion to determine the actual or mass airflow rate of the airstream. Differential pressure-based devices, including pitot tubes, pitot arrays, piezo-rings and devices measuring the pressure drop across a louver, damper or obstruction are not acceptable.

1. Each sensor node shall consist of two hermetically sealed bead-in-glass thermistors. The airflow of each sensor node shall be determined using one self-heated and ambient temperature sensing thermistor.
2. All internal wiring in the probe tube shall be chemical and abrasion resistant.
3. Each thermistor shall be independently calibrated to NIST traceable temperature standards to establish the resistance-temperature characteristics for the determination of airflow and temperature.
4. The specified sensor accuracy shall include the combined uncertainty of the sensor nodes and transmitter. Devices whose overall accuracy is based on individual accuracy specifications of the sensor probes and transmitter shall demonstrate compliance with the specified sensor accuracy over the entire operating range.
5. Transmitters shall be microprocessor-based and operate automatically after brownouts and/or transient power interruptions.
6. Remote transmitters shall be mounted in a location protected from moisture, rain and snow with an ambient temperature between -20 and 120 °F [-28.9 to 48.9 °C] and a humidity range between 5 and 95% RH (non-condensing). Provide a weatherproof enclosure and mount away from direct sunlight when outdoor mounting is required.
7. All components of each AMD shall be RoHS2 compliant.
8. Each AMD shall be UL/cUL listed as a final assembly.
9. Provide up to 16 sensing nodes per measurement location as required for the opening size and published sensor density tables to achieve an installed airflow accuracy of ±3% of reading (±5% of reading on close coupled outdoor air intakes) between 0 and 5,000 fpm over a temperature range of -20 to 160 °F and a humidity range between 0 and 100% RH (non-condensing).

10. Provide the velocity weighted temperature of the airstream with an accuracy of ±1.0 °F.
11. Transmitters shall provide the airflow, velocity-weighted temperature, velocity-weighted-humidity, velocity-weighted-enthalpy, dewpoint, airflow alarm status, individual sensor node airflow and temperature data and device fault status.

PART 3 - EXECUTION

3.1 COORDINATION

A. Power is to be sourced from existing electrical distribution system as necessary for the controls system. Must comply with the National Electrical Code.

B. Test and Balance

1. The contractor shall furnish a single set of all tools necessary to interface to the control system for test and balance purposes.
2. The tools used during the test and balance process shall be returned to the contractor at the completion of the testing and balancing.

3.2 INSTALLATION

A. Connect and configure equipment and software to achieve sequences of operations specified

B. Verify location of exposed control sensors with arhitect prior to installation. Install devices 48 inches above the floor, or lower if necessary.

C. Install damper moters on outside of duct in warm areas, not tin locations exposed to outdoor temperatures.

3.3 ELECTRICAL WIRING AND CONNECTION INSTALLATION

A. Where Class 2 wires are in concealed and accessible locations; including ceiling return air plenums, approved cables outside of electrical raceway can be used if the following conditions are met:

1. Circuits meet NEC Class 2 (current-limited) requirements. (Low-voltage power circuits shall be sub-fused when required to meet Class 2 current-limit.)
2. All cables shall be UL listed for application (i.e., cables used in ceiling plenums shall be UL listed specifically for that purpose).

B. Do not install Class 2 wiring in conduits containing Class 1 wiring. Boxes and panels containing high voltage may not be used for low voltage wiring except for the purpose of interfacing the two via control relays and transformers.

C. Where Class 2 wiring is run exposed, wiring shall be run parallel along a surface or perpendicular to it, and bundled, using approved wire ties at no greater than 3 m (10 ft.) intervals. Such bundled cable shall be fastened to the structure, using industry approved fasteners, at 1.5 m (5 ft.) intervals or more often to achieve a neat and workmanlike result.

D. Maximum allowable voltage for control wiring shall be 120Vac. If only higher voltages are available for use, use step-down transformers to achieve the desired control voltages.

E. All control wiring shall be installed as continuous lengths, where possible. Any required splices shall be made only within an approved junction box or other approved protective device.

F. Install wire and cable with sufficient slack and flexible connections to allow for vibration of piping and equipment

G. Install plenum wiring in sleeves where it passes through walls and floors. Maintain fire rating at all penetrations in accordance with Contract Documents and National and/or Local Codes.

H. Control and status relays are to be located in pre-fabricated enclosures that meet the application. These relays may also be located within packaged equipment control panel enclosures as coordinated. These relays shall not be located within Class 1 starter enclosures.

I. Follow manufacturer's installation recommendations for all communication and network bus cabling. Network or communication cabling shall be run separately from all control power wiring.

J. BAS manufacturer shall terminate all control and/or interlock wiring and shall maintain updated (as-built) wiring diagrams with terminations identified at the job site.

K. Flexible metal conduits and liquid-tight flexible metal conduits shall not exceed 3' in length and shall be supported at each end. Flexible metal conduit less than 1/2" electrical trade size shall not be used. In areas exposed to moisture, including chiller and boiler rooms, liquid-tight, flexible metal conduits shall be used.

3.4 WIRING METHODS

A. Routing:

1. Install cables in raceways and cable trays, except within consoles, cabinets, desks, and counters and except in accessible ceiling spaces, attics, and gypsum board

partitions where unenclosed wiring method may be used. Conceal raceway and cables, except in unfinished spaces.

a. Install plenum cable in environmental air spaces, including plenum ceilings.

2. Conceal conductors and cables in accessible ceilings, walls, and floors where possible.

B. Wiring within Enclosures: Bundle, lace, and train cables within enclosures. Connect to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools. Install conductors parallel with or at right angles to sides and back of enclosure.

3.5 INSTALLATION OF TWISTED-PAIR HORIZONTAL CABLES

A. Comply with NECA 1 and NECA/BICSI 568.

B. General Requirements for Cabling:

1. Comply with TIA-568-C.0, TIA-568-C.1, and TIA-568-C.2.
2. Comply with BICSI's "Information Transport Systems Installation Methods Manual (ITSIMM), Ch. 5, "Copper Structured Cabling Systems," "Cable Termination Practices" Section.
3. Install 110-style IDC termination hardware unless otherwise indicated.
4. Do not untwist twisted pair cables more than 1/2 inch (12 mm) from the point of termination to maintain cable geometry.
5. Terminate all conductors; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, cross-connects, and patch panels.
6. Consolidation points may be used only for making a direct connection to equipment outlets:

a. Do not use consolidation point as a cross-connect point, as a patch connection, or for direct connection to workstation equipment.
b. Locate consolidation points for twisted-pair cables at least 49 feet (15 m) from communications equipment room.

7. Cables may not be spliced. Secure and support cables at intervals not exceeding 30 inches (760 mm) and not more than 6 inches (150 mm) from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
8. Install lacing bars to restrain cables, prevent straining connections, and prevent bending cables to smaller radii than minimums recommended by manufacturer.
9. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in

BICSI Information Transport Systems Installation Methods Manual, Ch. 5, "Copper Structured Cabling Systems," "Cable Termination Practices" Section. Use lacing bars and distribution spools.

10. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.
11. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used for heating.
12. In the communications equipment room, install a 10-foot- (3-m-) long service loop on each end of cable.
13. Pulling Cable: Comply with BICSI Information Transport Systems Installation Methods Manual, Ch. 5, "Copper Structured Cabling Systems," "Pulling and Installing Cable" Section. Monitor cable pull tensions.

C. Open-Cable Installation:

1. Install cabling with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment.
2. Suspend twisted pair cabling, not in a wireway or pathway, a minimum of 8 inches (200 mm) above ceilings by cable supports not more than 60 inches (1524 mm) apart.
3. Cable shall not be run through structural members or in contact with pipes, ducts, or other potentially damaging items.

D. Group connecting hardware for cables into separate logical fields.

E. Separation from EMI Sources:

1. Comply with recommendations from BICSI's "Telecommunications Distribution Methods Manual" and TIA-569-D for separating unshielded copper communication cable from potential EMI sources, including electrical power lines and equipment.
2. Separation between open communications cables or cables in nonmetallic raceways and unshielded power conductors and electrical equipment shall be as follows:

    a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 5 inches (127 mm).
    b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 12 inches (300 mm).
    c. Electrical Equipment Rating More Than 5 kVA: A minimum of 24 inches (600 mm).

3. Separation between communications cables in grounded metallic raceways and unshielded power lines or electrical equipment shall be as follows:

    a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 2-1/2 inches (64 mm).
    b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 6 inches (150 mm).
    c. Electrical Equipment Rating More Than 5 kVA: A minimum of 12 inches (300 mm).

4. Separation between communications cables in grounded metallic raceways, power lines, and electrical equipment located in grounded metallic conduits or enclosures shall be as follows:

    a. Electrical Equipment Rating Less Than 2 kVA: No requirement.
    b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 3 inches (76 mm).
    c. Electrical Equipment Rating More Than 5 kVA: A minimum of 6 inches (150 mm).

5. Separation between Communications Cables and Electrical Motors and Transformers, 5 kVA or HP and Larger: A minimum of 48 inches (1200 mm).
6. Separation between Communications Cables and LED Lighting Fixtures: A minimum of 5 inches (127 mm).

3.6 FIRESTOPPING

A. Comply with requirements in Section 078413 "Penetration Firestopping."

B. Comply with TIA-569-D, Annex A, "Firestopping."

C. Comply with "Firestopping Systems" Article in BISCI's "Telecommunications Distribution Methods Manual."

3.7 GROUNDING

A. Install grounding according to the "Grounding, Bonding, and Electrical Protection" chapter in BICSI's "Telecommunications Distribution Methods Manual."

B. Comply with TIA-607-B and NECA/BICSI-607.

C. Locate grounding bus bar to minimize the length of bonding conductors. Fasten to wall, allowing at least a 2-inch (50-mm) clearance behind the grounding bus bar. Connect

grounding bus bar to suitable electrical building ground, using a minimum No. 4 AWG grounding electrode conductor.

D. Bond metallic equipment to the grounding bus bar, using not smaller than a No. 6 AWG equipment grounding conductor.

3.8 IDENTIFICATION

A. Cable Schedule: Install in a prominent location in each equipment room and wiring closet. List incoming and outgoing cables and their designations, origins, and destinations. Protect with rigid frame and clear plastic cover. Furnish an electronic copy of final comprehensive schedules for Project.

B. Cabling Administration Drawings: Show building floor plans with cabling administration-point labeling. Identify labeling convention and show labels for telecommunications closets, terminal hardware and positions, horizontal cables, work areas and workstation terminal positions, grounding buses and pathways, and equipment grounding conductors.

C. Cable and Wire Identification:

1. Label each cable within 4 inches (100 mm) of each termination and tap, where it is accessible in a cabinet or junction or outlet box, and elsewhere as indicated.
2. Each wire connected to building-mounted devices is not required to be numbered at the device if wire color is consistent with associated wire connected and numbered within panel or cabinet.
3. Exposed Cables and Cables in Cable Trays and Wire Troughs: Label each cable at intervals not exceeding 15 feet (4.5 m).
4. Label each terminal strip, and screw terminal in each cabinet, rack, or panel.

    a. Individually number wiring conductors connected to terminal strips, and identify each cable or wiring group, extended from a panel or cabinet to a building-mounted device, with the name and number of a particular device.
    b. Label each unit and field within distribution racks and frames.

5. Identification within Connector Fields in Equipment Rooms and Wiring Closets: Label each connector and each discrete unit of cable-terminating and -connecting hardware. Where similar jacks and plugs are used for both voice and data communication cabling, use a different color for jacks and plugs of each service.

D. Labels shall be preprinted or computer-printed type, with a printing area and font color that contrast with cable jacket color but still comply with TIA-606-B requirements for the following:

1. Cables use flexible vinyl or polyester that flexes as cables are bent.

3.9 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.

B. Perform the following field tests and inspections and prepare test reports:

1. 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. Test each point through its full operating range to verify that safety and operating control setpoints are as required.
4. Test each control loop to verify stable mode of operation and compliance with sequence of operation. Adjust PID actions.
5. Test each system for compliance with sequence of operation.
6. 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 flow instruments. Inspect tag number and line and bore size and verify that inlet side is identified and that meters are installed correctly.
5. Check control valves. Verify that they are in correct direction.
6. Check DDC system as follows:
    a. a. Verify that wires at control panels are tagged with their service designation and approved tagging system.
    b. b. Verify that DDC controllers are protected from power supply surges.

D. Replace damaged or malfunctioning controls and equipment and repeat testing procedures.

3.10 CONTROL SYSTEM DEMONSTRATION AND ACCEPTANCE

A. Demonstration: A complete demonstration of the capabilities of the BAS system shall be performed by the BAS manufacturer's field personnel. The BAS manufacturer shall dedicate a minimum of (16) hours on-site with the Owner representatives, and Engineer to demonstrate a complete functional test of all the BAS system requirements. This BAS demonstration shall constitute an acceptance inspection, and will represent the process of approving the BAS as designed and specified. Functional testing shall include, but is not limited to, the following system level components where installed:

B. Acceptance: The BAS will not be accepted as meeting the requirements of Completion until all tests described in this specification have been performed to the satisfaction of both the Engineer and Owner. Any tests that cannot be performed due to circumstances beyond the control of the Contractor may be exempt from the Completion requirements if stated as such in writing by the Owner's representative.

3.11 TRAINING

A. Two training sessions of four (4) hours minimum per session, with sessions on separate days for the facility maintenance staff. The training shall review accessing the web based building automation system (BAS) by password, show how to navigate through each of the system's graphic screens to identify each of the parameters which are just monitored and what parameters can be adjusted (setpoints and schedules), review each of the alarms which can be sent to the BAS and how the maintenance staff should address each, and proper logging out of the system.

1. Review with the maintenance staff current setpoints and instruct them how to adjust the setpoints. Instruct the staff in how to adjust equipment schedules and assist them in setting up each applicable schedule.
2. Instruct the staff in system troubleshooting. Instruct them in setup of trending / data logging and how to review the resulting data.
3. Instruct the staff how to do seasonal system startups and shutdowns.
4. Perform a walk-through of the building and review the location of room sensors and unit controllers.

END OF SECTION 250923

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SECTION 250993 - SEQUENCE OF OPERATIONS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes control sequences for direct digital controls for HVAC systems, subsystems, and equipment.

1.2 ACTION SUBMITTALS

A. Product Data:

1. An instrumentation points list for each controlled system. Label each element of the controlled system in table format. Show, in the table:
    a. Point Number
    b. Point Tag
    c. Description
    d. Manufacturer and Model Number
    e. System
    f. Equipment
    g. Instrument Tag
    h. Loop Number
    i. Control Function Matrix identifying: Binary In (BI), Analog In (AI), Binary Out (BO), Analog Out (AO)
    j. Ethernet Communication
    k. Hardware Installation Matrix identifying: Original Equipment Manufacturer (OEM) provided, Field Installed, Existing Device
    l. PLC or direct digital control panel ID
2. A complete description of the operation of the control system, including sequences of operation. Include and reference a schematic diagram of the controlled system.

B. Shop Drawings:

1. Riser diagrams showing control network layout, communication protocol, and wire types.
2. Schematic diagram of each controlled system. Include all control points labeled with point names shown or listed. Show the location of control elements in the system.

3. Wiring diagram for each controlled system. Show all control elements labels. Where a control element is the same as that shown on the control system schematic, label with the same name. Label all terminals.

1.3 GENERAL

A. Setpoints and schedules described in the operation of building systems are operator adjustable unless otherwise indicated.

B. Provide digital input from fire alarm system to indicate activation of system. Coordinate interface with the electrical contractor.

C. Data Logging: The building automation system trends all monitored values within a period of 1 year. The frequency of recording is adjustable from every 1 minute to 1 hour. The trends can be printed in the Microsoft Excel format with clearly defined headings.

D. Global Point Summary:
   a. Outdoor air temperature - AI
   b. Outdoor air dewpoint Temperature - AI
   c. Fire Alarm Status - BI

E. Hardwired Safeties (always enabled)
   1. When provided, the duct smoke detectors shall shut down the supply and exhaust fans on a smoke condition through the fire alarm system. The unit shutdown wiring from the fire alarm system output module to the variable frequency drive shutdown circuit shall be provided and installed by the fire alarm contractor. The fire alarm system shall notify the building automation system to restore normal controls upon deactivation of fire alarm condition.
   2. The building automation system shall shut down the supply and exhaust fans upon abnormal current detected by the variable frequency drives and raise critical alarm.

F. Freeze Protection:

   1. When any freezestat detects the temperature drops below 40°F (adjustable), the control valve is 100% open, the mixed air dampers are in the full return air position and the fan is off.

G. Space temperature setpoints:

   1. Occupied Cooling: 75°F (adjustable)
   2. Occupied Heating: 70°F (adjustable)
   3. Unoccupied Cooling: 80°F (adjustable)
   4. Unoccupied Heating: 60°F (adjustable)
   5. Maintain 5° dead band between heating and cooling setpoints for all systems.

H. Occupied space humidity set point: 50% RH

I. Points for all equipment:

1. Air Filter Timer: For all filters without differential pressure sensors, fan run compare fan run time to a filter maintenance timer setpoint which will notify the BAS at a user definable duration.
2. Alarms:
   a. Variable frequency drive fault.
   b. Fan failure: Commanded ON, but the status is OFF.
   c. Fan running in hand: commanded OFF, but the status is ON.
   d. Activation of the freezestat.

J. Typical Morning Start Up:

1. For all equipment, when space temperature reaches occupied space heating/cooling temperature setpoint, the system switches to occupied mode operation. Provide optimal start algorithm for morning warm-up mode to minimize warm-up period while achieving comfort conditions by the start of the scheduled occupied period.

K. Economizer Modes:

Units without energy recovery: When the space temperature rises above space cooling temperature setpoint and outdoor air temperature is less than space temperature, the mixed air damper modulates to increase outdoor air as required to maintain space cooling temperature setpoint. Provide low-limit override to prevent discharge air temperature from dropping below low limit setpoint of 55°F (adjustable) by modulating the mixed air damper to decrease the outdoor air without dropping below the minimum scheduled value.

1.4 **1,2 – AUDITORIUM**

A. System Components:

1. Roof top unit.
   a. Supply fan, variable volume with variable speed control.
   b. Mixed (outdoor and return) air damper, modulating.
   c. DX cooling with hot gas reheat, modulating. The refrigeration system is controlled by the unit's factory controller.
2. Ducted heating coil, steam control valve, modulating.
3. (3) Exhaust fans, variable volume with variable speed control and (3) exhaust dampers.
4. Relief air damper, 2-position.
5. Steam humidifier, modulating ducted steam header with airflow switch.

B. System Description:

1. A roof top unit provides ventilation, cooling and dehumidification, ducted heating coil provides heating, steam humidifier controls humidity levels, (3) exhaust fans provide exhaust, and relief air damper provides gravity relief in economizer mode.

C. System Off:

1. Roof top unit.
   a. Supply fan is off.
   b. Mixed air damper is in 100% return air position.
   c. DX is off.
2. Ducted heating coil, steam control valve is closed.
3. (3) Exhaust fans are off and exhaust dampers are closed.
4. Relief air damper is closed.
5. Steam humidifier is off.

D. Unoccupied/Start-Up Mode:

1. Roof Top Unit.
   a. Supply fan cycles.
   b. Mixed air damper is in 100% return air position.
   c. DX is on for cooling mode, otherwise it is off.
2. Steam control valve is open for heating mode, otherwise it is closed.
3. (3) Exhaust fans are off and exhaust dampers are closed.
4. Relief air damper is closed.
5. Steam humidifier modulates to maintain humidity setpoint.

E. Occupied Mode:

1. Roof top unit.
   a. Supply fan modulates as low as possible while maintaining occupied space temperature setpoint and minimum scheduled outdoor air quantity.
   b. Mixed air damper modulates to provide the following values of outdoor air as read by the airflow measurement station, unless economizer mode is activated:
      1) Normal mode: 1100 CFM.
      2) Event mode: 3800 CFM.
   c. DX modulates to maintain occupied space temperature setpoint in cooling and dehumidification mode otherwise it is off.
2. Steam control valve modulates in heating mode, otherwise it is closed.
3. (3) Exhaust fans are on to provide either scheduled normal mode or event mode CFM and exhaust dampers are open.
4. Relief air damper is closed, unless economizer mode is activated and damper is open.
5. Steam humidifier modulates to maintain occupied space relative humidity setpoint of 50% (adjustable).

1.5 **3 – HEAT PUMP**

A. System Components:

1. Heat pump system.
    a. Condensing unit, modulating.
    b. Indoor split units with supply fan and DX, modulating.

B. System Description:

1. The heat pump system, which is comprised of indoor split unit, and roof mounted condensing unit provide heating and cooling through the unit's factory provided, internal controls.

C. System Off:

1. Heat pump system is off.

D. Unoccupied/Start-Up Mode:

1. Heat pump system modulates to maintain unoccupied space temperature setpoint.

E. Occupied Mode:

1. Heat pump system modulates to maintain the space temperature setpoint.

END OF SECTION 250993

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SECTION 260500 – GENERAL ELECTRICAL REQUIREMENTS

PART 1 – GENERAL

1.1 SUMMARY

A. The General and Supplementary Conditions are a part of the requirements for the work under this Division of the Specifications.

1.2 WORK INCLUDED

A. Provide labor and materials required to install, test and place into operation the electrical systems as called for in the Contract Documents, and in accordance with applicable codes and regulations.

B. Provide labor, materials, and accessories required to provide complete, operating electrical systems. Labor, materials or accessories not specifically called for in the Contract Documents, but required to provide complete, operating electrical systems shall be provided without additional cost to the Owner.

1.3 QUALITY ASSURANCE

A. Comply with the current applicable codes, ordinances, and regulations of the Authority or Authorities Having Jurisdiction, the rules, regulations and requirements of the utility companies serving the project, and the Owner's insurance underwriter.

B. Drawings, specifications, codes and standards are minimum requirements. Where requirements differ, the most stringent apply.

C. Should any change in drawings or specifications be required to comply with governing regulations, notify the Engineer prior to submitting bid.

D. All electrical equipment, materials, devices and installations shall meet or exceed minimum requirements of ADA, ANSI, ASTM, IEEE, IES, NEC, NEMA, NETA, NFPA, OSHA, SMACNA, UL, and the State Fire Marshal.

E. Execute work in strict accordance with the best practices of the trades in a thorough, substantial, workperson-like manner by competent workpeople. Provide a competent, experienced, full-time Superintendent who is authorized to make decisions on behalf of the Contractor.

F. Equipment shall be certified for use in the state of New York and shall meet the New York State energy code.

1.4 ABBREVIATIONS AND DEFINITIONS

A. Abbreviations:

1.	ADA	Americans with Disabilities Act
2.	ANSI	American National Standards Institute
3.	ASA	Acoustical Society of America
4.	ASTM	American Society for Testing and Materials
5.	BIL	Basic Impulse Level
6.	CBM	Certified Ballast Manufacturers
7.	ECC	Engineer's Control Center
8.	EIA	Electronic Industries Alliance
9.	ETL	Electrical Testing Laboratories, Inc.
10.	FCC	Fire Control Center
11.	FM	Factory Mutual
12.	IEEE	Institute of Electrical and Electronic Engineers
13.	IES	Illuminating Engineering Society
14.	IPCEA	International Power Cable Engineers Association
15.	LED	Light Emitting Diode
16.	NEC	National Electric Code
17.	NEMA	National Electrical Manufacturers Association
18.	NETA	National Electrical Testing Association
19.	NFPA	National Fire Protection Association
20.	OEM	Original Equipment Manufacturer
21.	OSHA	Occupational Safety and Health Administration
22.	SCC	Security Control Center
23.	SMACNA	Sheet Metal and Air Conditioning Contractors National Association
24.	TIA	Telecommunications Industry Association
25.	UL	Underwriters Laboratories Inc.

B. Definitions:

1. Where it is stated in these specifications to submit to Engineer for review, refer to Architectural General and Supplementary Conditions for proper procedures.
2. FURNISH means to supply all materials, labor, equipment, testing apparatus, controls, tests, accessories and all other items customarily required for the proper and complete application.
3. INSTALL means to join, unite, fasten, link, attach, set up or otherwise connect together before testing and turning over to Owner, complete and ready for regular operation.
4. PROVIDE means to FURNISH and INSTALL.

5. AS DIRECTED means as directed by the Engineer, or the Engineer's Representative.
6. CONCEALED means embedded in masonry or other construction, installed behind wall furring or within drywall partitions, or installed within hung ceilings.
7. SUBMIT means submit to Engineer for review.

1.5 GUARANTEE

A. Submit a single guarantee stating that the work is in accordance with the Contract Documents. Guarantee work against faulty and improper material and workmanship for a period of one year from the date of final acceptance by the Owner, except that where guarantees or warranties for longer terms are provided or specified herein, the longer term shall apply. Manufacturer's warranty/guarantee on equipment shall be begin at time of equipment startup not upon receipt of equipment. Correct any deficiencies, which occur during the guarantee period, within 24 hours of notification, without additional cost to the Owner, to the satisfaction of the Owner. Obtain similar guarantees from subcontractors, manufacturers, suppliers and subtrade specialists.

1.6 USE OF THE ARCHITECT'S AND ENGINEER'S DRAWINGS

A. The Contractor shall obtain, at the Contractor's expense, from the Architect or Engineer a set of AutoCAD or compatible format architectural and engineering drawings on electronic media where desired by the Contractor and/or required by the Specifications for use in preparing the shop drawings, coordination drawings, and record drawings. The Contractor shall provide to the Architect and Engineer a written release of liability acceptable to the Architect and Engineer prior to receiving the electronic media.

PART 2 – PRODUCTS

2.1 EQUIPMENT AND MATERIALS

A. Provide products and materials that are new, clean, free of defects, and free of damage and corrosion.

B. Products and materials shall not contain asbestos, PCB, or any other material that is considered hazardous by the Environmental Protection Agency or any other Authority Having Jurisdiction.

C. Replace materials of less than specified quality and relocate work incorrectly installed as directed by the Architect or Engineer at no additional cost to the Owner.

D. Provide name/data plates on major components of equipment with manufacturer's name, model number, serial number, capacity data and electrical characteristics attached in a conspicuous place.

E. Install materials and equipment with qualified trades people.

F. Maintain uniformity of manufacturer for equipment used in similar applications and sizes.

G. Fully lubricate equipment where required.

H. Follow manufacturer's instructions for installing, connecting, and adjusting equipment. Provide a copy of such instructions at the equipment during installation.

I. Where factory testing of equipment is required to ascertain performance, and attendance by the Owner's Representative is required to witness such tests, associated travel costs and subsistence shall be paid for by the Contractor.

J. Equipment capacities, ratings, etc., are scheduled or specified for job site operating conditions. Equipment sensitive to altitude shall be derated with the method of derating identified on the submittals.

K. Enclosures for electrical equipment installed in mechanical and electrical equipment rooms shall be NEMA type 1 gasketed. Enclosures for electrical equipment installed outdoors shall be NEMA type 3R unless otherwise noted.

L. Energy consuming equipment shall be certified for use in the state of New York and shall meet the New York State Energy Code and local energy ordinances.

2.2 SUBSTITUTIONS

A. Contract Documents are based on equipment manufacturers as called out in the Specifications and indicated on the Drawings. Acceptance of substitute equipment manufacturers does not relieve Contractor of the responsibility to provide equipment and materials, which meet the performance as, stated or implied in the Contract Documents.

B. Submit proposals to provide substitute materials or equipment, in writing, with sufficient lead time for review prior to the date equipment must be ordered to

maintain project schedule. Reimburse Owner for costs associated with the review of the proposed substitution whether substitution is accepted or rejected.

C. Indicate revisions required to adapt substitutions including revisions by other trades. Substitutions that increase the cost of the work and related trades are not permitted.

D. The proposed substitution shall conform to the size, ratings, and operating characteristics of the equipment or systems as specified and shown on the Drawings.

E. Proposals for substitutions shall include the following information:

1. A description of the difference between the Contract Document requirements and that of the substitution, the comparative features of each, and the effect of the change on the end result performance. Include the impact of all changes on other contractors and acknowledge the inclusion of additional costs to the other trades.
2. Schematic drawings and details.
3. List of revisions to the Contract Documents that must be made if the substitution is accepted.
4. Estimate of costs the Owner may incur in implementing the substitution, such as test, evaluation, operating and support costs.
5. Statement of the time by which a Contract modification accepting the substitution must be issued, noting any effect on the Contract completion time or the delivery schedule.
6. A statement indicating the reduction to the Contract price if the Owner accepts the substitution. Include required modifications to all related trades.

PART 3 – EXECUTION

3.1 FEES AND PERMITS

A. Pay all required fees and obtain all required permits related to the electrical installation.

B. Pay royalties or fees in connection with the use of patented devices and systems.

C. Provide an electrical inspection for all related electrical work by a qualified New York State electrical inspection agency. The inspection shall be performed, in the presence of the engineer or architect of record. An electrical approval certificate shall be issued by the electrical inspection agency.

3.2 SUBMITTALS AND REVIEWS

A. Submit shop drawings, manufacturer's product data sheets, samples, and test reports as specified.

B. After execution of Owner/Contractor Agreement, submit a complete typed list of all electrical equipment manufacturers and material suppliers for the equipment proposed to be provided on this project, as well as names of all subcontractors.

C. After execution of Owner/Contractor Agreement, prepare an index of all submittals for the project. Include a submittal identification number, a cross-reference to the Specification sections or Drawing number, and an item description. Prefix the submittal identification number by the Specification sections to which they apply. Indicate on each submittal, the submittal identification number in addition to the other data specified. All subcontractors shall utilize the assigned submittal identification number.

D. After the Contract is awarded, obtain complete shop drawings, product data and samples from the manufacturers, suppliers, vendors, and all subcontractors, for all materials and equipment as specified. Submit data and details of such materials and equipment for review. Prior to submission, certify that the shop drawings, product data and samples are in compliance with the Contract Documents. Check all materials and equipment upon their arrival on the job site and verify their compliance with the Contract Documents. Modify any work, which proceeds prior to receiving accepted shop drawings as required to comply with the Contract Documents and the shop drawings.

E. Review of submittals is for general compliance with the design concept and Contract Documents. Comments or absence of comments shall not relieve the Contractor from compliance with the Contract Documents. The Contractor remains solely responsible for details and accuracy, for confirming and correlating all quantities and dimensions, for selecting fabrication processes, for techniques of construction, for performing the work in a safe manner, and for coordinating the work with that of other trades.

F. No part of the work shall be started in the shop or in the field until the shop drawings and samples for that portion of the work have been submitted and accepted.

G. A minimum period of ten working days, exclusive of transmittal time, will be required in the Engineer's office each time a shop drawing, product data and/or samples are submitted for review. This time period must be considered by the Contractor in the scheduling of the work.

H. Submit electronic copies, preferably in PDF format, of all items requiring shop drawings.

I. Submit materials and equipment by manufacturer, trade name, and model number. Include copies of applicable brochure or catalog material. Maintenance and operating manuals are not acceptable substitutes for shop drawings.

J. Identify each sheet of printed submittal pages (using arrows, underlining or circling) to show applicable sizes, types, model numbers, ratings, capacities and options actually being proposed. Cross out non-applicable information. Note specified features such as materials or paint finishes.

K. Include dimensional data for roughing in and installation and technical data sufficient to verify that equipment meets the requirements of the Contract Documents. Include wiring, conduit, outlet-type and service connection data; motor sizes complete with voltage ratings and schedules.

L. Maintain a complete set of reviewed and stamped shop drawings and product data on site.

M. Prepare and submit detailed shop drawings for major electrical and telecommunications conduit duct banks and other distribution services in 3/8" = 1'-0" sale, include locations and sizes of openings in floor decks, walls and roofs.

N. For each room or area of the building containing electrical equipment, submit the following:

1. Floor Plans: Plan and elevation layout drawings indicating the equipment in the exact location in which it is intended to be installed. These plans shall be of a scale not less than 1/4 inch to 1 foot. They shall be prepared in the following manner:
    a. Indicate the physical boundaries of the space including door swings and ceiling heights and ceiling types (as applicable).
    b. Illustrate all electrical equipment proposed to be contained therein. Include top and bottom elevations of all electrical equipment. The Drawings shall be prepared utilizing the dimensions contained in the individual equipment submittals. Indicate code and manufacturer's required clearances.
    c. Illustrate all other equipment therein such as conduits, detectors, luminaries, ducts, registers, pull boxes, wireways, structural elements, etc.
    d. Indicate the operating weight of each piece of equipment.
    e. Indicate the heat release from each piece of electrical equipment in terms of BTU per hour. This information shall be that which is supplied by the respective manufacturers.

f. Illustrate concrete pads, curbs, etc.
g. Indicate dimensions to confirm compliance with code-required clearances.
h. Indicate maximum normal allowable operating temperature for each piece of equipment (as per each respective manufacturer's recommendation).
i. Equipment removal routes.
j. Any exterior wall or foundation penetrations.

O. All shop drawings shall be prepared using AutoCAD software. Hand drawn shop drawings will not be accepted.

P. The work described in shop drawing submissions shall be carefully checked by all trades for clearances (including those required for maintenance and servicing), field conditions, maintenance of architectural conditions and coordination with other trades on the job. Each submitted shop drawing shall include a certification that related job conditions have been checked by the Contractor and each Subcontractor and that conflicts do not exist.

Q. The Contractor is not relieved of the responsibility for dimensions or errors that may be contained on submissions, or for deviations from the requirements of the Contract Documents. The noting of some errors but overlooking others does not grant the Contractor permission to proceed in error. Regardless of any information contained in the shop drawings, product data and samples, the Contract Documents govern the work and are neither waived nor superceded in any way by the review of shop drawings, product data and samples.

R. Inadequate or incomplete shop drawings, product data and/or samples will not be reviewed and will be returned to the Contractor for resubmittal.

3.3 COORDINATION OF WORK

A. The Contract Documents establish scope, materials and quality but are not detailed installation instructions. Drawings are diagrammatic.

B. Coordinate work with related trades and furnish, in writing, any information necessary to permit the work of related trades to be installed satisfactorily and with the least possible conflict or delay.

C. The electrical drawings show the general arrangement of equipment and appurtenances. Follow these drawings as closely as the actual construction and the work of other trades will permit. Provide offsets, fittings, and accessories, which may be required but not shown on the Drawings. Investigate the site, and review drawings of other trades to determine conditions affecting the work, and

provide such work and accessories as may be required to accommodate such conditions.

D. The locations of lighting fixtures, outlets, panels and other equipment indicated on the Drawings are approximately correct, but they are understood to be subject to such revision as may be found necessary or desirable at the time the work is installed in consequence of increase or reduction of the number of outlets, or in order to meet field conditions, or to coordinate with modular requirements of ceilings, or to simplify the work, or for other legitimate causes.

E. Exercise particular caution with reference to the location of panels, outlets, switches, etc., and have precise and definite locations accepted by the Engineer before proceeding with the installation.

F. The Drawings show only the general run of raceways and approximate locations of outlets. Any significant changes in location of outlets, cabinets, etc., necessary in order to meet field conditions shall be brought to the immediate attention of the Engineer for review before such alterations are made. Modifications shall be made at no additional cost to the Owner.

G. Verify with the Architect the exact location and mounting height of outlets and equipment not dimensionally located on the Drawings prior to installation.

H. Circuit tags in the form of numbers are used where shown to indicate the circuit designation numbers in electrical panels. Show the actual circuit numbers on the as-built Record Drawings and on the associated typed panelboard directory card. Where circuiting is not indicated, provide required circuiting in accordance with the loading indicated on the Drawings and/or as directed.

I. The Drawings generally do not indicate the number of wires in conduit for the branch circuit wiring of fixtures and outlets, or the actual circuiting. Provide the correct wire size and quantity as required by the indicated circuiting and/or circuit numbers indicated, the control intent, referenced wiring diagrams (if any), the specified voltage drop or maximum distance limitations, and the applicable requirements of the NEC. All power branch circuits shall be equipped with a ground conductor.

J. Carefully check space requirements with other trades to ensure that equipment can be installed in the spaces allotted.

K. Wherever work interconnects with work of other trades, coordinate with other trades to ensure that they have the information necessary so that they may properly install the necessary connections and equipment. Identify items (remote LED Drivers, pull boxes, etc.) requiring access in order that the ceiling trade will know where to install access doors and panels.

L. Consult with other trades regarding equipment so that, wherever possible, motor controls and distribution equipment are of the same manufacturer.

M. Furnish and set sleeves for passage of conduits through structural masonry and concrete walls and floors and elsewhere as required for the proper protection of each conduit passing through building surfaces.

N. Provide firestopping around all pipes, conduits, ducts, sleeves, etc. which pass through rated walls, partitions and floors.

O. Provide detailed information on openings and holes required in precast members for electrical work.

P. Provide required supports and hangers for conduit and equipment, designed so as not to exceed allowable loadings of structures.

Q. Examine and compare the Contract Documents with the drawings and specifications of other trades, and report any discrepancies between them to the Engineer and obtain written instructions for changes necessary in the work. Install and coordinate the work in cooperation with other related trades. Before installation, make proper provisions to avoid interferences.

R. Wherever the work is of sufficient complexity, prepare additional detail drawings to scale to coordinate the work with the work of other trades. Detailed work shall be clearly identified on the Drawings as to the area to which it applies. Submit these drawings to the Engineer for review. At completion include a set of these drawings with each set of Record Drawings.

S. Furnish services of an experienced Superintendent, who shall be in constant charge of all work, and who shall coordinate work with the work of other trades. No work shall be installed before coordinating with other trades.

T. Coordinate with the local electric utility company and the local telecommunications company as to their requirements for service connections and provide all necessary metering provisions, grounding, materials, equipment, labor, testing, and appurtenances.

U. Before commencing work, examine adjoining work on which this work is in any way affected and report conditions, which prevent performance of the work. Become thoroughly familiar with actual existing conditions to which connections must be made or which must be changed or altered.

V. Adjust location of conduits, panels, equipment, etc., to accommodate the work to prevent interferences, both anticipated and encountered. Determine the exact route and location of each conduit prior to fabrication.

1. Right-of-Way: Lines which pitch have the right-of-way over those which do not pitch. For example: condensate, steam, and plumbing drains normally have right-of-way. Lines whose elevations cannot be changed have right-of-way over lines whose elevations can be changed.
2. Provide offsets, transitions and changes in direction of conduit as required to maintain proper headroom and pitch on sloping lines.

W. In cases of doubt as to the work intended, or in the event of need for explanation, request supplementary instructions from the Engineer.

3.4 CONTRACTOR'S COORDINATION DRAWINGS

A. The Contractor shall coordinate efforts of all trades and shall furnish (in writing, with copies to the Engineer) any information necessary to permit the work of all trades to be installed satisfactorily and with the least possible interference or delay.

B. The Contractor and all trade contractors shall prepare a complete set of construction Coordination Drawings indicating the equipment actually purchased and the exact routing for all lines such as busway, conduit, piping, ductwork, etc., including conduit embedded in concrete floors and walls. The Coordination Drawings shall be submitted complete to the Architect and the Engineer, within three months after execution of Owner/Contractor Agreement, and in compliance with the construction schedule for the project. The sheet metal drawings, at a scale of not less than 1/4 inch to 1 foot, shall serve as the base drawings to which all other Contractors shall add their work. Each separate trade contractor shall draw their work on separate layers with different color assignments to facilitate coordination. Each Coordination Drawing shall be completed and signed off by the other Trade Contractors and the Contractor prior to the installation of the HVAC, plumbing, electrical and fire sprinkler work in the area covered by the specific drawing. The Contractor's work shall be installed according to the shop drawings and coordination drawings. If the Contractor allows one trade to install their work before coordination with the work of other trades, the Contractor shall make all necessary changes to correct the condition at no additional cost to the Owner.

C. The Contractors' Coordination Drawings shall indicate structural loads at support points for all piping 10 inch and larger, racked piping, racked conduit, busway, and suspended electrical equipment. Submit to Structural Engineer for review and approval. The elevation, location, support points, static, dynamic and expansion forces and loads imposed on the structure at support and anchor points shall be indicated. All beam penetrations and slab penetrations shall be indicated and sized and shall be coordinated. Work routed underground or embedded in concrete shall be indicated by dimension to column and building

lines and shall be coordinated. Coordination Drawings shall document all required structural penetrations for initial construction. Penetrations shall be dimensioned for walls, floors and roofs. These structural coordination requirements require review and approval by the Structural Engineer prior to completion and submittal of the Drawings.

D. This requirement for Coordination Drawings shall not be construed as authorization for the Contractor or trade contractors to make any unauthorized changes to the Contract Documents. Contract document space allocations shall be maintained such as ceiling height, designated clearance for future construction and flexibility, chase walls, equipment room size, unless prior written authorization is received from the Engineer to change them.

E. Prior to final acceptance of the Work, the Contractor shall submit the Coordination Drawings as part of the Record Drawings submittal.

3.5 EXAMINATION OF SITE

A. Prior to the submitting of bids, visit the project site and become familiar with all conditions affecting the proposed installation and make provisions as to the cost thereof.

B. The Contract Documents do not make representations regarding the character or extent of the sub-soils, water levels, existing structural, mechanical and electrical installations, above or below ground, or other sub-surface conditions which may be encountered during the work. Evaluate existing conditions, which may affect methods or cost of performing the work, based on examination of the site or other information. Failure to examine the Drawings or other information does not relieve the Contractor of responsibility for the satisfactory completion of the work.

3.6 CUTTING AND PATCHING

A. Where cutting, channeling, chasing or drilling of floors, walls, partitions, ceilings or other surfaces is necessary for the proper installation, support or anchorage of conduit or other equipment, lay out the work carefully in advance. Repair any damage to the building, piping, equipment or defaced finished plaster, woodwork, metalwork, etc., using skilled tradespeople of the trades required at no additional cost to the Owner.

B. Do not cut, channel, chase or drill unfinished masonry, tile, etc., unless permission from the Architect is obtained. If permission is granted, perform this work in a manner acceptable to the Architect.

C. Where conduit or equipment are mounted on a painted finished surface, or a surface to be painted, paint to match the surface. Utilize cold galvanized bare metal whenever support channels are cut.

D. Provide slots, chases, openings and recesses through floors, walls, ceilings, and roofs as required. Where these openings are not provided, provide cutting and patching to accommodate penetrations at no additional cost to the Owner.

3.7 MOUNTING HEIGHTS

A. Mounting heights shall conform to ADA requirements.

B. Verify exact locations and mounting heights with the Architect before installation.

C. Mounting heights of electrical device shall match what is indicated on the drawings. Use the following mounting heights if not indicated on the drawings (finished floor to center of device):

1. Electrical and telecommunications outlets: 15 inches, unless otherwise noted.
2. Lighting Switches/Wall Occupancy Sensors: 48 inches
3. Outlets for public and wall mounted telephones: conform to ADA mounting height.
4. Wall-mounted exit signs: 2 inches above top of door frame to bottom of sign.
5. Low-Level Exit Signs: 6" to bottom of sign.
6. Stairwell and utility corridor wall mounted fixtures: 8'-6" above finished floor or one foot below ceiling or structure above whichever is lower.

3.8 CLEANING UP

A. Avoid accumulation of debris, boxes, loose materials, crates, etc., resulting from the installation of this work. Remove from the premises each day all debris, boxes, etc., and keep the premises clean and free of dust and debris.

B. Clean all light fixtures and equipment at the completion of the project. Wipe clean exposed lighting fixture reflectors and trim pieces with a non-abrasive cloth just prior to occupancy.

C. All electrical equipment shall be thoroughly vacuumed and wiped clean prior to energization and at the completion of the project. Equipment shall be opened for observation by the Engineer as required.

3.9 WATERPROOFING

A. Avoid, if possible, the penetration of any waterproof membranes such as roofs, machine room floors, basement walls, and the like. If such penetration is necessary, make penetration prior to the waterproofing and furnish all sleeves or pitch-pockets required. Advise the Architect and obtain written permission before penetrating any waterproof membrane, even where such penetration is shown on the Drawings.

B. Restore waterproofing integrity of walls or surfaces after they have been penetrated without additional cost to the Owner.

3.10 SUPPORTS

A. Support work in accordance with the best industry practice. Provide supports, hangers, auxiliary structural members and supplemental hardware required for support of the work.

B. Provide supporting frames or racks extending from floor slab to ceiling slab for work indicated as being supported from walls where the walls are incapable of supporting the weight. In particular, provide such frames or racks in electric closets and mechanical equipment rooms.

C. Provide supporting frames or racks for equipment which is to be installed in a freestanding position.

D. Supporting frames or racks shall be of standard angle, standard channel or specialty support system steel members, rigidly bolted or welded together and adequately braced to form a substantial structure. Racks shall be of ample size to assure a workmanlike arrangement of all equipment mounted on them.

E. Adequate support of equipment (including outlet, pull and junction boxes and fittings) shall not depend on electric conduits, raceways, or cables for support.

F. Electrical equipment shall not rest on or depend for support on suspended ceiling media (tiles, lath, plaster, as well as splines, runners, bars and the like in the plane of the ceiling). Provide independent support of electrical equipment. Do not attach to supports provided for ductwork, piping or work of other trades.

G. Provide required supports and hangers for conduit, equipment, etc., so that loading will not exceed allowable loadings of structure. Electrical equipment and supports shall not come in contact with work of other trades.

3.11 FASTENINGS

A. Fasten equipment to building structure in accordance with the best industry practice.

B. Where weight applied to building attachment points is 100 pounds or less, conform to the following as a minimum:

1. Wood: Wood screws.
2. Concrete and solid masonry: Bolts and expansion shields.
3. Hollow construction: Toggle bolts.
4. Solid metal: Machine screws in tapped holes or with welded studs.
5. Steel decking or sub-floor: Fastenings as specified below for applied weights in excess of 100 pounds.

C. Where weight applied to building attachment points exceeds 100 pounds, but is 300 pounds or less, conform to the following as a minimum:

1. At concrete slabs provide 24-inch by 24-inch by 1/2-inch steel fishplates on top with through bolts. Fishplate assemblies shall be chased in and grouted flush with the top of slab screed line, where no fill is to be applied.
2. At steel decking or sub-floor for all fastenings, provide through bolts or threaded rods. The tops of bolts or rods shall be set at least one inch below the top fill screed line and grouted in. Suitable washers shall be used under bolt heads or nuts. In cases where the decking or sub-floor manufacturer produces specialty hangers to work with their decking or sub-floor, such hangers shall be provided.

D. Where weight applied to building attachment points exceeds 300 pounds, coordinate with and obtain the approval of Engineer and conform to the following as a minimum:

1. Provide suitable auxiliary channel or angle iron bridging between building structural steel elements to establish fastening points. Bridging members shall be suitably welded or clamped to building steel. Provide threaded rods or bolts to attach to bridging members.

E. For items, which are shown, as being ceiling-mounted at locations where fastening to the building construction element above is not possible, provide suitable auxiliary channel or angle iron bridging tying to the building structural elements.

F. Wall-mounted equipment may be directly secured to wall by means of steel bolts. Groups or arrays of equipment may be mounted on adequately sized steel

angles, channels, or bars. Prefabricated steel channels as manufactured by Kindorf or Unistrut are acceptable.

3.12 IDENTIFICATION

A. Identify electrical equipment with permanently attached black phenolic nameplates with 1/2-inch high white engraved lettering. Identification shall include equipment name or load served as appropriate. Nameplates for equipment connected to the emergency power system shall be red with white lettering. Nameplates shall be attached with cadmium-plated screws; peel-and-stick tape or glue-on type nameplates are not allowed.

B. Cable tags shall be flameproof secured with flameproof non-metallic cord.

C. Provide an engraved nameplate for each switch controlling loads, which are not local to the switch.

D. Wherever raceways for future use are terminated outside of the building, stake the location with a 2-foot long, 1-inch by 1-inch clear heart redwood stake.

E. See individual Sections for additional identification requirements.

3.13 PROHIBITED LABELS AND IDENTIFICATIONS

A. In all public areas, the inclusion or installation of any equipment or assembly which bears on any exposed surface any name, trademark, or other insignia which is intended to identify the manufacturer, the vendor, or other source(s) from which such object has been obtained, is prohibited, unless otherwise approved by Owner.

B. Required UL labels shall not be removed nor shall identification specifically required under the various technical sections of the Specifications be removed.

3.14 EQUIPMENT PADS AND ANCHOR BOLTS

A. Provide concrete pads under all floor-mounted electrical equipment. Equipment pads shall conform to the shape of the piece of equipment it serves with a minimum 1-inch margin around the equipment and supports. Pads shall be a minimum of 4 inches high and made of a minimum 28 day, 2500 psi concrete reinforced with 6-inch by 6-inch 6/6 gauge welded wire mesh. Trowel tops and sides of pad to smooth finishes, equal to those of the floors, with all external corners bullnosed to a 3/4-inch radius.

B. Provide galvanized anchor bolts for all equipment placed on concrete equipment pads, inertia blocks, or on concrete slabs. Provide bolts of the size and number recommended by the manufacturer of the equipment and locate by means of suitable templates. Equipment installed on vibration isolators shall be secured to the isolator. Secure the isolator to the floor, pad, or support as recommended by the vibration isolation manufacturer.

C. Where equipment is mounted on gypsum board partitions, the mounting screws shall pass through the gypsum board and securely attach to the partition studs. As an alternative, the mounting screws may pass through the gypsum board and be securely attached to 6 inches square, 18 gauge galvanized metal backplates, which are attached to the gypsum board with an approved non-flammable adhesive. Toggle bolts installed in gypsum board partitions are not allowed.

3.15 DELIVERY, DRAYAGE AND HAULING

A. Provide drayage, hauling, hoisting, shoring and placement in the building of equipment specified and be responsible for the timely delivery and installation of equipment as required by the construction schedule. If any item of equipment is received prior to the time that it is required, the Contractor shall be responsible for its proper storage and protection until the time it is required. Pay for all costs of drayage or storage.

B. If equipment is not delivered or installed at the project site in a timely manner as required by the project construction schedule, the Contractor shall be responsible for resulting disassembly, re-assembly, manufacturer's supervision, shoring, general construction modification, delays, overtime costs, etc., at no additional cost to the Owner.

3.16 EQUIPMENT AND MATERIAL PROTECTION

A. Protect the work, equipment, and material of other trades from damage by work or workmen of this trade, and correct damaged caused without additional cost to the Owner.

B. Take responsibility for work, materials, and equipment until finally inspected, tested and accepted. Protect work against theft, injury, or damage, and carefully store material and equipment received on site, which is not immediately installed. Close open ends of work with temporary covers or plugs during construction to prevent entry of obstructing material. Cover and protect equipment and materials from damage due to water, spray-on fireproofing, construction debris, etc. Store equipment to moisture damage in dry, heated spaces.

C. Provided adequate means for fully protecting finished parts of materials and equipment against damage from whatever cause during the progress of the work until final acceptance. Protect materials and equipment in storage and during construction in such a manner that no finished surfaces will be damaged or marred, and moving parts are kept clean and dry. Do not install damaged items; take immediate steps to obtain replacement or repair.

3.17 TESTING OF ELECTRICAL SYSTEMS

A. Comply with the project construction schedule for the date of final performance and acceptance testing, and complete work sufficiently in advance of the Contract completion date to permit the execution of the testing prior to occupancy and Contract close-out. Complete any adjustments and/or alterations, which the final acceptance tests indicate as necessary for the proper functioning of all equipment prior to the completion date. See individual Sections for extent of testing required.

B. Provide a detailed schedule of completion indicating when each system is to be completed and outlining when field testing will be performed. Submit completion schedule for review within six months after the notice to proceed by Owner's Representative has been given. Update this schedule periodically as the project progresses.

3.18 OPERATING INSTRUCTIONS

A. Provide the services of factory-trained specialists to provide an operating instructions seminar for equipment and systems. The seminar shall be conducted over a five-day (consecutive) period. Instruction time is defined as straight time working hours and does not include nights, weekends, or travel time to and from the project.

B. Submit seminar agenda, schedule and list of representatives to the Owner for approval 30 days prior to suggested date of seminar. Do not commence seminar until the Owner has issued a written acceptance of the starting time and attendees. Confirm attendance of seminar by written notification to participants.

C. Instruct Owner's operating personnel in proper starting sequences, operation, shut-down, general maintenance and preventative maintenance procedures, including normal and emergency procedures.

D. Submit final copies of Record Drawings and Operating and Maintenance Manuals to Owner at seminar.

E. Submit a written record of minutes and attendees of the seminar to the Owner.

3.19 OPERATING AND MAINTENANCE MANUALS

A. Provide Operating and Maintenance Manuals for equipment and materials furnished under this Division.

B. Submit three final copies of Operating and Maintenance Manuals for review at least ten weeks before the completion date. Assemble data in a completely indexed volume or volumes in three-ring binders and identify the size, model, and features indicated for each item. Print the project name on the outside of the binders.

C. Maintenance manuals shall include complete cleaning and servicing data compiled in a clear and easily understandable format. Show model numbers of each piece of equipment, complete lists of replacement parts, capacity ratings, and actual loads.

D. Provide the following information where applicable:

1. Identifying name and mark number
2. Locations (where several similar items are used, provide a list)
3. Complete nameplate data
4. Certified Record Drawings and Final Reviewed submittals
5. Parts list
6. Performance curves and data
7. Wiring diagrams
8. Manufacturer's recommended operating and maintenance instructions with all non-applicable information deleted
9. List of spare parts recommended for normal service requirements
10. Assembly and disassembly instructions with exploded-view drawings where necessary
11. Test reports
12. Trouble shooting diagnostic instructions, where applicable

3.20 RECORD DRAWINGS

A. The Contractor shall maintain on a daily basis at the Project site a complete set of black and white "As-built Drawings" reflecting an accurate dimensional record of all deviations between work shown on the Contract Drawing and that actually installed.

B. Record dimensions clearly and accurately to delineate the work as installed. Suitably identify locations of all equipment by at least two dimensions to permanent structures. In addition, mark the Record Drawings to show the precise location of concealed work and equipment, including concealed or embedded conduit and all changes and deviations in the electrical work from that shown on

the Contract Documents. This requirement is not construed as authorization for the Contractor to make changes in the layout or work without written instructions from the Engineer.

C. AutoCAD files shall be electronically updated to record all revisions of the original drawings as actually installed. Bear the cost of making required changes. Upon completion of the installation, submit electronic PDFs and (1) set of black and white prints of these revised drawings to the Architect and Engineer for review of completeness.

D. After the Architect's and Engineer's review, and any required Contractor revisions, the Record Drawings shall be delivered to the Owner on electronic media in AutoCAD format.

E. The Contractor and Subcontractor shall mark all in-progress Record Drawings on the front lower right hand corner with a rubber stamp impression or an AutoCAD image similar to the following:

RECORD DRAWING
(3/8-inch high letters)

To be used for recording Field Deviations and Dimensional Data Only
(5/16-inch high letters)

F. Upon completion of the work, the Contractor shall certify all Record Drawings on the front lower right hand corner adjacent to the above marking with a rubber stamp impression or an AutoCAD image similar to the following:

RECORD DRAWING
CERTIFIED CORRECT
(3/8-inch high letters)

(Printed Name of General Contractor)
(5/16-inch high letters)
Date:_____

(Printed Name of Subcontractor)
(5/16-inch high letters)
Date:_____

G. Indicate Contractor's firm name on the record and as-built drawings.

3.21 FINAL PUNCHLIST

A. Prior to the Final Punchlist, certify that systems and equipment are complete, operational, and are in compliance with the Contract Documents.

B. At a time designated by the Owner with assistance from the Contractor, the installation will be reviewed for compliance with the Contract Drawings and Specifications. Contractor shall be available at all time during these surveys.

C. During the Final Punchlist, provide personnel with access keys, hand held radios, and necessary expertise to operate each system and piece of equipment to demonstrate operational compliance with the Contract Documents.

D. Any deficiencies noted on the Final Punchlist shall be expeditiously corrected and certified in writing.

3.22 PROJECT CLOSEOUT

A. At the time of project closeout and prior to the final payment, this contractor shall provide/submit the following for owner to review and sign off:

1. Review with Owner and confirm that all field issues are resolved.
2. Submit two (2) binder books with all electrical system testing report, equipment certificate and operation manual as per these specifications.
3. Submit electrical 3-phase load balancing report with the Engineer's review
4. Provide the Owner with required training as per these specifications.
5. Provide spare parts, fuses, switches, components, as per these specifications.
6. Turn all keys, including door access keys and panelboard keys to the Owner with proper tags.
7. Submit construction record as-built sets with A/E review stamp.
8. All proposals and change orders are fully executed and submit a certified statement that no change orders will be submitted after project closeout.
9. Submit copies of the Authority's inspection and approval letters.

END OF SECTION 260500

SECTION 260505 - SELECTIVE DEMOLITION FOR ELECTRICAL

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Electrical demolition.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.1 EXAMINATION

A. Verify field measurements and circuiting arrangements are as indicated.

B. Verify that abandoned wiring and equipment serve only abandoned facilities.

C. Demolition drawings are based on casual field observation and existing record documents.

D. Report discrepancies to Architect before disturbing existing installation.

E. Beginning of demolition means contractor accepts existing conditions.

3.2 PREPARATION

A. Disconnect electrical systems in walls, floors, and ceilings to be removed.

B. Disconnect electrical and electrified equipment to be removed.

C. Coordinate utility service outages with utility company(s) and Owner.

D. 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.

E. Existing Electrical Service: Maintain existing systems and/or subsystems in service until new systems and/or subsystems are complete and ready for service. Disable systems only to make switchovers and connections. Minimize outage durations.
   1. Obtain permission from Owner at least 24 hours before partially or completely disabling system.
   2. Make temporary connections to maintain service in areas adjacent to work area.

F. Existing Fire Alarm System: Maintain existing system in service until new system is accepted. Disable system only to make switchovers and connections. Minimize outage duration.
   1. Notify Owner before partially or completely disabling system.
   2. Notify local fire service.
   3. Make notifications at least 24 hours in advance.
   4. Make temporary connections to maintain service in areas adjacent to work area.

G. Existing Telecommunications/Data 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.
   2. Notify telecommunications/data utility company at least 24 hours before partially or completely disabling system.
   3. Make temporary connections to maintain service in areas adjacent to work area.

3.3 DEMOLITION AND EXTENSION OF EXISTING ELECTRICAL WORK

A. Remove, relocate, and extend existing installations to accommodate new construction.

B. Remove abandoned wiring to source of supply.

C. Remove exposed abandoned conduit, including abandoned conduit above accessible ceiling finishes, unless otherwise indicated. Remove hangers, supports, and other accessories. Cut conduit flush with walls and floors, and patch surfaces.

D. 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.

E. Disconnect and remove abandoned panelboards and distribution equipment. Remove hangers, supports, and other accessories.

F. Disconnect and remove electrical devices and equipment serving utilization equipment that has been removed.

G. Disconnect and remove abandoned luminaires. Remove brackets, stems, hangers, and other accessories.

H. Repair adjacent construction and finishes damaged during demolition and extension work.

I. Maintain access to existing electrical installations that remain active. Modify installation or provide access panel as appropriate.

J. Extend existing installations using materials and methods compatible with existing electrical installations, or as specified.

3.4 CLEANING AND REPAIR

A. Clean and repair existing materials, products, and equipment that remain or that are to be reused.

B. 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.

C. Luminaires: Clean all existing luminaires in and adjacaent to areas of demolition and construction after all new work is completed. Use mild detergent to clean all exterior and interior surfaces; rinse with clean water and wipe dry. Replace defective lamps, ballasts, drivers , and broken electrical parts.

END OF SECTION 260505

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SECTION 260519 - LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Copper building wire rated 600 V or less.
2. Metal-clad cable, Type MC, rated 600 V or less.
3. Connectors, splices, and terminations rated 600 V and less.

1.2 DEFINITIONS

A. PV: Photovoltaic.

B. RoHS: Restriction of Hazardous Substances.

C. VFC: Variable-frequency controller.

1.3 SUBMITTALS

A. Product Data: For each type of product.

B. Product Schedule: Indicate type, use, location, and termination locations.

C. Qualification Data: For testing agency.

D. Field quality-control reports.

1.4 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member company of NETA.

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

PART 2 - PRODUCTS

2.1 COPPER BUILDING WIRE

A. Description: Flexible, insulated and uninsulated, drawn copper current-carrying conductor with an overall insulation layer or jacket, or both, rated 600 V or less.

B. Standards:

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.
2. RoHS compliant.
3. Conductor and Cable Marking: Comply with wire and cable marking according to UL's "Wire and Cable Marking and Application Guide."

C. Conductors: Copper, complying with ASTM B 3 for bare annealed copper and with ASTM B 8 for stranded conductors.

D. Conductor Insulation:

1. Type RHH and Type RHW-2: Comply with UL 44.
2. Type THHN and Type THWN-2: Comply with UL 83.
3. Type THW and Type THW-2: Comply with NEMA WC-70/ICEA S-95-658 and UL 83.
4. Type XHHW-2: Comply with UL 44.
5. Type TC-ER: Comply with NEMA WC 70/ICEA S-95-658 and UL 1277.
    a. Type TC-ER: Cable designed for use with VFCs, with oversized crosslinked polyethylene insulation, spiral-wrapped foil plus 85 percent braided shields with full size drain wire, full sized insulated ground wire, and sunlight- and oil-resistant outer PVC jacket. Provide this cable between VFCs and motor loads as indicted on drawings.

2.2 METAL-CLAD CABLE, TYPE MC

A. Description: A factory assembly of one or more current-carrying insulated conductors in an overall metallic sheath.

B. Standards:

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.
2. Comply with UL 1569.
3. RoHS compliant.
4. Conductor and Cable Marking: Comply with wire and cable marking according to UL's "Wire and Cable Marking and Application Guide."

C. Circuits:

1. Single circuit and multicircuit with color-coded conductors.

D. Conductors: Copper, complying with ASTM B 3 for bare annealed copper and with ASTM B 8 for stranded conductors.

E. Ground Conductor: Insulated.

F. Conductor Insulation:

1. Type TFN/THHN/THWN-2: Comply with UL 83.
2. Type XHHW-2: Comply with UL 44.

G. Armor: Steel, interlocked.

H. Jacket: PVC applied over armor (when Specified).

2.3 CONNECTORS AND SPLICES

A. Description: Factory-fabricated connectors, splices, and lugs of size, ampacity rating, material, type, and class for application and service indicated; listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.

2.4 INSULATING TAPE

A. Provide vinyl plastic tape that meets the requirements of UL 510 and has the following characteristics:

1. 8.5 Mil minim thickness.
2. ASTM D-3005 Standard specification for low-temperature resistant vinyl Chloride plastic pressure-sensitive electrical insulating type – type1.
3. Rated 600 volts and 150°C, suitable for indoor and outdoor applications.
4. Retains flexibility, adhesion, and applicable at temperature ranges from 0 through 100°F without loss of physical or electrical properties.
5. Resistant to abrasion, moisture, alkalis, acid, corrosion, and sunlight
6. Tape manufacturer: 3M “Scotch Super 88” or approved equal.

2.5 MANUFACTURERS

A. Wire Manufacturers: subject to compliance with requirements, provide products by one of the following (no exceptions):

1. Southwire Company
2. General Cable
3. The Okonite Company
4. Belden

5. VitaLink
6. Pyrotenax

B. Connectors Manufacturers: subject to compliance with requirements, provide products by one of the following (no exceptions):

1. Hubbell
2. Thomas & Betts
3. 3M Company

PART 3 - EXECUTION

3.1 CONDUCTOR MATERIAL APPLICATIONS

A. Feeders/Branch circuits: Copper; solid for No. 10 AWG and No. 12 AWG; stranded for No. 8 AWG and larger.

B. VFC Output Circuits Cable: Extra-flexible stranded for all sizes.

3.2 CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

A. Service Entrance: Type THHN/THWN-2, single conductors in raceway;

B. Exposed Feeders: Type THHN/THWN-2, single conductors in raceway.

C. Feeders Concealed in Ceilings, Walls, Partitions, and Crawlspaces: Type THHN/THWN-2, single conductors in raceway.

D. Feeders Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN/THWN-2, single conductors in raceway.

E. Feeders Installed below Raised Flooring: Type THHN/THWN-2, single conductors in raceway.

F. Exposed Branch Circuits, Including in Crawlspaces: Type THHN/THWN-2, single conductors in raceway.

G. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Type THHN/THWN-2, single conductors in raceway;

H. Branch Circuits Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN/THWN-2, single conductors in raceway.

I. Branch Circuits Installed below Raised Flooring: Type THHN/THWN-2, single conductors in raceway.

J. Cord Drops and Portable Appliance Connections: Type SO, hard service cord with stainless-steel, wire-mesh, strain relief device at terminations to suit application.

K. VFC Output Circuits: Type XHHW-2 in metal conduit; Type TC-ER cable with dual tape shield.

3.3 INSTALLATION OF CONDUCTORS AND CABLES

A. Conceal cables in finished walls, ceilings, and floors unless otherwise indicated.

B. Contract drawings do not indicate size of branch circuit wiring; use No.12 AWG as a minimum wire size for branch circuit wiring. For 20 Ampere branch circuits whose length from the panel to the furthest outlet exceeds 100 feet for 120-volt circuits or 150 feet for 277-volt circuits; use No. 10 AWG or larger for the entire branch circuit installation.

C. A shared neutral may be utilized for circuits other than circuits used for dimmers, ground fault interrupter receptacles or circuit breakers, isolated ground receptacles, and isolated ground surge suppressor type devices

D. Complete raceway installation between conductor and cable termination points prior to pulling conductors and cables.

E. Use manufacturer-approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.

F. Do not install wire in incomplete conduit runs nor until after concrete work and plastering is completed and moisture is swabbed from the conduits. Eliminate splices where possible. Where necessary, splice in readily accessible pull, junction or outlet box.

G. Take precautions to avoid entrance of dirt and water into the conduit and cuts. Clean conduits and ducts to remove and pulling compound prior to pulling cables. Do not damage conductor insulation, braid jacket or sheet during installation. Any damaged conductors shall be replaced immediately.

H. Use pulling means, including fish tape, cable, rope, cable reels on jacks, and basket-weave wire/cable grips, that will not damage cables or raceway. Do not exceed maximum recommended pulling tension of wire and cable

I. Install exposed cables parallel and perpendicular to surfaces of exposed structural members, and follow surface contours where possible.

J. Support cables according to Section 260529 "Hangers and Supports for Electrical Systems."

3.4 CONNECTIONS

A. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A-486B.

B. Except where lugs are furnished with equipment, Make splices, terminations, and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.

C. Circumferential compression type connector (provide for splices and connections No. 6 AWG and larger)
   1. Use for incoming and outgoing cable connections at enclosures and for ground connections.
   2. Use manufacturer’s approved tool and correct size hex head with embosses die number on the connector or lug.
   3. Make crimped indentions parallel with insulation putty.
   4. Fill voids and irregularities with insulation putty.
   5. Cover nearly with four (4) layers of vinyl plastic tape except where insulated covers are permitted; half-lap tape in two (2) directions.

D. Wiring at Outlets: Install conductor at each outlet, with at least 12 inches of slack.

3.5 IDENTIFICATION

A. Identify each spare conductor at each end with identity number and location of other end of conductor, and identify as spare conductor.

3.6 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

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

3.7 FIRESTOPPING

A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly according to the project specifications.

3.8 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

B. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

C. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

D. Perform tests and inspections.

1. After installing conductors and cables and before electrical circuitry has been energized, test service entrance and feeder conductors for compliance with requirements.
2. After installing conductors and cables and before electrical circuitry has been energized, test service entrance and feeder conductors and conductors feeding the following critical equipment and services for compliance with requirements:
3. Perform each of the following visual and electrical tests:
    a. Inspect exposed sections of conductor and cable for physical damage and correct connection according to the single-line/riser diagram.
    b. Test bolted connections for high resistance using one of the following:
        1) A low-resistance ohmmeter.
        2) Calibrated torque wrench.
        3) Thermographic survey.
    c. Inspect compression-applied connectors for correct cable match and indentation.
    d. Inspect for correct identification.
    e. Inspect cable jacket and condition.
    f. Insulation-resistance test on each conductor for ground and adjacent conductors. Apply a potential of 500-V dc for 300-V rated cable and 1000-V dc for 600-V rated cable for a one-minute duration.
    g. Continuity test on each conductor and cable.
    h. Uniform resistance of parallel conductors.
    i. Insulation resistance to comply with ICEA values.

4. Initial Infrared Scanning: After Substantial Completion, but before Final Acceptance, perform an infrared scan of each splice in conductors No. 3 AWG and larger. Remove box and equipment covers so splices are accessible to portable scanner. Correct deficiencies determined during the scan.
    a. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
    b. Record of Infrared Scanning: Prepare a certified report that identifies switches checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

E. Cables will be considered defective if they do not pass tests and inspections.

F. Prepare test and inspection reports to record the following:

1. Procedures used.
2. Results that comply with requirements.
3. Results that do not comply with requirements, and corrective action taken to achieve compliance with requirements.

END OF SECTION 260519

SECTION 260526 - GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Provide a complete grounding system in accordance with the Contract Documents and as specified herein.

1.2 SUBMITTALS

A. Minimum 1/8" scale floor plan drawings depicting the building ground electrode system as to be installed.

B. Detailed riser diagram depicting the building ground electrode system and bonding as to be installed.

C. Product data sheets (cut sheets) for all ground bus bars and other components of the grounding system.

D. Field test reports.

1.3 QUALITY ASSURANCE

A. Testing Agency Qualifications: Certified by NETA.

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

2.2 CONDUCTORS

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

B. Bare Copper Conductors:

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

C. Grounding Bus: Predrilled rectangular bars of annealed copper, 1/4 by 4 inches in cross section, with 9/32-inch holes spaced 1-1/8 inches apart. Stand-off insulators for mounting shall comply with UL 891 for use in switchboards, 600 V and shall be Lexan or PVC, impulse tested at 5000 V.

2.3 CONNECTORS

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

B. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.

C. Bus-Bar Connectors: Compression type, copper or copper alloy, with two wire terminals.

D. Beam Clamps: Mechanical type, terminal, ground wire access from four directions, with dual, tin-plated or silicon bronze bolts.

E. Cable-to-Cable Connectors: Compression type, copper or copper alloy.

F. Cable Tray Ground Clamp: Mechanical type, zinc-plated malleable iron.

G. Conduit Hubs: Mechanical type, terminal with threaded hub.

H. Ground Rod Clamps: Mechanical type, copper or copper alloy, terminal with hex head bolt.

I. Lay-in Lug Connector: Mechanical type, copper rated for direct burial terminal with set screw.

J. Signal Reference Grid Clamp: Mechanical type, stamped-steel terminal with hex head screw.

K. Straps: Solid copper, copper lugs. Rated for 600 A.

L. Tower Ground Clamps: Mechanical type, copper or copper alloy, terminal two-piece clamp.

M. U-Bolt Clamps: Mechanical type, copper or copper alloy, terminal listed for direct burial.

N. Water Pipe Clamps:

1. Mechanical type, two pieces with stainless-steel bolts.
   a. Material: Die-cast zinc alloy.
   b. Listed for direct burial.
2. U-bolt type with malleable-iron clamp and copper ground connector.

2.4 GROUNDING ELECTRODES

A. Ground Rods: Copper-clad steel; 3/4 inch by 10 feet.

B. Ground Plates: 1/4-inch-thick, hot-dip galvanized.

PART 3 - EXECUTION

3.1 APPLICATIONS

A. Conductors: Install solid conductor for No. 8 AWG and smaller, and stranded conductors for No. 6 AWG and larger unless otherwise indicated.

B. Underground Grounding Conductors: Install bare copper conductor, No. 2 AWG minimum.

1. Bury at least 24 inches below grade.

C. Isolated Grounding Conductors: Green-colored insulation with continuous yellow stripe. On feeders with isolated ground, identify grounding conductor where visible to normal inspection, with alternating bands of green and yellow tape, with at least three bands of green and two bands of yellow.

D. Grounding Bus: Install in electrical equipment rooms, in rooms housing service equipment, and elsewhere as indicated on drawings.

1. Install bus horizontally, on insulated spacers 2 inches minimum from wall, 6 inches above finished floor unless otherwise indicated.
2. Where indicated on both sides of doorways, route bus up to top of door frame, across top of doorway, and down; connect to horizontal bus.

E. Conductor Terminations and Connections:

1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
2. Underground Connections: Welded connectors except at test wells and as otherwise indicated.
3. Connections to Ground Rods at Test Wells: Bolted connectors.
4. Connections to Structural Steel: Welded connectors.

3.2 EQUIPMENT GROUNDING

A. Install insulated equipment grounding conductors with all feeders and branch circuits.

B. Air-Duct Equipment Circuits: Install insulated equipment grounding conductor to duct-mounted electrical devices operating at 120 V and more, including air cleaners, heaters, dampers, humidifiers, and other duct electrical equipment. Bond conductor to each unit and to air duct and connected metallic piping.

C. Water Heater, Heat-Tracing, and Antifrost Heating Cables: Install a separate insulated equipment grounding conductor to each electric water heater and heat-tracing cable. Bond conductor to heater units, piping, connected equipment, and components.

3.3 INSTALLATION

A. Grounding Conductors: Route along shortest and straightest paths possible unless otherwise indicated or required by Code. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.

B. Ground Rods: Drive rods until tops are 2 inches below finished floor or final grade unless otherwise indicated.

1. Interconnect ground rods with grounding electrode conductor below grade and as otherwise indicated. Make connections without exposing steel or damaging coating if any.
2. Use Exothermic welds for all below-grade connections.
3. For grounding electrode system, install at least three rods spaced at least one-rod length from each other and located at least the same distance from other grounding electrodes, and connect to the service grounding electrode conductor.

C. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance except where routed through short lengths of conduit.

1. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.
2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install bonding so vibration is not transmitted to rigidly mounted equipment.
3. Use exothermic-welded connectors for outdoor locations; if a disconnect-type connection is required, use a bolted clamp.

D. Grounding and Bonding for Piping:

1. Metal Water Service Pipe: Install insulated copper grounding conductors, in conduit, from building's main service equipment, or grounding bus, to main metal water service entrances to building. Connect grounding conductors to main metal water service pipes; use a bolted clamp connector or bolt a lug-type connector to a pipe flange by using one of the lug bolts of the flange. Where a dielectric main water fitting is installed, connect grounding conductor on street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.
2. Water Meter Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with a bolted connector.

E. Grounding for Steel Building Structure: Install a driven ground rod at base of each corner column and at intermediate exterior columns at distances not more than 60 feet apart.

3.4 FIELD QUALITY CONTROL

A. Perform tests and inspections with the assistance of a factory-authorized service representative.

B. Tests and Inspections:

1. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.
2. Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with a calibrated torque wrench according to manufacturer's written instructions.
3. Test completed grounding system at each location where a maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal, and at individual ground rods. Make tests at ground rods before any conductors are connected.

a. Measure ground resistance no fewer than two full days after last trace of precipitation and without soil being moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance.
b. Perform tests by fall-of-potential method according to IEEE 81.

4. Prepare dimensioned Drawings locating each test well, ground rod and ground-rod assembly, and other grounding electrodes. Identify each by letter in alphabetical order, and key to the record of tests and observations. Include the number of rods driven and their depth at each location, and include observations of weather and other phenomena that may affect test results. Describe measures taken to improve test results.

C. Grounding system will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

E. Report measured ground resistances that exceed the following values:

1. Power and Lighting Equipment or System with Capacity of 500 kVA and Less: 10 ohms.
2. Power and Lighting Equipment or System with Capacity of 500 to 1000 kVA: 5 ohms.
3. Power Distribution Units or Panelboards Serving Electronic Equipment: 3 ohm(s).
4. Substations and Pad-Mounted Equipment: 5 ohms.
5. Manhole Grounds: 10 ohms.

Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Architect promptly and include recommendations to reduce ground resistance.

END OF SECTION 260526

SECTION 260529 - HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Hangers and supports for electrical equipment and systems.

1.2 SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for the following:
   a. Hangers.
   b. Steel slotted support systems.
   c. Nonmetallic support systems.
   d. Trapeze hangers.
   e. Clamps.
   f. Turnbuckles.
   g. Sockets.
   h. Eye nuts.
   i. Saddles.
   j. Brackets.

2. Include rated capacities and furnished specialties and accessories.

B. Shop Drawings: For fabrication and installation details for electrical hangers and support systems.

1. Trapeze hangers. Include product data for components.
2. Steel slotted-channel systems.
3. Equipment supports.
4. Vibration Isolation Base Details: Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.

C. Coordination Drawings: Reflected ceiling plan(s) 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. Suspended ceiling components.
2. Structural members to which hangers and supports will be attached.
3. Size and location of initial access modules for acoustical tile.
4. Items penetrating finished ceiling, including the following:
    a. Lighting fixtures.
    b. Air outlets and inlets.
    c. Speakers.
    d. Sprinklers.
    e. Access panels.
    f. Projectors.

PART 2 - PRODUCTS

2.1 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

A. Steel Slotted Support Systems: Performed steel channels and angles with a minimum of 13/32-inch diameter holes at a maximum of 8 inches o.c. in at least one surface.

1. Standard: Comply with MFMA-4 factory-fabricated components for field assembly.
2. Material for Channel, Fittings, and Accessories: Stainless Steel, Type 304
3. Channel Width: 1-5/8 inches.
4. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.
5. Nonmetallic Coatings: Manufacturer's standard PVC, polyurethane, or polyester coating applied according to MFMA-4.
6. Channel Dimensions: Selected for applicable load criteria.

B. Conduit and Cable Support Devices: Steel, Stainless-steel or Glass-fiber-resin hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.

C. Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for non-armored electrical conductors or cables in riser conduits. Plugs shall have number, size, and shape of conductor gripping pieces as required to suit individual conductors or cables supported. Body shall be made of malleable iron.

D. Structural Steel for Fabricated Supports and Restraints: ASTM A 36/A 36M steel plates, shapes, and bars; black and galvanized.

E. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:

1. Mechanical-Expansion Anchors: Insert-wedge-type, stainless steel, for use in hardened portland cement concrete, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.
2. Concrete Inserts: Steel or malleable-iron, slotted support system units are similar to MSS Type 18 units and comply with MFMA-4 or MSS SP-58.
3. Clamps for Attachment to Steel Structural Elements: MSS SP-58 units are suitable for attached structural element.
4. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM A 325.
5. Toggle Bolts: Stainless-steel springhead type.
6. Hanger Rods: Threaded stainless- steel.

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

1. Allied Tube & Conduit; a part of Atkore International.
2. B-line, an Eaton business.
3. CADDY; a brand of nVent.
4. Thomas & Betts Corporation; A Member of the ABB Group.
5. Unistrut; Part of Atkore International.

PART 3 - EXECUTION

3.1 APPLICATION

A. Comply with NECA 1 and NECA 101 for application of hangers and supports for electrical equipment and systems unless requirements in this Section are stricter.

B. Provide nonmetallic coated steel slotted channel to support PVC conduit run inside building and in damp/corrosive environments.

C. Maximum Support Spacing and Minimum Hanger Rod Size for Raceway:

1. Support vertically installed raceways less than 2 inches trade size at intervals no greater than 8 feet. Support such raceways 2 inches trade size or larger and made up with threaded couplings, at intervals no greater 15 feet.
2. Support horizontally installed raceways less than 1 inch trade size at intervals no greater than 6 feet. Support such raceways 1 inch trade size or larger, at intervals no greater than 10 feet.
3. Minimum rod size shall be 1/4 inch in diameter.

D. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted or other support system, sized so capacity can be increased by at least 25 percent in future without exceeding specified design load limits.

1. Secure raceways and cables to these supports with two-bolt conduit clampers.

3.2 SUPPORT INSTALLATION

A. Comply with NECA 1 and NECA 101 for installation requirements except as specified in this article.

B. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb.

C. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise indicated by code:

1. To Wood: Fasten with lag screws or through bolts.
2. To New Concrete: Bolt to concrete inserts.
3. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
4. To Existing Concrete: Expansion anchor fasteners.
5. To Steel: Welded threaded studs complying with AWS D1.1/D1.1M, with lock washers and nuts.
6. To Light Steel: Sheet metal screws.
7. Items Mounted on Hollow Walls and Nonstructural Building Surfaces: Mount cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices on slotted-channel racks attached to substrate.

D. Drill holes for expansion anchors in concrete at locations and to depths that avoid the need for reinforcing bars.

END OF SECTION 260529

SECTION 260533 - RACEWAYS AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Metal conduits, tubing, and fittings.
2. Nonmetal conduits, tubing, and fittings.
3. Metal wireways and auxiliary gutters.
4. Nonmetal wireways and auxiliary gutters.
5. Surface raceways.
6. Boxes, enclosures, and cabinets.

1.2 DEFINITIONS

A. EMT: Electrical metallic tubing

B. FMC: Flexible metal conduit

C. GRC: Galvanized rigid steel conduit.

D. MC: Metal Clad Cable

E. LFMC: Liquid-tight flexible metal conduit

F. RNC: Rigid nonmetallic conduit

1.3 SUBMITTALS

A. Product Data: For surface raceways, wireways and fittings, floor boxes, hinged-cover enclosures, and cabinets.

B. Coordination Drawings: Conduit routing plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of items involved:

1. Structural members in paths of conduit groups with common supports.
2. HVAC and plumbing items and architectural features in paths of conduit groups with common supports.

PART 2 - PRODUCTS

2.1 METAL CONDUITS, TUBING, AND FITTINGS

A. Listing and Labeling: Metal conduits, tubing, and fittings shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. GRC: Comply with ANSI C80.1 and UL 6.

C. MC: Comply with UL 1569 and NEC article 330.

D. EMT: Comply with ANSI C80.3 and UL 797.

E. FMC: Comply with UL 1; single strip, continuous, flexible interlocked double-wrapped steel, galvanized inside and outside forming smooth internal wiring channel.

F. Metal Fittings: Comply with NEMA FB 1 and UL 514:

1. Conduit Fittings for Hazardous (Classified) Locations: Comply with UL 886 and NFPA 70.
2. Fittings for EMT:
   a. Set-screw type.
   b. In slab or concrete work, concrete tight fittings
3. All conduit bodies shall be NEMA 4x Rated with encapsulated stainless steel screws.
4. Fittings for LFMC: Body, gland and lock nut shall be steel of malleable iron. Ground cone shall be steel, sealing ring and insulator shall be blue molded thermoplastic at 150°C (221°F) maximum.
5. Fittings for GRC: Threaded rigid steel conduit fittings. Comply with NEMA FB 2.10.

G. Joint Compound for GRC: Approved, as defined in NFPA 70, by authorities having jurisdiction for use in conduit assemblies, and compounded for use to lubricate and protect threaded conduit joints from corrosion and to enhance their conductivity.

2.2 METAL WIREWAYS AND AUXILIARY GUTTERS

A. Description: Sheet metal, complying with UL 870 and NEMA 250, Type 1 unless otherwise indicated, and sized according to NFPA 70.

1. Metal wireways installed outdoors shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Fittings and Accessories: Include covers, couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.

C. Wireway Covers: Hinged cover secured with captive screws unless otherwise indicated.

D. Finish: Manufacturer's standard enamel finish NEMA 250 rated.

2.3 NONMETALLIC WIREWAYS AND AUXILIARY GUTTERS

A. Listing and Labeling: Nonmetallic wireways and auxiliary gutters shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Description: Fiberglass polyester, extruded and fabricated to required size and shape, without holes or knockouts. Cover shall be gasketed with oil-resistant gasket material and fastened with captive screws treated for corrosion resistance. Connections shall be flanged and have stainless-steel screws and oil-resistant gaskets.

C. Fittings and Accessories: Couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings shall match and mate with wireways as required for complete system.

D. Solvents and Adhesives: As recommended by conduit manufacturer.

2.4 SURFACE RACEWAYS

A. Listing and Labeling: Surface raceways and tele-power poles shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Surface Metal Raceways:
   1. Refer to drawings for location(s), type(s), and quantity(s) of surface metal raceway.
      a. Surface finish: be satin, anodized #204 type clear, Class R1 mil-Spec with minimum anodized finish of .004” unless otherwise noted.

2.5 BOXES, ENCLOSURES, AND CABINETS

A. General Requirements for Boxes, Enclosures, and Cabinets: Boxes, enclosures, and cabinets installed in wet locations shall be listed for use in wet locations.

B. Sheet Metal Outlet and Device Boxes: Comply with NEMA OS 1 and UL 514A.

C. Cast-Metal Outlet and Device Boxes: Comply with NEMA FB 1, ferrous alloy.

D. Nonmetallic Outlet and Device Boxes: Comply with NEMA OS 2 and UL 514C.

E. Luminaire Outlet Boxes: Nonadjustable, designed for attachment of luminaire weighing 50 lb. Outlet boxes designed for attachment of luminaires weighing more than 50 lb shall be listed and marked for the maximum allowable weight.

F. Paddle Fan Outlet Boxes: Nonadjustable, designed for attachment of paddle fan weighing 70 lb.

1. Listing and Labeling: Paddle fan outlet boxes shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

G. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.

H. Cast-Metal Access, Pull, and Junction Boxes: Comply with NEMA FB 1 and UL 1773, cast aluminum with gasketed cover.

I. Box extensions used to accommodate new building finishes shall be of same material as recessed box.

J. Device Box Dimensions: 4 inches square by 2-1/8 inches deep.

K. Gangable boxes are allowed.

L. Cabinets:

1. NEMA 250, Type 1 galvanized-steel box with removable interior panel and removable front, finished inside and out with manufacturer's standard enamel.
2. Hinged door in front cover with flush latch and concealed hinge.
3. Key latch to match panelboards.
4. Metal barriers to separate wiring of different systems and voltage.
5. Accessory feet where required for freestanding equipment.
6. Nonmetallic cabinets shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.6 MANUFACTURERS

A. Raceway and Fitting Manufacturers: subject to compliance with requirements, provide products by one of the following (no exceptions):

1. Wheatland Tube
2. Allied Tube & Conduit

3. Thomas & Betts
4. Hubbell
5. Legrand
6. Calbond
7. Plasti Bond
8. Western Tube and Conduit
9. Republic Conduit
10. Crouse-Hinds

B. Wireways, surface raceways, boxes, enclosure and cabinets Manufacturers: subject to compliance with requirements, provide products by one of the following (no exceptions):

1. Legrand
2. Hubbell
3. Thomas & Betts
4. Hoffman
5. OZ Gedney
6. Appleton Electric Company
7. Crouse-Hinds

PART 3 - EXECUTION

3.1 RACEWAY APPLICATION

A. The following application must be adhered to. Raceways installed that are not conforming to this listing must be removed and replace with specified material at no additional expense.

Raceway Types	Applications
Galvanized Rigid Steel Conduit (GRC)	Where exposed to mechanical injury, where specifically required; indoors where exposed to moisture; where required by codes and for all circuits in excess of 600 volts. Outdoor locations, sump and ejector pits, elevator pits, loading docks, garage, rooftops and gymnasium.
Electrical Metallic tubing (EMT)	Use in every instance except where another material is not specified.

Raceway Types	Applications
Metal Clad Cable (MC)	Lighting and receptacle branch circuits concealed in dry hollow spaces of a building. May not be used in areas where it would be subjected to physical damage, or where prohibited by Code.
Flexible Metal Conduit (FMC)	Use in dry areas for connections to lighting fixtures in hung ceilings, connections to equipment installed in removable panels of hung ceilings; at all transformer or equipment raceway connections where sound and vibration isolation is required.
Liquid-Tight Flexible Metal Conduit (LFMC)	Use in areas subject to moisture where flexible metal conduit is unacceptable, at connections to all motors, and all raised floor areas.
Rigid Non-Metallic Conduit (RNC)	Schedule 40 - Where raceways are in a slab below grade levels; for raceway duct banks. Schedule 80 - For underground raceways outside of the building which are not encased in concrete.
Wireways and Auxiliary Gutters	Where indicated on the Contract Documents and as otherwise specifically required.
Boxes and Enclosures	NEMA 250, Type 1, except use NEMA 250, Type 4 in kitchens and damp/or wet locations. Outdoors use NEMA 250, Type 3R.

B. Provide separate raceways for all wiring systems, including security, data, paging, low voltage et al. All 480Y/277 volt wiring must be kept independent of 208Y/120 volt wiring. Emergency system wiring must be kept independent of the normal system wiring. Provide grounding conductor within all circuits. Minimum size 3/4-inch for home runs and 1-inch minimum for power distribution. Wiring of each type and system must be installed in separate raceways.

C. Raceway Fittings: Compatible with raceways and suitable for use and location.

1. Rigid Galvanized Steel Conduit (GRC): Use threaded rigid steel conduit fittings. Comply with NEMA FB 2.10.
2. EMT: Use setscrew steel fittings. Comply with NEMA FB 2.10.
3. Flexible Conduit: Use only fittings listed for use with flexible conduit. Comply with NEMA FB 2.20.

D. Do not install aluminum conduits, boxes, or fittings in contact with concrete or earth.

E. Install surface raceways only where indicated on Drawings.

F. Do not install nonmetallic conduit where ambient temperature exceeds 120 deg F.

3.2 INSTALLATION

A. Comply with NECA 1 and NECA 101 for installation requirements except where requirements on Drawings or in this article are stricter. Comply with NFPA 70 limitations for types of raceways allowed in specific occupancies and number of floors.

B. Keep raceways at least 6 inches away from parallel runs of flues and steam or hot-water pipes. Install horizontal raceway runs above water and steam piping.

C. Complete raceway installation before starting conductor installation.

D. Install capped bushings on the raceways as soon as they are installed and remove only when cables are pulled. Securely tie embedded raceway in place prior to embedment.

E. Arrange stub-ups so curved portions of bends are not visible above finished slab. Raceways installed below or in floor slabs must extend a minimum of 4 inches above the finished slab to the first connector.

F. Conceal conduit within finished walls, ceilings, and floors unless otherwise indicated. Install conduits parallel or perpendicular to building lines.

G. Install exposed raceways parallel or at right angles with building lines.

H. Support conduit within 12 inches of enclosures to which attached.

I. Provide one (1) empty 3/4 inch raceway for each three (3) spare unused poles or spaces of each flush-mounted panelboard. Terminate empty 3/4 inch conduits in a junction box, which after completion is accessible to facilitate future branch circuit extension. Provide pull lines in each raceway.

J. Raceways in hung ceilings shall be installed on and secured to the slab or primary structural members of the ceiling, not to lathing channels or T-bars, Z-bars or other elements which are direct supports of the ceiling panels. Secure conduit firmly to the steel with clips and fittings designed for that purpose. Install as high as possible but not less than 1'-0" above the hung ceilings.

K. Raceways Embedded in Slabs:

1. Install no raceway in the concrete slab except with the permission of the Structural Engineer and written consent of the Owner.
2. Do not install raceways larger than 1-1/4 inch size in structural concrete slabs.
3. In no case will the installation of raceways be permitted to interfere with proper placement of principal reinforcement.
4. Place raceways in the structural slabs between the upper and lower layers of reinforcing steel. Careful bending of the conduits is required.
5. Space the raceways embedded in concrete slabs not less than eight (8) inches on centers and as widely spaced as possible where they converge at panels or junction boxes.
6. Install raceways running parallel to slabs supports, such as beams, columns and structural walls, not less than 12 inches from such supporting elements.
7. Secure saddle supports for conduit, outlet boxes, junction boxes, inserts, etc. with suitable adhesives during concrete pour of the slab to prevent displacement.
8. Arrange raceways to cross building expansion joints at right angles with expansion fittings.

L. Stub-ups to Above Recessed Ceilings:

1. Use EMT for raceways.
2. Use a conduit bushing or insulated fitting to terminate stub-ups not terminated in hubs or in an enclosure.

M. Threaded Conduit Joints, Exposed to Wet, Damp, Corrosive, or Outdoor Conditions: Apply listed compound to threads of raceway and fittings before making up joints. Follow compound manufacturer's written instructions.

N. Terminate threaded conduits into threaded hubs or with locknuts on inside and outside of boxes or cabinets. Install bushings on conduits up to 1-1/4-inch trade size and insulated throat metal bushings on 1-1/2-inch trade size and larger conduits terminated with locknuts. Install insulated throat metal grounding bushings on service conduits.

O. Install raceways square to the enclosure and terminate at enclosures with locknuts. Install locknuts hand tight plus 1/4 turn more.

P. Do not rely on locknuts to penetrate nonconductive coatings on enclosures. Remove coatings in the locknut area prior to assembling conduit to enclosure to assure a continuous ground path.

Q. Cut conduit perpendicular to the length. For conduits 2-inch trade size and larger, use roll cutter or a guide to make cut straight and perpendicular to the length.

R. Clear all raceways of all obstructions and dirt prior to pulling in cables. Use ball mandrel (diameter approximately 85% of the conduit inside diameter) followed by close fitting wire brush and wad of felt. This assembly may be pulled in together with, but ahead of any cable being installed. Clean all empty raceways similarly. Clear any raceway which rejects ball mandrel, then re-attempt mandrel application.

S. Install labeled pull wires in empty raceways. Use polypropylene or monofilament plastic line with not less than 200-lb tensile strength. Leave at least 5 feet of slack at each end of pull wire. Tag both ends of the cable denoting opposite and termination location with black India ink on flameproof linen tag. Cap underground raceways designated as spare above grade alongside raceways in use.

T. Surface Raceways:

1. Install surface raceway with a minimum 2-inch radius control at bend points.
2. Secure surface raceway with screws or other anchor-type devices at intervals not exceeding 48 inches and with no less than two supports per straight raceway section. Support surface raceway according to manufacturer's written instructions. Tape and glue are not acceptable support methods.

U. Install raceway sealing fittings at accessible locations according to NFPA 70 and fill them with listed sealing compound. For concealed raceways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install raceway sealing fittings according to NFPA 70.

V. Install devices to seal raceway interiors at accessible locations. Locate seals so no fittings or boxes are between the seal and the following changes of environments. Seal the interior of all raceways at the following points:

1. Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.
2. Where an underground service raceway enters a building or structure.
3. Where otherwise required by NFPA 70.

W. Comply with manufacturer's written instructions for solvent welding RNC and fittings.

X. Expansion-Joint Fittings:

1. Install in each run of aboveground RNC that is located where environmental temperature change may exceed 30 deg F and that has straight-run length that exceeds 25 feet. Install in each run of aboveground RMC and EMT conduit that is located where environmental temperature change may exceed 100 deg F and that has straight-run length that exceeds 100 feet.

2. Install type and quantity of fittings that accommodate temperature change listed for each of the following locations:
   a. Outdoor Locations Not Exposed to Direct Sunlight: 125 deg F temperature change.
   b. Outdoor Locations Exposed to Direct Sunlight: 155 deg F temperature change.
   c. Indoor Spaces Connected with Outdoors without Physical Separation: 125 deg F temperature change.
3. Install fitting(s) that provide expansion and contraction for at least 0.000078 inch per foot of length of straight run per deg F of temperature change for metal conduits.
4. Install expansion fittings at all locations where conduits cross building or structure expansion joints.
5. Install each expansion-joint fitting with position, mounting, and piston setting selected according to manufacturer's written instructions for conditions at specific location at time of installation. Install conduit supports to allow for expansion movement.
6. Provide necessary bonding conductor for each raceway expansion joint.

Y. Flexible Conduit Connections: Comply with NEMA RV 3. Use a maximum of 72 inches flexible conduit for recessed and semirecessed luminaires, equipment subject to vibration, noise transmission, or movement; and for transformers and motors.

1. Use LFMC in damp or wet locations subject to severe physical damage.
2. Use LFNC in damp or wet locations not subject to severe physical damage.

3.3 OUTLET, JUNCTION, AND PULL BOXES

A. Provide outlet, junction, and pull boxes as indicated on the Contract Documents and as required for the complete installation of the various electrical systems, and to facilitate proper pulling of the cables. Size the junction boxes and pull boxes per the NEC. Size the boxes on any empty conduit systems as if containing conductors of No.4 AWG.

B. The exact location of outlets and equipment is governed by the structural conditions and obstructions, or other equipment items. When necessary, relocate outlets so that when fixtures or equipment are installed, they will be symmetrically located according to the room layout and will not interfere with other work or equipment. Verify final location of outlets, panels equipment, etc., with the Architect prior to installation.

1. Back-to-back outlets in the same wall, or "thru-wall" type boxes are not permitted. Provide 12-inch minimum spacing for outlets shown on opposite sides of a common wall to minimize sound transmission.

2. Fit outlet boxes in finished ceilings or walls with appropriate covers, set flush with the finished surface. Where more than one (1) switch or device is located at one (1) point, use gang boxes and covers unless otherwise indicated. Sectional switch boxes or utility boxes are not permitted. Provide tile box or 4 inch square box with tile ring in masonry walls not plastered or furred. Where drywall material is utilized, provide plaster ring. Provide outlet boxes of type and size suitable for the specific application. Where outlet boxes contain two (2) or more 277 volt devices, or where devices occur of different applied voltages, or where normal and emergency devices occur in the same box, provide suitable barrier(s).
3. All outlet and device box depths shall have sufficient depth to prevent damage to the conductors when devices or utilization equipment are installed as intended in
4. Mount boxes at heights indicated on Drawings. If mounting heights of boxes are not individually indicated, give priority to ADA requirements. Install boxes with height measured to center of box unless otherwise indicated.
5. Recessed Boxes in Masonry Walls: Saw-cut opening for box in center of cell of masonry block, and install box flush with surface of wall. Prepare block surfaces to provide a flat surface for a raintight connection between box and cover plate or supported equipment and box.
6. Horizontally separate boxes mounted on opposite sides of walls so they are not in the same vertical channel.
7. Locate boxes so that cover or plate will not span different building finishes.
8. Support boxes of three gangs or more from more than one side by spanning two framing members or mounting on brackets specifically designed for the purpose.
9. Fasten junction and pull boxes to or support from building structure. Do not support boxes by conduits.
10. Types of Boxes and Fittings for Various Locations:

Location	Type
Outlet	Galvanized pressed steel
Outlet exposed to moisture or outdoors	Cast type conduit fitting
Splice	Galvanized pressed steel
Splice exposed to moisture or outdoors	Cast type conduit fitting or sheet metal (4½" x 5" x 3" minimum)
Pull or Junction	Cast type conduit fitting or sheet metal (4½" x 5" x 3" minimum)
Pull or Junction - Outdoors	Aluminum (4½" x 5" x 3" minimum)
Terminal	Sheet steel (6" x 6" x 3" minimum)

Location	Type
Terminal - Outdoors	Aluminum (6" x 6" x 3" minimum)

C. PULL BOX SPACING

1. Provide pull boxes so no individual conduit run contains more than the equivalent of four (4) quarter bends (360° total).
2. Conduit Sizes 1¼" and Larger:
   a. Provide boxes to prevent cable from being excessively twisted, stretched or flexed during installation.
   b. Provide boxes so that maximum pulling tensions do not exceed the cable manufacturer's recommendations.
   c. Provide support racks for boxes with multiple sets of conductors so that the conductors do not rest on any metal work inside the box.
3. Conduit Sizes 1 inch and Smaller, provide boxes at every (Maximum Distances):

Distance	Run Type
150 feet	straight runs
100 feet	runs with one (1) 90° bend or equivalent
75 feet	runs with two (2) 90° bends or equivalent
50 feet	runs with three (3) or (4) four 90° bends or equivalent.

4. Boxes shall be sized to permit pulling, racking and splicing of cables (if not indicated on the contract drawings). They shall be sized to avoid exceeding the manufacturer’s minimum bending radius recommendations for conductors.
5. Provide access for the removal and replacement of the conductors, splices and equipment.
6. Minimum distance of boxes in runs of 1-1/2 inch or larger conduit:
   a. Straight pulls: size length 8 times nominal diameter of the largest conduit.
   b. Angle or U-pulls: size such that the distance between the conduit entry and the opposite wall of box is 6 times the nominal diameter of the largest conduit.
7. Covers: fasten to the flange or framework of the box with machine bolts, machine screws threaded into tapered holes or sheet metal screws as required.
8. Identification labels for all pull, splice and junction boxes in main feeder and sub-feeder runs, shall indicate nominal system voltage:
   a. Apply labels after painting of any boxes, conduits, and surrounding areas are completed.

b. Clean surfaces before applying labels; clean aluminum surfaces with solvent wipe.
c. Apply labels on the cover and a minimum of 1 fixed side; 1 label visible from the floor where the boxes are installed exposed.

3.4 FIRESTOPPING

A. Install firestopping at penetrations of all fire-rated floor and wall assemblies, per the project specifications.

3.5 PROTECTION

A. Protect coatings, finishes, and cabinets from damage and deterioration.

1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.

END OF SECTION 260533

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SECTION 260553 - IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Color and legend requirements for raceways, conductors, and warning labels and signs.
2. Labels.
3. Tapes and stencils.
4. Tags.
5. Signs.
6. Cable ties.
7. Paint for identification.
8. Fasteners for labels and signs.

1.2 SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for electrical identification products.

B. Identification Schedule: For each piece of electrical equipment and electrical system components to be an index of nomenclature for electrical equipment and system components used in identification signs and labels. Use same designations indicated on Drawings.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Comply with ASME A13.1 and IEEE C2.

B. Comply with NFPA 70.

C. Comply with 29 CFR 1910.144 and 29 CFR 1910.145.

D. Comply with ANSI Z535.4 for safety signs and labels.

E. Comply with NFPA 70E requirements for arc-flash warning labels.

F. Adhesive-attached labeling materials, including label stocks, laminating adhesives, and inks used by label printers, shall comply with UL 969.

G. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes.

1. Temperature Change: 120 deg F, ambient; 180 deg F, material surfaces.

2.2 COLOR AND LEGEND REQUIREMENTS

A. Raceways and Cables Carrying Circuits at 600 V or Less:

1. Black letters on an orange field.
2. Legend: Indicate voltage and system or service type.

B. Color-Coding for Phase and Voltage-Level Identification, 600 V or Less: Use colors listed below for ungrounded service, feeder and branch-circuit conductors.

1. Color shall be factory applied.
2. Colors for 208/120-V Circuits:
    a. Phase A: Black.
    b. Phase B: Red.
    c. Phase C: Blue.
    d. Neutral: White.
3. Colors for 240-V Circuits:
    a. Phase A: Black.
    b. Phase B: Red.
    c. Neutral: White.
4. Colors for 480/277-V Circuits:
    a. Phase A: Brown.
    b. Phase B: Orange.
    c. Phase C: Yellow.
    d. Neutral: Gray.
5. Color for Equipment Grounds: Green.
6. Colors for Isolated Grounds: Green with yellow stripe.

C. Raceways and Cables Carrying Circuits at more Than 600 V:

1. Black letters on an orange field.
2. Legend: "DANGER – CONCEALED HIGH VOLTAGE WIRING."

D. Warning Label Colors:

1. Identify system voltage with black letters on an orange background.

E. Warning labels and signs shall include, but are not limited to, the following legends:

1. Multiple Power Source Warning: "DANGER - ELECTRICAL SHOCK HAZARD - EQUIPMENT HAS MULTIPLE POWER SOURCES."
2. Workspace Clearance Warning: "WARNING - OSHA REGULATION - AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR 36 INCHES."

F. Equipment Identification labels:

1. Black Letters on a white field unless otherwise noted.
2. Equipment supplied by the emergency system shall be white letters on a red field.

2.3 LABELS

A. Self-Adhesive Wraparound Labels: Preprinted, 3-mil-thick, polyester or vinyl flexible label with acrylic pressure-sensitive adhesive.

1. Self-Lamination: Clear; UV-, weather- and chemical-resistant; self-laminating, protective shield over the legend. Labels sized such that the clear shield overlaps the entire printed legend.
2. Marker for Labels: Machine-printed, permanent, waterproof, black ink recommended by printer manufacturer.

2.4 TAPES AND STENCILS

A. Marker Tapes: Vinyl or vinyl-cloth, self-adhesive wraparound type, with circuit identification legend machine printed by thermal transfer or equivalent process.

B. Self-Adhesive Vinyl Tape: Colored, heavy duty, waterproof, fade resistant; not less than 3 mils thick by 1 to 2 inches wide; compounded for outdoor use.

C. Underground-Line Warning Tape:

1. Tape:
   a. Recommended by manufacturer for the method of installation and suitable to identify and locate underground electrical and communications utility lines.
   b. Printing on tape shall be permanent and shall not be damaged by burial operations.

c. Tape material and ink shall be chemically inert and not subject to degradation when exposed to acids, alkalis, and other destructive substances commonly found in soils.

2. Color and Printing:
   a. Comply with ANSI Z535.1, ANSI Z535.2, ANSI Z535.3, ANSI Z535.4, and ANSI Z535.5.
   b. Inscriptions for Red-Colored Tapes: "ELECTRIC LINE, HIGH VOLTAGE".
   c. Inscriptions for Orange-Colored Tapes: "TELEPHONE CABLE, CATV CABLE, COMMUNICATIONS CABLE, OPTICAL FIBER CABLE".

D. Stenciled Legend: In nonfading, waterproof, black ink or paint. Minimum letter height shall be 1 inch.

2.5 TAGS

A. Nonmetallic Preprinted Tags: Polyethylene tags, 0.015-inch-thick, color-coded for phase and voltage level, with factory printed permanent designations; punched for use with self-locking cable tie fastener.

B. Write-on Tags:

1. Polyester Tags: 0.010-inch-thick, with corrosion-resistant grommet and cable tie for attachment.
2. Marker for Tags: Machine-printed, permanent, waterproof, black ink marker recommended by printer manufacturer.

2.6 SIGNS

A. Laminated Acrylic or Melamine Plastic Signs:

1. Engraved legend.
2. Thickness:
   a. For signs up to 20 sq. in., minimum 1/16 inch.
   b. For signs larger than 20 sq. in., 1/8 inch thick.
   c. Engraved legend with black letters on white face.
   d. Punched or drilled for mechanical fasteners with 1/4-inch grommets in corners for mounting.
   e. Framed with mitered acrylic molding and arranged for attachment at applicable equipment.

2.7 CABLE TIES

A. General-Purpose Cable Ties: Fungus inert, self-extinguishing, one piece, self-locking, and Type 6/6 nylon.

1. Minimum Width: 3/16 inch.
2. Tensile Strength at 73 Deg F according to ASTM D 638: 12,000 psi.
3. Temperature Range: Minus 40 to plus 185 deg F.
4. Color: Black, except where used for color-coding.

B. UV-Stabilized Cable Ties: Fungus inert, designed for continuous exposure to exterior sunlight, self-extinguishing, one piece, self-locking, and Type 6/6 nylon.

1. Minimum Width: 3/16 inch.
2. Tensile Strength at 73 Deg F according to ASTM D 638: 12,000 psi.
3. Temperature Range: Minus 40 to plus 185 deg F.
4. Color: Black.

C. Plenum-Rated Cable Ties: Self-extinguishing, UV stabilized, one piece, and self-locking.

1. Minimum Width: 3/16 inch.
2. Tensile Strength at 73 Deg F according to ASTM D 638: 7000 psi.
3. UL 94 Flame Rating: 94V-0.
4. Temperature Range: Minus 50 to plus 284 deg F.
5. Color: Black.

2.8 MISCELLANEOUS IDENTIFICATION PRODUCTS

A. Paint: Comply with requirements in painting Sections for paint materials and application requirements. Retain paint system applicable for surface material and location (exterior or interior).

B. Fasteners for Labels and Signs: Self-tapping, stainless-steel screws or stainless-steel machine screws with nuts and flat and lock washers.

PART 3 - EXECUTION

3.1 PREPARATION

A. Self-Adhesive Identification Products: Before applying electrical identification products, clean substrates of substances that could impair bond, using materials and methods recommended by manufacturer of identification product.

3.2 INSTALLATION

A. Verify and coordinate identification names, abbreviations, colors, and other features with requirements in other Sections requiring identification applications, Drawings, Shop Drawings, manufacturer's wiring diagrams, and operation and maintenance manual. Use consistent designations throughout Project.

B. Install identifying devices before installing acoustical ceilings and similar concealment.

C. Verify identity of each item before installing identification products.

D. Coordinate identification with Project Drawings, manufacturer's wiring diagrams, and operation and maintenance manual.

E. Apply identification devices to surfaces that require finish after completing finish work.

F. Install signs with approved legend to facilitate proper identification, operation, and maintenance of electrical systems and connected items.

G. Auxiliary Electrical Systems Conductor Identification: Identify field-installed alarm, control, and signal connections.

H. Emergency Operating Instruction Signs: Install instruction signs with white legend on a red background with minimum 3/8-inch-high letters for emergency instructions at equipment used for power transfer.

I. Elevated Components: Increase sizes of labels, signs, and letters to those appropriate for viewing from the floor.

J. Accessible Fittings for Raceways: Identify the covers of each junction and pull box of the following systems with the wiring system legend and system voltage. System legends shall be as follows:

1. "EMERGENCY POWER."
2. “POWER."
3. "FIRE ALARM."

K. Self-Adhesive Wraparound Labels: Secure tight to surface at a location with high visibility and accessibility.

L. Marker Tapes: Secure tight to surface at a location with high visibility and accessibility.

M. Self-Adhesive Vinyl Tape: Secure tight to surface at a location with high visibility and accessibility.

N. Nonmetallic Preprinted Tags:

1. Place in a location with high visibility and accessibility.

O. Laminated Acrylic or Melamine Plastic Signs:

1. Attach signs that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.
2. Unless otherwise indicated, provide a single line of text with 1/2-inch-high letters on 1-1/2-inch-high sign; where two lines of text are required, use labels 2 inches high.

P. Cable Ties: General purpose, for attaching tags, except as listed below:

1. Outdoors: UV-stabilized nylon.
2. In Spaces Handling Environmental Air: Plenum rated.

3.3 IDENTIFICATION SCHEDULE

A. Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment. Install access doors or panels to provide view of identifying devices.

B. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, pull points, and locations of high visibility. Identify by system and circuit designation.

C. Accessible Fittings for Raceways and Cables within Buildings: Identify the covers of each junction and pull box of the following systems with self-adhesive labels containing the wiring system legend and system voltage. System legends shall be as follows:

1. "EMERGENCY POWER."
2. "POWER."
3. "FIRE ALARM."

D. Power-Circuit Conductor Identification, 600 V or Less: For conductors in vaults, pull and junction boxes, manholes, and handholes, use nonmetallic preprinted cable tags to identify each conductor. Tags shall indicate the load served, type, and size of cable the overcurrent device protecting the cable.

E. Conductors to Be Extended in the Future: Attach write-on tags to conductors and list source.

F. Locations of Underground Lines: Underground-line warning tape for power, lighting, communication, and control wiring and optical-fiber cable.

G. Instructional Signs: Self-adhesive labels, including the color code for grounded and ungrounded conductors.

H. Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting: Self-adhesive labels.

1. Apply to exterior of door, cover, or other access.
2. For equipment with multiple power or control sources, apply to door or cover of equipment, including, but not limited to, the following:

    a. Power-transfer switches.
    b. Controls with external control power connections.
    c. Switchboards
    d. Switchgear

I. Operating Instruction Signs: Self-adhesive labels.

J. Emergency Operating Instruction Signs: Self-adhesive labels with white legend on a red background with minimum 3/8-inch high letters for emergency instructions at equipment used for power transfer.

K. Equipment Identification Labels:

1. Indoor Equipment: Engraved Backlite plates mounted with rivers or screws.

2. Outdoor Equipment: Laminated acrylic.

3. Panelboards: Typewritten directory of circuits in the location provided by panelboard manufacturer. Mount label at top of panel
    a. Include on directory of the panel the cable and raceway size of panel feeder and the feeder origination point.

4. Switchgear, Switchboards, substations, meter center, and motor controls center: furnish and install a master nameplate on each switchboard, substation, meter center and motor control center engraved with the equipment identification indicated on Contract Drawings. Mount at top of the incoming section.
    a. Provide on each main switch an identifying nameplate. Where multiple mains are employed each switch shall be numbered. Inscription shall be “Main Switch” or “Main Switch No. 1” et al.

5. Feeder switches in Switchboards, switchgear and motor control centers:
    a. One nameplate engraved with the load served, the size and type of cable and raceway used. Example:

        Panels LP-4, LP-5, LP-6
        4#500MCM-THWN-CU-3-1/2”C

6. Transformers: Provide nameplate that includes tag designation indicated on Contract Drawings for the transformer. Identify panelboards or equipment supplied by the secondary on nameplate label.

7. Enclosed disconnect switches and circuit breakers: nameplate engraved with equipment designation.

8. Variable-speed controllers and motor controllers: nameplate engraved with equipment designation. Coordinating final equipment names with mechanical contractor prior to fabrication.

9. Automatic Transfer Switches: Nameplate engraved with switch number, load served, feeder sizes and the sources of normal and generator power.

10. Generator control Panel: nameplate engraved with generator designation.

11. Lighting control panels: Provide nameplate similar to that of panelboards.

END OF SECTION 260553

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SECTION 262416 - PANELBOARDS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Lighting and appliance branch-circuit panelboards.

1.2 DEFINITIONS

A. ATS: Acceptance testing specification.

B. GFCI: Ground-fault circuit interrupter.

C. GFEP: Ground-fault equipment protection.

D. HID: High-intensity discharge.

E. MCCB: Molded-case circuit breaker.

F. SPD: Surge protective device.

G. VPR: Voltage protection rating.

1.3 SUBMITTALS

A. Product Data: For each type of panelboard.

1. Include materials, switching and overcurrent protective devices, SPDs, accessories, and components indicated.
2. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.

B. Shop Drawings: For each panelboard and related equipment.

1. Include dimensioned plans, elevations, sections, and details.
2. Show tabulations of installed devices with nameplates, conductor termination sizes, equipment features, and ratings.
3. Detail enclosure types including mounting and anchorage, environmental protection, knockouts, corner treatments, covers and doors, gaskets, hinges, and locks.
4. Detail bus configuration, current, and voltage ratings.
5. Short-circuit current rating of panelboards and overcurrent protective devices.

6. Include evidence of NRTL listing for SPD as installed in panelboard (where applicable).
7. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
8. Include wiring diagrams for power, signal, and control wiring.
9. Key interlock scheme drawing and sequence of operations.
10. Include time-current coordination curves for each type and rating of overcurrent protective device included in panelboards. Submit on translucent log-log graft paper; include selectable ranges for each type of overcurrent protective device. Include an Internet link for electronic access to downloadable PDF of the coordination curves.

C. Qualification Data: For testing agency.

D. Panelboard Schedules: For installation in panelboards. Submit final versions after load balancing.

E. Operation and Maintenance Data: For panelboards and components to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in other sections, include the following:
   a. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
   b. Time-current curves, including selectable ranges for each type of overcurrent protective device that allows adjustments.

1.4 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. Keys: Two spares for each type of panelboard cabinet lock.
2. Circuit Breakers Including GFCI and GFEP Types: Two spares for each panelboard.
3. Fuses for Fused Switches: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.
4. Fuses for Fused Power-Circuit Devices: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.

1.5 QUALITY ASSURANCE

A. Manufacturer Qualifications: ISO 9001 or 9002 certified.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Handle and prepare panelboards for installation according to NEMA PB 1.

1.7 FIELD CONDITIONS

A. Environmental Limitations:

1. Do not deliver or install panelboards until spaces are enclosed and weathertight, wet work in spaces is complete and dry, work above panelboards is complete, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.
2. Rate equipment for continuous operation under the following conditions unless otherwise indicated:
   a. Ambient Temperature: Not exceeding 23 deg F to plus 104 deg F.
   b. Altitude: Not exceeding 6600 feet.

B. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:

1. Notify Construction manager and Owner no fewer than five business days in advance of proposed interruption of electric service.
2. Do not proceed with interruption of electric service without Owner's written permission.
3. Comply with NFPA 70E.

1.8 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to repair or replace panelboards that fail in materials or workmanship within specified warranty period.

1. Panelboard Warranty Period: 18 months from the date of Substantial Completion.

B. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace SPD that fails in materials or workmanship within specified warranty period.

1. SPD Warranty Period: 3 years from the date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PANELBOARDS AND LOAD CENTERS COMMON REQUIREMENTS

A. Product Selection for Restricted Space: Drawings indicate maximum dimensions for panelboards including clearances between panelboards and adjacent surfaces and other items. Comply with indicated maximum dimensions.

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

C. Comply with NEMA PB 1.

D. Comply with NFPA 70.

E. Enclosures: Flush and Surface-mounted, dead-front cabinets.

1. Rated for environmental conditions at installed location.
   a. Indoor Dry and Clean Locations: NEMA 250, Type 1.
   b. Outdoor Locations: NEMA 250, Type 3R.
   c. Kitchen and Wash-Down Areas: NEMA 250, Type 4X, stainless steel.
   d. Other Wet or Damp Indoor Locations: NEMA 250, Type 4.
2. Height: 84 inches maximum.
3. Front: Secured to box with concealed trim clamps. For surface-mounted fronts, match box dimensions; for flush-mounted fronts, overlap box. Trims shall cover all live parts and shall have no exposed hardware.
4. Skirt for Surface-Mounted Panelboards: Same gage and finish as panelboard front with flanges for attachment to panelboard, wall and ceiling or floor.
5. Gutter Extension and Barrier: Same gage and finish as panelboard enclosure; integral with enclosure body. Arrange to isolate individual panel sections.
6. Finishes:
   a. Panels and Trim: Galvanized steel, factory finished immediately after cleaning and pretreating with manufacturer's standard two-coat, baked-on finish consisting of prime coat and thermosetting topcoat.
   b. Back Boxes: Galvanized steel.
   c. Fungus Proofing: Permanent fungicidal treatment for overcurrent protective devices and other components.

F. Incoming Mains:

1. Location: Convertible between top and bottom.
2. Main Breaker: Main lug interiors up to 400 amperes shall be field convertible to main breaker.

G. Phase, Neutral, and Ground Buses:

1. Material: Hard-drawn copper, 98 percent conductivity.
   a. Plating shall run entire length of bus.
   b. Bus shall be fully rated the entire length.

2. Interiors shall be factory assembled into a unit. Replacing switching and protective devices shall not disturb adjacent units or require removing the main bus connectors.

3. Equipment Ground Bus: Adequate for feeder and branch-circuit equipment grounding conductors; bonded to box.
4. Full-Sized Neutral: Equipped with full-capacity bonding strap for service entrance applications. Mount electrically isolated from enclosure. Do not mount neutral bus in gutter.

H. Conductor Connectors: Suitable for use with conductor material and sizes.

1. Material: Hard-drawn copper, 98 percent conductivity.
2. Terminations shall allow use of 75 deg C rated conductors without derating.
3. Size: Lugs suitable for indicated conductor sizes, with additional gutter space, if required, for larger conductors.
4. Main and Neutral Lugs: Mechanical type, with a lug on the neutral bar for each pole in the panelboard.
5. Ground Lugs and Bus-Configured Terminators: Mechanical type, with a lug on the bar for each pole in the panelboard.
6. Feed-Through Lugs: Mechanical type, suitable for use with conductor material. Locate at opposite end of bus from incoming lugs or main device.
7. Subfeed (Double) Lugs: Mechanical type suitable for use with conductor material. Locate on load side of main device unless otherwise noted on plans.
8. Gutter-Tap Lugs: Mechanical type suitable for use with conductor material and with matching insulating covers. Locate at same end of bus as incoming lugs or main device.

I. NRTL Label: Panelboards shall be labeled by an NRTL acceptable to authority having jurisdiction for use as service equipment with one or more main service disconnecting and overcurrent protective devices. Panelboards or load centers shall have meter enclosures, wiring, connections, and other provisions for utility metering. Coordinate with utility company for exact requirements.

J. Future Devices: Panelboards or load centers shall have mounting brackets, bus connections, filler plates, and necessary appurtenances required for future installation of devices.

1. Percentage of Future Space Capacity: 20 percent or what is shown on contract drawings (whichever value is greater).

K. Panelboard Short-Circuit Current Rating: Fully rated to interrupt symmetrical short-circuit current available at terminals. Assembly listed by an NRTL for 100 percent interrupting capacity.

1. Panelboards and overcurrent protective devices rated 240 V or less shall have short-circuit ratings as shown on Drawings, but not less than 10,000 A rms symmetrical.

2. Panelboards and overcurrent protective devices rated above 240 V and less than 600 V shall have short-circuit ratings as shown on Drawings, but not less than 14,000 A rms symmetrical.

2.2 PERFORMANCE REQUIREMENTS

A. Surge Suppression: Factory installed as an integral part of indicated panelboards, complying with UL 1449 SPD Type 1 or Type 2.

2.3 LIGHTING AND APPLIANCE BRANCH-CIRCUIT PANELBOARDS

A. Approved manufacturers:
1. Eaton
2. Square D
3. Siemens
4. General Electric

B. Panelboards: NEMA PB 1, lighting and appliance branch-circuit type.

C. Mains: Circuit breaker or lugs only.

D. Branch Overcurrent Protective Devices: Bolt-on circuit breakers, replaceable without disturbing adjacent units.

E. Doors: Door-in-door construction with concealed hinges; secured with multipoint latch with tumbler lock; keyed alike. Outer door shall permit full access to the panel interior. Inner door shall permit access to breaker operating handles and labeling, but current carrying terminals and bus shall remain concealed.

2.4 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

A. MCCB: Comply with UL 489, with interrupting capacity to meet available fault currents.

1. Electronic Trip Circuit Breakers:

a. 100 percent rated
b. RMS sensing.
c. Field-replaceable rating plug or electronic trip.
d. Digital display of settings, trip targets, and indicated metering displays.
e. Multi-button keypad to access programmable functions and monitored data.
f. Ten-event, trip-history log. Each trip event shall be recorded with type, phase, and magnitude of fault that caused the trip.
g. Integral test jack for connection to portable test set or laptop computer.
h. Field-Adjustable Settings:

1) Instantaneous trip.
2) Long- and short-time pickup levels.
3) Long and short time adjustments.
4) Ground-fault pickup level, time delay, and I squared T response.

2. GFCI Circuit Breakers: Single- and double-pole configurations with Class A ground-fault protection (6-mA trip).
3. GFEP Circuit Breakers: Class B ground-fault protection (30-mA trip).
4. Arc-Fault Circuit Interrupter Circuit Breakers: Comply with UL 1699; 120/240-V, single-pole configuration.
5. Subfeed Circuit Breakers: Vertically mounted.
6. MCCB Features and Accessories:
   a. Standard frame sizes, trip ratings, and number of poles.
   b. Breaker handle indicates tripped status.
   c. UL listed for reverse connection without restrictive line or load ratings.
   d. Lugs: Mechanical style, suitable for number, size, trip ratings, and conductor materials.
   e. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and HID lighting circuits.
   f. Ground-Fault Protection: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
   g. Communication Capability: Circuit-breaker-mounted or integral communication module with functions and features compatible with power monitoring and control system.
   h. Shunt Trip: 120-V trip coil energized from separate circuit, set to trip at 55 percent of rated voltage.
   i. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage with field-adjustable 0.1- to 0.6-second time delay.
   j. Rating Plugs: Three-pole breakers with ampere ratings greater than 150 amperes shall have interchangeable rating plugs or electronic adjustable trip units.
   k. Alarm Switch: Single-pole, normally open contact that actuates only when circuit breaker trips.
   l. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.
   m. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function with other upstream or downstream devices.
   n. Multipole units enclosed in a single housing with a single handle or factory assembled to operate as a single unit.
   o. Handle Padlocking Device: Fixed attachment, for locking circuit-breaker handle in off position.

2.5 IDENTIFICATION

A. Panelboard Label: Manufacturer's name and trademark, voltage, amperage, number of phases, and number of poles shall be located on the interior of the panelboard door.

B. Breaker Labels: Faceplate shall list current rating, UL and IEC certification standards, and AIC rating.

C. Circuit Directory: Computer-generated circuit directory mounted inside panelboard door with transparent plastic protective cover.

1. Circuit directory shall identify specific purpose with detail sufficient to distinguish it from all other circuits.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify actual conditions with field measurements prior to ordering panelboards to verify that equipment fits in allocated space in, and comply with, minimum required clearances specified in NFPA 70.

B. Receive, inspect, handle, and store panelboards according to NEMA PB 1.1.

C. Examine panelboards before installation. Reject panelboards that are damaged, rusted, or have been subjected to water saturation.

D. Examine elements and surfaces to receive panelboards for compliance with installation tolerances and other conditions affecting performance of the Work.

E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Coordinate layout and installation of panelboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Comply with NECA 1.

C. Install panelboards and accessories according to NEMA PB 1.1.

D. Equipment Mounting:

1. Attach panelboard to the vertical finished or structural surface behind the panelboard.

E. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from panelboards.

F. Mount top of trim at a height so that the operating handle of the top-most switch or circuit breaker, in ON position, is not higher than 79 inches (2000 mm) above finished floor or grade, unless otherwise indicated.

G. Mount panelboard cabinet plumb and rigid without distortion of box.

H. Mount recessed panelboards with fronts uniformly flush with wall finish and mating with back box.

I. Mount surface-mounted panelboards to steel slotted supports 5/8 inch in depth. Orient steel slotted supports vertically.

J. Install overcurrent protective devices and controllers not already factory installed.

1. Set field-adjustable, circuit-breaker trip ranges.
2. Tighten bolted connections and circuit breaker connections using calibrated torque wrench or torque screwdriver per manufacturer's written instructions.

K. Make grounding connections and bond neutral for services and separately derived systems to ground. Make connections to grounding electrodes, separate grounds for isolated ground bars, and connections to separate ground bars.

L. Install filler plates in unused spaces.

M. Stub four 1-inch empty conduits from recessed mounted panelboard into accessible ceiling space or space designated to be ceiling space in the future. Stub four 1-inch empty conduits into raised floor space or below slab not on grade.

N. Arrange conductors in gutters into groups and bundle and wrap with wire ties after completing load balancing.

3.3 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with the project specification requirements for identification.

B. Create a directory to indicate installed circuit loads after balancing panelboard loads; incorporate Owner's final room designations. Obtain approval before installing. Handwritten directories are not acceptable. Install directory inside panelboard door.

C. Panelboard Nameplates: Label each panelboard with a nameplate complying with the project specifications.

D. Device Nameplates: Label each branch circuit device in power panelboards with a nameplate complying with the project specifications.

E. Install warning signs complying with requirements of the project specifications.

3.4 FIELD QUALITY CONTROL

A. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

B. Acceptance Testing Preparation:

1. Test insulation resistance for each panelboard bus, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.

C. Tests and Inspections:

1. Perform each visual and mechanical inspection and electrical test for low-voltage air circuit breakers and low-voltage surge arrestors stated in NETA ATS, Paragraph 7.6 Circuit Breakers and Paragraph 7.19.1 Surge Arrestors, Low-Voltage. Do not perform optional tests. Certify compliance with test parameters.
2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
3. Perform the following infrared scan tests and inspections and prepare reports:
    a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each panelboard. Remove front panels so joints and connections are accessible to portable scanner.

        1) Use an infrared scanning device to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

D. Panelboards will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports, including a certified report that identifies panelboards included and that describes scanning results, with comparisons of the two scans. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.5 ADJUSTING

A. Adjust moving parts and operable components to function smoothly, and lubricate as recommended by manufacturer.

B. Load Balancing: After Substantial Completion, but not more than 60 days after Final Acceptance, measure load balancing and make circuit changes. Prior to making circuit changes to achieve load balancing, inform Engineer of effect on phase color coding.

1. Measure loads during period of normal facility operations.
2. Perform circuit changes to achieve load balancing outside normal facility operation schedule or at times directed by the Owner.
3. After changing circuits to achieve load balancing, recheck loads during normal facility operations. Record load readings before and after changing circuits to achieve load balancing.
4. Tolerance: Maximum difference between phase loads, within a panelboard, shall not exceed 20 percent.
5. Update panelboard directories accordingly, and provide updated directories to Owner within five business days of load balancing.

3.6 PROTECTION

A. Temporary Heating: Prior to energizing panelboards, apply temporary heat to maintain temperature according to manufacturer's written instructions.

END OF SECTION 262416

SECTION 262726 - WIRING DEVICES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Standard-Grade receptacles.
2. GFCI receptacles.
3. Toggle switches.
4. Wall plates.
5. Floor Service Fittings

1.2 SUBMITTALS

A. Product Data: For each type of product. Highlight exact model being proposed in each submittal

1.3 WARRANTY

A. Provide five (5) year manufacturer's warranty on all components.

PART 2 - PRODUCTS

2.1 GENERAL WIRING-DEVICE REQUIREMENTS

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

B. Comply with NFPA 70.

C. Devices for Owner-Furnished Equipment:

1. Receptacles: Match plug configurations.

D. Source Limitations: Obtain each type of wiring device and associated wall plate from single source from single manufacturer.

2.2 STANDARD-GRADE RECEPTACLES

A. Simplex or Duplex Receptacles: 125 V, 20 A:

1. Description: Two pole, three wire, and self-grounding.
2. Configuration: NEMA WD 6, Configuration 5-20R.
3. Standards: Comply with NEMA WD 1, UL498, and FS W-C-596.

B. Weather-Resistant Duplex Receptacles: 125 V, 20 A:

1. Description: Two pole, three wire, and self-grounding. Integral shutters that operate only when a plug is inserted in the receptacle. Square face.
2. Configuration: NEMA WD 6, Configuration 5-20R.
3. Standards: Comply with NEMA WD 1, UL498.
4. Marking: Listed and labeled as complying with NFPA 70, “Receptacles in Damp or Wet Locations” Article.

2.3 GFCI RECEPTACLES

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

1. Description: Integral GFCI with “Test” and “Reset” buttons. Two pole, three wire, and self-grounding, Feed Through type.
2. Include indicator light that shows when the GFCI has malfunctioned and no longer provides proper GFCI protection.
3. GFCI shall interrupt ground leak currents between 4-6 mA with a tripping time of .025 seconds.
4. Configuration: NEMA WD 6, Configuration 5-20R.
5. Standards: Comply with NEMA WD 1, UL498, UL 943 Class A, and FS W-C-596.

2.4 TOGGLE SWITCHES

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

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

C. Key-Operated Switches: 120/277 V, 20 A.

1. Description: Single pole, with factory-supplied key in lieu of switch handle.

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

E. Key-Operated, Single-Pole, Double-Throw, Momentary-Contact, Center-off Switches: 120/277 V, 20 A; for use with mechanically held lighting contactors, with factory-supplied key in lieu of switch handle.

2.5 WALL PLATES

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

1. Plate-Securing Screws: Metal with head color to match plate finish.
2. Material for Finished Spaces: As selected by the Architect.
3. Material for Unfinished Spaces: Galvanized steel.
4. Material for Damp Locations: Cast aluminum with spring-loaded lift gasketed cover, and listed and labeled for use in wet and damp locations (Mechanical rooms, pool rooms, garages etc).

B. Wet-Location, Weatherproof Cover Plates: NEMA 250, complying with Type 3R, weather-resistant, die-cast aluminum with lockable cover.

2.6 FLOOR SERVICE FITTINGS

A. Type: Modular, flush-type or flap-type, dual-service units suitable for wiring method used.

B. Compartments: Barrier separates power from voice and data communication cabling.

C. Service Plate: Rectangular, die-cast aluminum with satin finish.

D. Power Receptacle: NEMA WD 6 Configuration 5-20R, gray finish, unless otherwise indicated.

E. Data Communication Outlet: Blank cover with bushed cable opening.

2.7 DEVICE FINISHES

A. Device Color:

1. All normal Wiring Devices: As selected by Architect unless otherwise indicated.
2. Receptacles Connected to Emergency Power System: Red.
3. Isolated-Ground Receptacles: Orange.

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

1. Pass & Seymour/Legrand.

2. Hubbell
3. Leviton
4. Eaton

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with NECA 1, including mounting heights listed in that standard, unless otherwise indicated. See table below for refence.

TYPICAL MOUNTING HEIGHTS	
DEVICE	**MOUNTING HEIGHT**
Wall switches, card readers	48 inches above finished floor to center
Receptacle outlets, data outlets, CATV outlets	18 inches above finished floor to center
Receptacle outlets – above counter	42 inches above finished floor to center, or 8 inches to center above countertops
Wall telephone outlets	48 inches above finished floor to center
Clock outlets	96 inches above finished floor to center, or 6 inches below ceiling. Above doors, centered between door trim and ceiling

B. Coordination with Other Trades:

1. Protect installed devices and their boxes. Do not place wall finish materials over device boxes and do not cut holes for boxes with routers that are guided by riding against outside of boxes.
2. Keep outlet boxes free of plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other material that may contaminate the raceway system, conductors, and cables.
3. Install device boxes in brick or block walls so that the cover plate does not cross a joint unless the joint is troweled flush with the face of the wall.
4. Install wiring devices after all wall preparation, including painting, is complete.

C. Conductors:

1. Do not strip insulation from conductors until right before they are spliced or terminated on devices.
2. Strip insulation evenly around the conductor using tools designed for the purpose. Avoid scoring or nicking of solid wire or cutting strands from stranded wire.
3. The length of free conductors at outlets for devices shall meet provisions of NFPA 70, Article 300, without pigtails.
4. Existing Conductors:
    a. Cut back and pigtail, or replace all damaged conductors.
    b. Straighten conductors that remain and remove corrosion and foreign matter.
    c. Pigtailing existing conductors is permitted, provided the outlet box is large enough.

D. Device Installation:

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

E. Receptacle Orientation:

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

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

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

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

I. Switch Installation:

1. Install all switches vertically with the "ON" position on top, unless otherwise noted or specified.
2. Where switches are indicated near doors, corner walls, etc. install not less than two (2) inches and not more than twelve (12) inches from the trim.
3. Carefully coordinate location of switches to insure locations are at the strike side of the doors.

3.2 GFCI RECEPTACLES

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

B. Swab all conduits and outlet boxes clear of moisture.

C. Do not combine GFCI protected circuits with other circuits in the same raceway: only one (1) GFCI circuit per raceway.

D. Do not substitute GFCI circuit breakers for GFCI receptacles.

E. All GFCI receptacles shall be installed in a ready accessible location per the NEC.

3.3 IDENTIFICATION

A. Identify each receptacle with panelboard identification and circuit number. Use hot, stamped, or engraved machine printing with black-filled lettering on face of plate, and durable wire markers or tags inside outlet boxes.

3.4 FIELD QUALITY CONTROL

A. Test Instruments: Use instruments that comply with UL 1436.

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

C. Tests for Receptacles:

1. Line Voltage: Acceptable range is 105 to 132 V.

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

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

3.5 SPARE PARTS

A. Provide Five (5) spare devices for each type used on the project. Turn over to owner after project completion.

END OF SECTION 262726

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SECTION 262816 - ENCLOSED SWITCHES AND CIRCUIT BREAKERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Fusible switches.
2. Nonfusible switches.
3. Shunt trip switches.
4. Molded-case circuit breakers (MCCBs).
5. Enclosures.

1.2 SUBMITTALS

A. Product Data: For each type of enclosed switch, circuit breaker, accessory, and component indicated. Include nameplate ratings, dimensioned elevations, sections, weights, and manufacturers' technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.

1. Enclosure types and details for types other than NEMA 250, Type 1.
2. Current and voltage ratings.
3. Short-circuit current ratings (interrupting and withstand, as appropriate).
4. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices, accessories, and auxiliary components.
5. Include time-current coordination curves (average melt) for each type and rating of overcurrent protective device; include selectable ranges for each type of overcurrent protective device. Provide in PDF electronic format.

B. Shop Drawings: For enclosed switches and circuit breakers.

1. Include plans, elevations, sections, details, and attachments to other work.
2. Include wiring diagrams for power, signal, and control wiring.

1.3 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. Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.

2. Fuse Pullers: Two for each size and type.

1.4 FIELD CONDITIONS

A. Environmental Limitations: Rate equipment for continuous operation under the following conditions unless otherwise indicated:

1. Ambient Temperature: Not less than minus 22 deg F and not exceeding 104 deg F.
2. Altitude: Not exceeding 6600 feet.

1.5 WARRANTY

A. Manufacturer's Warranty: Manufacturer and Installer agree to repair or replace components that fail in materials or workmanship within specified warranty period.

1. Warranty period: 2 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS

A. Approved manufacturers:
1. Eaton
2. Square D
3. Siemens
4. General Electric

B. Source Limitations: Obtain enclosed switches and circuit breakers, overcurrent protective devices, components, and accessories, within same product category, from single manufacturer.

C. Product Selection for Restricted Space: Drawings indicate maximum dimensions for enclosed switches and circuit breakers, including clearances between enclosures, and adjacent surfaces and other items. Comply with indicated maximum dimensions.

D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.

E. Comply with NFPA 70.

2.2 FUSIBLE SWITCHES

A. Manufacturer shall be the same as the switchboards and panelboards.

B. Type HD, Heavy Duty:

1. Single throw.
2. Three or six pole. Provide six pole for connection to motors requiring six motor leads.
3. 600-V ac.
4. UL 98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate specified fuses.
5. Lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.
6. Amperage rating as indicated on the drawings.

C. Accessories:

1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper neutral conductors.
3. Class R Fuse Kit: Provides rejection of other fuse types when Class R fuses are specified.
4. Lugs: Mechanical type, suitable for number, size, and copper conductors.
5. Service-Rated Switches: Labeled for use as service equipment.

2.3 NONFUSIBLE SWITCHES

A. Manufacturer shall be the same as the switchboards and panelboards.

B. Type HD, Heavy Duty, Three Pole, Single Throw, 600-V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

C. Type HD, Heavy Duty, Six Pole, Single Throw, 600-V ac, 200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position. Provide six pole switch for connection to motors requiring six motor leads.

D. Refer to drawings for amperage rating of switch(es).

E. Accessories:

1. Equipment Ground Kit: Internally mounted and labeled for copper ground conductors.
2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and neutral conductors.
3. Class R Fuse Kit: Provides rejection of other fuse types when Class R fuses are specified.
4. Lugs: Mechanical type, suitable for number, size, and copper conductors.
5. Service-Rated Switches: Labeled for use as service equipment.

2.4 SHUNT TRIP SWITCHES

A. General Requirements: Comply with ASME A17.1, UL 50, and UL 98, with Class J fuse block and 200-kA interrupting and short-circuit current rating.

B. Type HD, Heavy-Duty, Nonfusible or fusible Switches:

1. Single throw.
2. Three pole.
3. 600-V ac.
4. UL 98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate specified fuses.
5. Integral shunt trip mechanism
6. Lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.
7. Amperage rating and type as indicated on the drawings.

C. Control Circuit: 120-V ac; obtained from integral control power transformer, with primary and secondary fuses, with a control power transformer of enough capacity to operate shunt trip, pilot, indicating and control devices.

2.5 MOLDED-CASE CIRCUIT BREAKERS

A. Manufacturer shall be the same as the switchboards and panelboards.

B. Circuit breakers shall be constructed using glass-reinforced insulating material. Current carrying components shall be completely isolated from the handle and the accessory mounting area.

C. Circuit breakers shall have a toggle operating mechanism with common tripping of all poles, which provides quick-make, quick-break contact action. The circuit-breaker handle shall be over center, be trip free, and reside in a tripped position between on and off to provide local trip indication. Circuit-breaker escutcheon shall be clearly marked on and off in addition to providing international I/O markings. Equip circuit breaker with a push-to-trip button, located on the face of the circuit breaker to

mechanically operate the circuit-breaker tripping mechanism for maintenance and testing purposes.

D. The maximum ampere rating and UL, IEC, or other certification standards with applicable voltage systems and corresponding interrupting ratings shall be clearly marked on face of circuit breaker. Circuit breakers shall be 100 percent rated.

E. MCCBs shall be equipped with a device for locking in the isolated position.

F. Lugs shall be suitable for 194 deg F rated wire, sized according to the 167 deg F (75 deg C) temperature rating in NFPA 70.

G. Standards: Comply with UL 489 and NEMA AB 3, with interrupting capacity to comply with available fault currents.

H. Thermal-Magnetic Circuit Breakers: Inverse time-current thermal element for low-level overloads and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.

I. Adjustable, Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.

J. Electronic Trip Circuit Breakers: Field-replaceable rating plug, rms sensing, with the following field-adjustable settings:

1. Instantaneous trip.
2. Long- and short-time pickup levels.
3. Long- and short-time time adjustments.
4. Ground-fault pickup level, time delay, and I-squared t response.

K. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller, and let-through ratings less than NEMA FU 1, RK-5.

L. Ground-Fault Equipment-Protection (GFEP) Circuit Breakers: With Class B ground-fault protection (30-mA trip).

M. Features and Accessories:

1. Standard frame sizes, trip ratings, and number of poles.
2. Lugs: Mechanical type, suitable for number, size, trip ratings, and conductor material.
3. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge lighting circuits.

4. Ground-Fault Protection: Comply with UL 1053; integrally mounted, self-powered type with mechanical ground-fault indicator; relay with adjustable pickup and time-delay settings, push-to-test feature, internal memory, and shunt trip unit; and three-phase, zero-sequence current transformer/sensor.
5. Shunt Trip: Trip coil energized from separate circuit, with coil-clearing contact.
6. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.
7. Alarm Switch: One NO/NC contact that operates only when circuit breaker has tripped.
8. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.
9. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function.

2.6 ENCLOSURES

A. Enclosed Switches and Circuit Breakers: UL 489, NEMA KS 1, NEMA 250, and UL 50, to comply with environmental conditions at installed location.

B. Enclosure Finish: The enclosure shall be finished with gray baked enamel paint, electrodeposited on cleaned, phosphatized steel (NEMA 250 Type 1) gray baked enamel paint, electrodeposited on cleaned, phosphatized galvannealed steel (NEMA 250 Types 3R, 12) a brush finish on Type 304 stainless steel (NEMA 250 Type 4-4X stainless steel).

C. Conduit Entry: NEMA 250 Types 4, 4X, and 12 enclosures shall contain no knockouts. NEMA 250 Types 7 and 9 enclosures shall be provided with threaded conduit openings in both endwalls.

D. Enclosures designated as NEMA 250 Type 4, 4X stainless steel, 12, or 12K shall have a dual cover interlock mechanism to prevent unintentional opening of the enclosure cover when the circuit breaker is ON and to prevent turning the circuit breaker ON when the enclosure cover is open.

E. NEMA 250 Type 7/9 enclosures shall be furnished with a breather and drain kit to allow their use in outdoor and wet location applications.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine elements and surfaces to receive enclosed switches and circuit breakers for compliance with installation tolerances and other conditions affecting performance of the Work.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

1. Commencement of work shall indicate Installer's acceptance of the areas and conditions as satisfactory.

3.2 PREPARATION

3.3 ENCLOSURE ENVIRONMENTAL RATING APPLICATIONS

A. Enclosed Switches and Circuit Breakers: Provide enclosures at installed locations with the following environmental ratings.

1. Indoor, Dry and Clean Locations: NEMA 250, Type 1.
2. Outdoor Locations: NEMA 250, Type 3R.
3. Kitchen and Wash-Down Areas: NEMA 250, Type 4X, stainless steel.
4. Other Wet or Damp, Indoor Locations: NEMA 250, Type 4.
5. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: NEMA 250, Type 12.

3.4 INSTALLATION

A. Coordinate layout and installation of switches, circuit breakers, and components with equipment served and adjacent surfaces. Maintain code required workspace clearances and required clearances for equipment access doors and panels, regardless of location indicated on the drawings.

B. Install individual wall-mounted switches and circuit breakers with tops at uniform height unless otherwise indicated.

C. Temporary Lifting Provisions: Remove temporary lifting of eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

D. Install fuses in fusible devices.

E. Comply with NFPA 70 and NECA 1.

3.5 IDENTIFICATION

A. Comply with requirements in Section 260553 "Identification for Electrical Systems."

1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
2. Label each enclosure with engraved metal or laminated-plastic nameplate.

3.6 ADJUSTING

A. Adjust moving parts and operable components to function smoothly, and lubricate as recommended by manufacturer.

END OF SECTION 262816

SECTION 263323 - CENTRAL BATTERY EQUIPMENT

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Standard-transfer interruptible power supply (IPS) centralized emergency lighting inverters.

1.2 REFERENCE STANDARDS

A. IEEE C62.41.2 - IEEE Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and less) AC Power Circuits; 2002 (Corrigendum 2012).

B. NEMA EN 10250 - Enclosures for Electrical Equipment (1000 Volts Maximum); 2024.

C. NETA ATS - Standard for Acceptance Testing Specifications for Electrical Power Equipment And Systems; 2025.

D. NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.

E. NFPA 101 - Life Safety Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.

F. NFPA 111 - Standard on Stored Electrical Energy Emergency and Standby Power Systems; 2025.

G. UL 924 - Emergency Lighting and Power Equipment; Current Edition, Including All Revisions.

H. UL 2043 - Fire Test for Heat and Visible Smoke Release for Discrete Products and Their Accessories Installed in Air-Handling Spaces; Current Edition, Including All Revisions.

1.3 ADMINISTRATIVE REQUIREMENTS

A. Coordination:

1. Coordinate compatibility of centralized emergency lighting inverters to be installed with work provided under other sections or by others.
   a. Luminaires: See Section .
2. 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.

3. Coordinate arrangement of electrical equipment with the dimensions and clearance requirements of the actual equipment to be installed.
4. Coordinate the work with placement of supports, anchors, etc. required for mounting.

B. Where work of this section involves interruption of power to existing emergency lighting, arrange power interruption with Owner.

1.4 SUBMITTALS

A. Product Data: Provide manufacturer's standard catalog pages and data sheets for each product, including ratings, configurations, dimensions, finishes, weights, service condition requirements, and installed features.

1. Where applicable, include characteristic trip curves for overcurrent protective devices.
2. Indicate any inverter load restrictions.

B. Shop Drawings: Indicate dimensions, input/output voltages, power ratings, overcurrent protective device arrangement and sizes, short circuit current ratings, conduit entry locations, and installed features and accessories.

1. Include wiring diagrams showing all factory and field connections.

C. Derating Calculations: Indicate ratings adjusted for applicable service conditions and/or inverter load restrictions.

D. Specimen Warranty: Submit sample of manufacturer's warranty.

E. Evidence of qualifications for manufacturer.

F. Evidence of qualifications for installer.

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, installation, and operation of product.

H. Manufacturer's certification that products meet or exceed specified requirements.

I. Source quality control test reports.

J. Manufacturer’s detailed field testing procedures.

K. Field quality control test reports.

L. Operation and Maintenance Data: Include detailed information on system operation, equipment programming and setup, replacement parts, and recommended maintenance procedures and intervals.

M. Executed Warranty: Submit documentation of final executed warranty completed in Owner's name and registered with manufacturer.

N. Project Record Documents: Record actual locations of system components, installed circuiting arrangements and routing, and final equipment settings.

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

1. Enclosure Keys: of each different key.
2. Battery Fuses: See Section for requirements for spare fuses and spare fuse cabinets.

1.5 QUALITY ASSURANCE

A. Comply with the following:

1. NFPA 70 (National Electrical Code).
2. NFPA 101 (Life Safety Code).
3. NFPA 111.

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 years experience.

D. Installer Qualifications: Company with minimum years experience with centralized emergency lighting inverter systems of similar size, type, and complexity.

1.6 DELIVERY, STORAGE, AND HANDLING

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

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 instructions to avoid damage to inverter system components, enclosure, and finish.

D. Do not exceed maximum ambient temperature requirements for batteries at any time, which reduces battery service life. Replace batteries exposed to temperatures in excess of manufacturer's requirements.

1.7 FIELD CONDITIONS

A. Maintain field conditions within manufacturer's required service conditions during and after installation.

1.8 WARRANTY

A. Inverter Assemblies: Provide minimum year manufacturer warranty covering repair or replacement due to defective materials or workmanship.

B. Batteries: Provide pro-rata warranty for the duration of rated design life.

PART 2 PRODUCTS

2.1 CENTRALIZED EMERGENCY LIGHTING INVERTERS - GENERAL REQUIREMENTS

A. Provide complete centralized emergency lighting inverter system consisting of all required equipment, conduit, boxes, wiring, supports, accessories, system programming, etc. as necessary for a complete operating system that provides the functional intent indicated.

B. Provide products listed, classified, and labeled as suitable for the purpose intended.

C. Inverter Assemblies: Manufactured units consisting of inverters, batteries, enclosures, and associated components specifically designed for emergency lighting applications; microprocessor-based utilizing pulse width modulation (PWM) with insulated gate bipolar transistors (IGBT's); listed and labeled as complying with UL 924.

1. Battery Run Times of 90 Minutes: Listed as complying with UL 924 for "emergency lighting and power equipment".
2. Battery Run Times Other than 90 Minutes: Listed as complying with UL 924 for "auxiliary lighting and power equipment".

D. Provide inverters and associated components suitable for operation at indicated ratings under the service conditions at the installed location.

E. Increase indicated power ratings as required to accommodate any applicable inverter load restrictions.

F. Inverters Installed in Spaces Used for Environmental Air: Plenum rated; listed and labeled as complying with UL 2043, suitable for use in air-handling spaces.

G. Battery System:

1. Provide battery capacity as required for achieving battery run time indicated.

2. Battery Charger: Microprocessor-controlled, temperature compensated; capable of returning supplied battery(s) from fully discharged to fully charged condition within unless otherwise indicated.
3. Provide automatic low voltage battery disconnect to prevent battery "deep discharge" damage.

H. Enclosures:

1. Environment Type per NEMA EN 10250:
   a. Indoor Clean, Dry Locations:
   b. Outdoor Locations:
2. Hinged Doors: Lockable, with all locks keyed alike.
3. Finish:

I. Surge Tolerance: Capable of withstanding characteristic surges according to IEEE C62.41.2, location category B.

J. Automatic Sequence of Operations:

1. Upon failure or degradation of primary/normal input power, transfer load to battery power.
2. When primary/normal input power has been restored, retransfer load to primary/normal power and recharge battery.

K. Input Tolerance:

1. Voltage Range:
2. Frequency Range:
3. Total Harmonic Distortion (THD): maximum at full load.

L. Output Requirements:

1. Voltage Regulation:
2. Frequency Range:
3. Total Harmonic Distortion (THD): maximum for linear load.
4. Load Power Factor Capability:

M. Features:

1. Control Functions:
   a. Automatic mode.
   b. Manual Test Mode: Simulates failure of primary/normal source.
   c. Automatic Shutdown Mode (IPS Inverters Only): Upon applicable inverter circuit trouble/fault unit shuts down.
   d. Self-testing/self-diagnostics.
2. Status Indications:
   a. Connected to primary/normal source.

b. Connected to battery power.
c. Primary/normal source available.
d. Battery charging.

3. Alarm Indications:
   a. Output overload/overcurrent.
   b. High temperature.
   c. Low battery.
4. Other Features:
   a. Input circuit breaker.
   b. Event log.

2.2 STANDARD-TRANSFER INTERRUPTIBLE POWER SUPPLY (IPS) CENTRALIZED EMERGENCY LIGHTING INVERTERS

A. Description: Offline/standby type inverters with maximum transfer time to battery power source upon loss of normal power source; suitable for operation of incandescent, LED, and fluorescent light sources (not suitable for HID light sources).

B. Basis of Design - Standard-Transfer Interruptible Power Supply (IPS) Centralized Emergency Lighting Inverter: Isolite Corporation; E3MAC-1000 1P; www.isolite.com/#sle.

1. Nominal Input/Output Voltage: 120 or 277 VAC, field selectable.
2. Nominal Power Rating: 1000VA.
3. Battery Type: LC - Lead calcium.
4. Mounting: MB - Back mount.
5. Battery Run Time: 90 minutes.
6. Transfer Time: Selectable (50 milliseconds, 1 second, 2 seconds).
7. Outputs:
   a. One dedicated normally on.
   b. Three configurable switched/normally off.
8. Provide the following:
   a. FD - Three-zone, 0-10 V DALI dimming and fire alarm interface.

2.3 SOURCE QUALITY CONTROL

A. Perform production tests on inverter assemblies at factory to verify operation and performance characteristics prior to shipment. Include certified test report with submittals .

PART 3 EXECUTION

3.1 EXAMINATION

A. Verify that field measurements are as indicated.

B. Verify that the ratings and configurations of inverter assemblies are consistent with the indicated requirements.

C. Verify that rough-ins for field connections are in the proper locations.

D. Verify that mounting surfaces are ready to receive inverter assemblies.

E. Verify that conditions are satisfactory for installation prior to starting work.

3.2 INSTALLATION

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

B. Arrange equipment to provide minimum clearances and required maintenance access.

C. Install inverter assemblies plumb and level.

D. Provide grounding and bonding in accordance with Section .

E. Identify inverter assemblies and associated system wiring in accordance with Section .

3.3 FIELD QUALITY CONTROL

A. Notify Owner and Architect at least prior to scheduled inspections and tests.

B. Notify authorities having jurisdiction and comply with their requirements for scheduling inspections and tests and for observation by their personnel.

C. Provide all equipment, tools, and supplies required to accomplish inspection and testing, including load bank.

D. Prepare and start system in accordance with manufacturer's instructions.

E. Perform acceptance test in accordance with NFPA 111.

F. Inspect and test in accordance with NETA ATS, except Section 4.

G. Perform inspections and tests listed in NETA ATS, Section 7.22.2.

H. Batteries and Charger: Perform inspections and tests listed in NETA ATS, Section 7.18.

I. Correct defective work, adjust for proper operation, and retest until entire system complies with Contract Documents.

J. Submit detailed reports indicating inspection and testing results and corrective actions taken.

3.4 CLEANING

A. Clean exposed surfaces to remove dirt, paint, or other foreign material and restore to match original factory finish.

3.5 CLOSEOUT ACTIVITIES

A. Demonstration: Demonstrate proper operation of emergency lighting inverter system to Owner, and correct deficiencies or make adjustments as directed.

B. Training: Train Owner's personnel on operation, adjustment, and maintenance of emergency lighting inverter system.

1. Use operation and maintenance manual as training reference, supplemented with additional training materials as required.
2. Instructor:
3. Location:

3.6 PROTECTION

A. Protect installed inverter assemblies from subsequent construction operations.

END OF SECTION 263323

SECTION 265119 - LED INTERIOR LIGHTING

PART 1 - PART 1 - GENERAL

1.1 SUMMARY

A. Section includes the following types of LED luminaires:

1. Lighting Fixtures.
2. Materials.
3. Finishes.
4. Fixture support.

1.2 DEFINITIONS

A. CCT: Correlated color temperature.

B. CRI: Color Rendering Index.

C. Fixture: See "Luminaire."

D. IP: International Protection or Ingress Protection Rating.

E. LED: Light-emitting diode.

F. Lumen: Measured output of lamp and luminaire, or both.

G. Luminaire: Complete lighting unit, including lamp, reflector, and housing.

1.3 SUBMITTALS

A. Product Data: For each type of product.

1. Arrange in order of luminaire designation.
2. Include data on features, accessories, and finishes.
3. Include physical description and dimensions of luminaires.
4. Include emergency lighting units, including batteries and chargers.
5. Include life, output (lumens, CCT, and CRI), and energy efficiency data.
6. Photometric data and adjustment factors based on laboratory tests, complying with IES Lighting Measurements Testing and Calculation Guides, of each luminaire type. The adjustment factors shall be for lamps and accessories identical to those indicated for the luminaire as applied in this Project IES LM-79 and IES LM-80.

a. Manufacturers' Certified Data: Photometric data certified by manufacturer's laboratory with a current accreditation under the National Voluntary Laboratory Accreditation Program for Energy Efficient Lighting Products.

B. Shop Drawings: For nonstandard or custom luminaires.

1. Include plans, elevations, sections, and mounting and attachment details.
2. Include details of luminaire 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.

C. Product Schedule: For luminaires and lamps. Use same designations indicated on Drawings.

1.4 QUALITY ASSURANCE

A. Luminaire Photometric Data Testing Laboratory Qualifications: Luminaire manufacturer's laboratory that is accredited under the NVLAP for Energy Efficient Lighting Products.

B. Provide luminaires from a single manufacturer for each luminaire type.

C. Each luminaire type shall be binned within a three-step MacAdam Ellipse to ensure color consistency among luminaires.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Protect finishes of exposed surfaces by applying a strippable, temporary protective covering before shipping.

1.6 WARRANTY

A. Warranty: Manufacturer and Installer agree to repair or replace components of luminaires that fail in materials or workmanship within specified warranty period.

PART 2 - PRODUCTS

2.1 PRODUCTS

A. Refer to the Lighting Fixture Schedule on the drawings for the specified fixtures and options.

2.2 LUMINAIRE 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. Standards:

1. ENERGY STAR certified.
2. California Title 24 compliant.
3. NRTL Compliance: Luminaires for hazardous locations shall be listed and labeled for indicated class and division of hazard by an NRTL.
4. FM Global Compliance: Luminaires for hazardous locations shall be listed and labeled for indicated class and division of hazard by FM Global.
5. UL Listing: Listed for damp location.
6. Recessed luminaires shall comply with NEMA LE 4.

C. CRI as indicated on the drawings. CCT as indicated on the drawings.

D. Rated lamp life of minimum 50,000 hours to L80.

E. Lamps dimmable from 100 percent to 0 percent of maximum light output.

F. Internal driver.

2.3 MATERIALS

A. Metal Parts:

1. Free of burrs and sharp corners and edges.
2. Sheet metal components shall be steel unless otherwise indicated.
3. Form and support to prevent warping and sagging.

B. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.

C. Factory-Applied Labels: Comply with UL 1598. Include recommended lamps. Locate labels where they will be readily visible to service personnel, but not seen from normal viewing angles when lamps are in place.

1. Label shall include the following lamp characteristics:
   a. "USE ONLY" and include specific lamp type.
   b. Lamp diameter, shape, size, wattage, and coating.
   c. CCT and CRI for all luminaires.

2.4 METAL FINISHES

A. Variations in finishes are unacceptable in the same piece. Variations in finishes of adjoining components are acceptable if they are within the range of approved Samples and if they can be and are assembled or installed to minimize contrast.

2.5 LUMINAIRE SUPPORT

A. Single-Stem Hangers: 1/2-inch steel tubing with swivel ball fittings and ceiling canopy. Finish same as luminaire.

B. Wires: ASTM A 641/A 641 M, Class 3, soft temper, zinc-coated steel, 12 gage.

C. Rod Hangers: 3/16-inch minimum diameter, cadmium-plated, threaded steel rod.

D. Hook Hangers: Integrated assembly matched to luminaire, line voltage, and equipment with threaded attachment, cord, and locking-type plug.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, 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 luminaire to verify actual locations of luminaire and electrical connections before luminaire installation. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 TEMPORARY LIGHTING

A. If approved by the Owner, use selected permanent luminaires for temporary lighting. When construction is sufficiently complete, clean luminaires used for temporary lighting and install new lamps.

3.3 INSTALLATION

A. Comply with NECA 1.

B. Install luminaires level, plumb, and square with ceilings and walls unless otherwise indicated.

C. Install lamps in each luminaire.

D. Supports:

1. Sized and rated for luminaire weight.
2. Able to maintain luminaire position after cleaning and relamping.
3. Provide support for luminaire without causing deflection of ceiling or wall.
4. Luminaire mounting devices shall be capable of supporting a horizontal force of 100 percent of luminaire weight and vertical force of 400 percent of luminaire weight.

E. Flush-Mounted Luminaire Support:

1. Secured to outlet box.
2. Attached to ceiling structural members at four points equally spaced around circumference of luminaire.
3. Trim ring flush with finished surface.

F. Wall-Mounted Luminaire Support:

1. Attached to structural members in walls or Attached to a minimum 20 gauge backing plate attached to wall structural members.
2. Do not attach luminaires directly to gypsum board.

G. Ceiling-Mounted Luminaire Support:

1. Ceiling mount with minimum two 5/32-inch- diameter aircraft cable supports adjustable to 120 inches in length.
2. Pendant mount with 5/32-inch- diameter aircraft cable supports adjustable to 120 inches in length.
3. Ceiling mount with hook mount.

H. Suspended Luminaire Support:

1. Pendants and Rods: Where longer than 48 inches, brace to limit swinging.
2. Stem-Mounted, Single-Unit Luminaires: Suspend with twin-stem hangers. Support with approved outlet box and accessories that hold stem and provide damping of luminaire oscillations. Support outlet box vertically to building structure using approved devices.
3. Continuous Rows of Luminaires: Use tubing or stem for wiring at one point and tubing or rod for suspension for each unit length of luminaire chassis, including one at each end.
4. Do not use ceiling grid as support for pendant luminaires. Connect support wires or rods to building structure.

I. Ceiling-Grid-Mounted Luminaires:

1. Secure to any required outlet box.
2. Use approved devices and support components to connect luminaire to ceiling grid and building structure in a minimum of four locations, spaced near corners of luminaire.

3.4 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Operational Test: After installing luminaires, switches, and accessories, and after electrical circuitry has been energized, test units to confirm proper operation.
2. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify transfer from normal power to battery power and retransfer to normal.

B. Luminaire will be considered defective if it does not pass operation tests and inspections.

C. Prepare test and inspection reports.

3.5 ADJUSTING

A. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting the direction of aim of luminaires to suit occupied conditions. Make up to two visits to Project during other-than-normal hours for this purpose. Some of this work may be required during hours of darkness.

1. During adjustment visits, inspect all luminaires. Replace lamps or luminaires that are defective.
2. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.

END OF SECTION 265119

SECTION 284621 – MODIFICATIONS TO EXISTING FIRE ALARM SYSTEM

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. The specified modifications will replace existing fire alarm systems within all areas of renovation and expand the existing fire alarm system as necessary to serve all areas of renovation in the School. Modifications made to the existing School fire alarm system:

1. Carbon monoxide detectors.
2. Fire-alarm notification appliances.
3. Fire-alarm addressable interface devices.
4. Engineering and reprogramming associated with the installation of the new equipment and updating existing information.

B. Related Requirements:

1. Section 260519 "Low-Voltage Electrical Power Conductors and Cables"
2. Section 260523 "Control Voltage Electrical Power Cables" for cables and conductors for fire-alarm systems.

1.3 DESCRIPTION OF EXISTING FIRE ALARM SYSTEM

A. The existing Fire Alarm Control Panel (FACP) operates as the head-end for an integrated fire alarm, monitoring and control system providing addressable operation and analog detection. Changes in the status of monitored points are detected by the FACP, located as indicated on the drawings.

1.4 DEFINITIONS

A. EMT: Electrical metallic tubing.

B. NICET: National Institute for Certification in Engineering Technologies.

C. Voltage Class: For specified circuits and equipment, voltage classes are defined as follows:

1. Control Voltage: Listed and labeled for use in remote-control, signaling, and power-limited circuits supplied by a Class 2 or Class 3 power supply having rated output not greater than 150 V and 5 A, allowing use of alternate wiring methods complying with NFPA 70, Article 725.
2. Low Voltage: Listed and labeled for use in circuits supplied by a Class 1 or other power supply having rated output not greater than 1000 V, requiring use of wiring methods complying with NFPA 70, Article 300, Part I.

1.5 SEQUENCING AND SCHEDULING

A. Existing Fire-Alarm Equipment: Maintain existing equipment fully operational until system modifications have been tested and accepted. When new equipment is installed, label it "NOT IN SERVICE" until it is accepted. Remove labels from new equipment when put into service, and label existing fire-alarm equipment "NOT IN SERVICE" until removed from building.

B. Equipment Removal: After acceptance of the specified fire-alarm system modifications, remove existing disconnected fire-alarm equipment and associated wiring.

1.6 ACTION SUBMITTALS

A. Approved Permit Submittal: Submittals must be approved by authorities having jurisdiction prior to submitting them to Architect.

B. Product Data: For each type of product, including furnished options and accessories.

1. Include construction details, material descriptions, dimensions, profiles, and finishes.
2. Include rated capacities, operating characteristics, and electrical characteristics.

C. Shop Drawings: For fire-alarm system.

1. Comply with recommendations and requirements in "Documentation" section of "Fundamentals" chapter in NFPA 72.
2. Include plans, elevations, sections, and details, including details of attachments to other Work.
3. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and locations. Indicate conductor sizes, indicate termination locations and requirements, and distinguish between factory and field wiring.
4. Include voltage drop calculations for notification-appliance circuits.
5. Include battery-size calculations.
6. Include input/output matrix.

7. Include written statement from manufacturer that equipment and components have been tested as a system and comply with requirements in this Section and in NFPA 72.

1.7 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

B. Qualification Statements: For Installer.

C. Sample Warranty: Submittal must include line item pricing for replacement parts and labor.

1.8 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For fire-alarm systems and components to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following and deliver copies to authorities having jurisdiction:
   a. Comply with "Records" section of "Inspection, Testing and Maintenance" chapter in NFPA 72.
   b. Provide "Fire-Alarm and Emergency Communications System Record of Completion Documents" in accordance with "Completion Documents" Article in "Documentation" section of "Fundamentals" chapter in NFPA 72.
   c. Complete wiring diagrams showing connections between devices and equipment. Each conductor must be numbered at every junction point with indication of origination and termination points.
   d. Device addresses.
   e. Provide "Inspection and Testing Form" in accordance with "Inspection, Testing and Maintenance" chapter in NFPA 72, and include the following:
      1) Equipment tested.
      2) Frequency of testing of installed components.
      3) Frequency of inspection of installed components.
      4) Requirements and recommendations related to results of maintenance.
      5) Manufacturer's user training manuals.
   f. Manufacturer's required maintenance related to system warranty requirements.

1.9 QUALITY ASSURANCE

A. UL Listing: The system products for the modifications shall be listed in the UL Fire Protection Equipment Directory under product category "Control Units System (UOJZ)".

B. Company Field Advisor: Company Field Advisor shall be National Institute for Certification in Engineering Technologies (NICET) certified as Level III or higher Fire Alarm Protection/Fire Alarm Systems Engineering Technician. Secure the services of a Company Field Advisor from the Company of the existing system for a minimum of 24 working hours at the contract site for the following:

1. Render advice and witness test of existing system.
2. Render advice regarding modifications to the system.
3. Assist in reprogramming the system.
4. Witness final system test and then certify with an affidavit that the modifications were installed in accordance with the contract documents and are operating properly.

C. Installer Qualifications:

1. Personnel must be trained and certified by manufacturer for installation of units required for this Project.
2. Installation must be by personnel certified by NICET technician.
3. Obtain certification by NRTL in accordance with NFPA 72.
4. Licensed or certified by authorities having jurisdiction.

1.10 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace fire-alarm system equipment and components modifications that fail because of defects in materials or workmanship within specified warranty period.

1. Warranty Period: 5 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 EXISTING FIRE-ALARM SYSTEM TO BE MODIFIED

A. Source Limitations for Fire-Alarm System and Components: Components must be compatible with, and operate as extension of, existing system. Provide system manufacturer's certification that components provided have been tested as, and will operate as, a system. Provide all necessary system components and associated wiring connections to accommodate all system work indicated on the drawings.

2.2 CARBON MONOXIDE DETECTORS

A. Description: Carbon monoxide detector listed for connection to fire-alarm system.

B. Performance Criteria:

1. Regulatory Requirements:
   a. NFPA 72
   b. NFPA 720.
   c. UL 2075.

2. General Characteristics:
   a. Mounting: Adapter plate for outlet box mounting.
   b. Testable by introducing test carbon monoxide into sensing cell.
   c. Detector must provide alarm contacts and trouble contacts.
   d. Detector must send trouble alarm when nearing end-of-life, power supply problems, or internal faults.
   e. Locate, mount, and wire in accordance with manufacturer's written instructions.
   f. Provide means for addressable connection to fire-alarm system.
   g. Test button simulates alarm condition.

2.3 FIRE-ALARM NOTIFICATION APPLIANCES

A. Fire-Alarm Audible Notification Appliances:
1. Description: Horns or other notification devices that cannot output voice messages.
2. Performance Criteria:
   a. Regulatory Requirements:
      1) NFPA 72.
   b. General Characteristics:
      1) Individually addressed, connected to signaling-line circuit, equipped for mounting as indicated, and with screw terminals for system connections.
      2) Connected to notification-appliance signal circuits, zoned as indicated, equipped for mounting as indicated, and with screw terminals for system connections.

B. Tone Notification Appliances:

1. Horns: Electric-vibrating-polarized type, 24-V dc; with provision for housing the operating mechanism behind a grille. Comply with UL 464. Horns shall produce a sound-pressure level of 90 dBA, measured 10 feet from the horn, using the coded signal prescribed in UL 464 test protocol.

2. Performance Criteria:
    a. Regulatory Requirements:
        1) NFPA 72.
        2) UL 1480.
        3) Combination Devices: Factory-integrated audible and visible devices in single-mounting assembly, equipped for mounting as indicated, and with screw terminals for system connections.

C. Fire-Alarm Visible Notification Appliances:

1. Performance Criteria:
    a. Regulatory Requirements:
        1) NFPA 72.
        2) UL 1971.
    b. General Characteristics:
        1) Rated Light Output:
            a) 15/30/75/110 cd, selectable in field.
        2) Clear or nominal white polycarbonate lens mounted on aluminum faceplate.
        3) Mounting: Wall mounted unless otherwise indicated.
        4) For units with guards to prevent physical damage, light output ratings must be determined with guards in place.
        5) Flashing must be in temporal pattern, synchronized with other units.
        6) Strobe Leads: Factory connected to screw terminals.
        7) Mounting Faceplate: Factory finished, Red.

2.4 FIRE-ALARM ADDRESSABLE INTERFACE DEVICES

A. Performance Criteria:

1. Regulatory Requirements:
    a. NFPA 72.
2. General Characteristics:
    a. Include address-setting means on module.
    b. Store internal identifying code for control panel use to identify module type.
    c. Listed for controlling HVAC fan motor controllers.
    d. Monitor Module: Microelectronic module providing system address for alarm-initiating devices for wired applications with normally open contacts.
    e. Integral Relay: Capable of providing direct signal to circuit-breaker shunt trip for power shutdown.
        1) Allow control panel to switch relay contacts on command.

2) Have minimum of two normally open and two normally closed contacts available for field wiring.

f. Control Module:
1) Operate notification devices.
2) Operate solenoids for use in sprinkler service.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions for compliance with requirements for ventilation, temperature, humidity, and other conditions affecting performance of the Work.

1. Verify that manufacturer's written instructions for environmental conditions have been permanently established in spaces where equipment and wiring are installed before installation begins.

B. Prior to modifying the system, perform tests to ascertain the operating condition of the existing system. Tests shall be witnessed by the Company Field Advisor. Prepare a written report for the District indicating any repairs necessary to make the existing sub-systems function properly and insure full capability of supporting the work indicated on the drawings.

C. Examine roughing-in for electrical connections to verify actual locations of connections before installation.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Preinstallation Testing: Perform verification of functionality of installed components of existing system prior to starting work. Document equipment or components not functioning as designed.

B. Interruption of Existing Fire-Alarm Service: Do not interrupt fire-alarm service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary guard service in accordance with requirements indicated:

1. Notify Construction Manager no fewer than 7 days in advance of proposed interruption of fire-alarm service.
2. Do not proceed with interruption of fire-alarm service without Construction Manager's written permission.

C. Protection of In-Place Conditions: Protect devices during construction unless devices are placed in service to protect facility during construction.

3.3 INSTALLATION OF EQUIPMENT

A. Comply with NECA 305, NFPA 72, NFPA 101, and requirements of authorities having jurisdiction for installation and testing of fire-alarm equipment. Install electrical wiring to comply with requirements in NFPA 70 including, but not limited to, Article 760, "Fire Alarm Systems."

1. Devices placed in service before other trades have completed cleanup must be replaced.
2. Devices installed, but not yet placed, in service must be protected from construction dust, debris, dirt, moisture, and damage in accordance with manufacturer's written storage instructions.

B. Connecting to Existing Equipment: Verify that the existing fire-alarm system is operational before making changes or connections.

1. Connect new equipment to existing control panel in existing part of building.
2. Connect new equipment to existing monitoring equipment at supervising station.
3. Expand, modify, and supplement existing control and monitoring equipment as necessary to extend existing control and monitoring functions to new points. New components must be capable of merging with existing configuration without degrading the performance of either system.

C. Audible Alarm-Indicating Devices: Install not less than 6 inch (150 mm) below ceiling. Install bells and horns on flush-mounted back boxes with device-operating mechanism concealed behind grille. Install devices at same height unless otherwise indicated.

D. Visible Alarm-Indicating Devices: Install adjacent to each alarm bell or alarm horn and at least 6 inch (150 mm) below ceiling. Install devices at same height unless otherwise indicated.

E. Device Location-Indicating Lights: Locate in public space near device they monitor.

3.4 ELECTRICAL CONNECTIONS

A. Connect wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."

C. Install electrical devices furnished by manufacturer, but not factory mounted, in accordance with NFPA 70 and NECA 1.

D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.

1. Nameplate must be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."

3.5 CONTROL CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring in accordance with Section 260523 "Control-Voltage Electrical Power Cables."

C. Install nameplate for each control connection, indicating field control panel designation and I/O control designation feeding connection.

3.6 PATHWAYS

A. Pathways above recessed ceilings and in inaccessible locations may be routed exposed.

1. Exposed pathways located less than 96 inch (2440 mm) above floor must be installed in EMT.

B. Pathways must be installed in EMT. Exceptions: Pathways installed exposed at Outdoor locations, sump and ejector pits, elevator pits, loading docks, garages, rooftops, gymnasiums and Boiler/Mechanical Rooms/Main Electrical Rooms must be installed in GRC: Galvanized rigid steel conduit.

C. Exposed conduit must be painted red enamel.

3.7 CONNECTIONS

A. Make addressable connections with supervised interface device. Install interface device less than 36 inch (910 mm) from device controlled. Make addressable confirmation connection when such feedback is available at device or system being controlled.

B. For fire-protection systems related to doors in fire-rated walls and partitions and to doors in smoke partitions, comply with requirements in Section 087100 "Door Hardware." Connect hardware and devices to fire-alarm system.

1. Verify that hardware and devices are listed for use with installed fire-alarm system before making connections.

3.8 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 270553 "Identification for Communications Systems."

B. Install framed instructions in location visible from FACP.

3.9 GROUNDING

A. Ground FACP and associated circuits in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."

B. Ground shielded cables at control panel location only. Insulate shield at device location.

3.10 FIELD QUALITY CONTROL

A. Field tests must be witnessed by authorities having jurisdiction.

B. Administrant for Tests and Inspections:

1. Perform tests and inspections with assistance of factory-authorized service representative.

C. Tests and Inspections:

1. Visual Inspection: Conduct visual inspection prior to testing.
    a. Inspection must be based on completed record Drawings and system documentation that is required by "Completion Documents, Preparation" table in "Documentation" section of "Fundamentals" chapter in NFPA 72.
    b. Comply with "Visual Inspection Frequencies" table in "Inspection" section of "Inspection, Testing and Maintenance" chapter in NFPA 72; retain "Initial/Reacceptance" column and list only installed components.
2. System Testing: Comply with "Test Methods" table in "Testing" section of "Inspection, Testing and Maintenance" chapter in NFPA 72.
3. Test audible appliances for public operating mode in accordance with manufacturer's written instructions. Perform test using portable sound-level meter complying with Type 2 requirements in ASA S1.4 Part 1/IEC 61672-1.
4. Test audible appliances for private operating mode in accordance with manufacturer's written instructions.

5. Test visible appliances for public operating mode in accordance with manufacturer's written instructions.
6. Factory-authorized service representative must prepare "Fire Alarm System Record of Completion" in "Documentation" section of "Fundamentals" chapter in NFPA 72 and "Inspection and Testing Form" in "Records" section of "Inspection, Testing and Maintenance" chapter in NFPA 72.

D. Reacceptance Testing: Perform reacceptance testing to verify proper operation of added or replaced devices and appliances.

E. The fire alarm system will be considered defective if it does not pass tests and inspections.

F. Prepare test and inspection reports.

G. Maintenance Test and Inspection: Perform tests and inspections listed for weekly, monthly, quarterly, and semiannual periods. Use forms developed for initial tests and inspections.

H. Annual Test and Inspection: One year after date of Substantial Completion, test fire-alarm system complying with visual and testing inspection requirements in NFPA 72. Use forms developed for initial tests and inspections.

END OF SECTION 284621