April 15, 2024

PROJECT MANUAL

VOLUME 3 OF 4: Divisions 19 - 25

Newburgh Enlarged City School District
New CTE Building

CTE Building

SED No. 44-16-00-01-0-053-001

CSArch Project # 108-2303.00

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

CSARCH

DOCUMENT 000114 - TABLE OF CONTENTS

VOLUME 01

DIVISION 00 – PROCUREMENT AND CONTRACTING REQUIREMENTS

Introductory Information

Procurement Requirements

Project Information

Procurement Forms and Supplements

Contracting Requirements & Supplements

Quality Requirements

Temporary Facilities and Controls

Product Requirements

Execution and Closeout requirements

Life Cycle Activities

DIVISION 02 – EXISTING CONDITIONS

DIVISION 03 – CONCRETE

DIVISION 04 – MASONRY

DIVISION 23 – HEATING, VENTILATION, AND AIR-CONDITIONING (HVAC)

DIVISION 25 – INTEGRATED AUTOMATION

DIVISION 26 – ELECTRICAL

DIVISION 27 – COMMUNICATIONS

DIVISION 28 – ELECTRONIC SAFETY AND SECURITY

DIVISION 31 – SITEWORK

DIVISION 32 – EXTERIOR IMPROVEMENTS

DIVISION 33 – UTILITIES

END OF DOCUMENT 000114

SECTION 191000 PERFORMANCE SOUND SYSTEM

PART 1 GENERAL

1.1 PROJECT INFORMATION:

A. Owner: Newburgh Enlarged City School District
405 Union Avenue
New Windsor, NY 12553

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. Gymnasium Audio System
   1. Automated and Manal Controls
   2. Loudspeakers and processing
   3. ADA Hearing Assistance System
   4. Wireless microphones
   5. Wired Microphones
   6. Racks
   7. Wiring
   8. Tuning, Commissioning training and closeout.

B. Studio Video & Audio Recording Systems
   1. Studio Cameras and Tripods
   2. Studio Video Switcher
   3. Camera Recorders and Controls
   4. Audio Recording Console
   5. Racks
   6. Wiring
   7. 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 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. 7' TOUCHSCREEN CONTROLLER: REFERENCED PRODUCT ALLEN & HEATH CC-7
1. The touch panel shall be pre-configured to run the Allen & Heath Custom Control app in kiosk mode and prevent unauthorized user access to system settings. It shall be capable of controlling an Allen & Heath AHM, Avantis and dLive mixing system.
2. The touch panel shall have a minimum resolution of 1024x600 and minimum brightness of 240 cd/m2.
3. An RJ46 Gigabit Ethernet port shall be provided for connection to the control network.
4. Industry standard VESA 75x75 mounting points shall be provided for installation.
5. The touch panel shall be powered via Power over Ethernet (PoE) or via an external 12V DC power supply.
6. Recommended operating temperature for the touch panel shall be 0 to 40 degrees Celsius.

2.4 MULTIFORMAT AV SWITCHER: REFERENCED PRODUCT CRESTRON HD-PS622

A. Video
1. Switcher 8x2 auto-switching or manual, audio-follows-video, Crestron Auto-Locking® and QuickSwitch HD™ technologies
2. Scaler (mirrored HDMI and DM Lite outputs) 4K60 4:4:4 video scaler with motion-adaptive deinterlacing, intelligent frame rate conversion; Deep Color support; HDR10, HDR10+, and Dolby Vision support; content-adaptive noise reduction; and 3:2/2:2 pull-down detection and recovery
3. Input Signal Types HDMI with HDR10, HDR10+, and Dolby Vision support, Deep Color support, and 4K60 4:4:4 support (DVI and Dual-Mode DisplayPort™ interface compatible3) on Inputs 1-6, DM Lite with Deep Color and 4K on Inputs 7-8
4. Output Signal Types HDMI, DM Lite, and HDBaseT with HDR10, HDR10+, and Dolby Vision pass-through support, Deep Color support, and 4K60 4:4:4 support (DVI compatible4)
5. Copy Protection HDCP 2.3

B. Audio, General
1. Audio Inputs Two mono 1-channel MIC/LINE inputs
2. Six mono 1-channel LINE inputs
3. One stereo 2-channel LPCM audio extracted from the selected HDMI or DM Lite input source
4. Audio Outputs One mirrored HDMI 1 and DM Lite 1 audio output

5. One mirrored HDMI 2 and DM Lite 2 audio output
6. One AUX 1 output, stereo 2-channel
7. One AUX 2 output, stereo 2-channel
8. Analog-to-Digital Conversion 24-bit 48 kHz
9. Digital-to-Analog Conversion 24-bit 48 kHz

C. Audio - Source Inputs
1. Six HDMI and two DM Lite inputs (HDMI 1-6 and DM Lite 7-8)
2. Input Signal Types HDMI (Dual-Mode DisplayPort interface compatible3), DM Lite
3. FormatsDolby 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

D. Audio - Microphone/Line Inputs
1. Two balanced 1-channel microphone/line inputs (CH1-CH2)
2. Input Signal Type Mono analog
3. Gain Range -10 dB to +10 dB in 1 dB increments
4. Phantom Power +48 VDC, 12 mA, enable or disable per channel
5. Mute Enable or disable per channel

E. Audio - Line Inputs
1. Six balanced 1-channel line inputs (CH3-CH8)
2. Input Signal Type Mono analog
3. Gain Range -10 dB to +10 dB in 1 dB increments
4. Balanced Line Input Level 4 Vrms
5. Unbalanced Line Input Level 2 Vrms
6. Line Input Impedance >10k ohms

F. Audio - Digital Output
1. Output Signal Type HDMI
2. FormatsDolby 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
3. Source Gain -80 dB to +20 dB adjustment range, plus Mute
4. Volume Control -80 dB to +20 dB adjustment range, plus Mute
5. Delay 0 to 150 ms adjustment range
6. Audio - Analog Line Output
7. Output Signal Type/Format Stereo 2-channel
8. Frequency Response ±0.5 dB, 20 Hz to 20 kHz
9. THD+N <0.005%, 1 kHz, 4 Vrms
10. S/N Ratio >95 dB, 4 Vrms, 20 Hz to 20 KHz, A-weighted
11. Crosstalk >90 dB, 1 KHz, for multiple inputs only
12. Stereo Separation >80 dB, 20 Hz to 20 kHz

13. Volume Control -80 dB to +20 dB adjustment range, plus Mute, Mono, and Stereo

G. Communications
1. Ethernet 100/1000 Mbps, auto-switching, auto-negotiating, auto-discovery, full/half duplex, DHCP, Web browser setup and control, Crestron control system integration, IEEE 802.1X, Secure CIP, Authentication, SSH/SSL, TLS
2. USB For firmware loading, configuration management, USB host for one TT-100 cable caddy (sold separately), or power to a USB powered device
3. HDMI HDCP 2.3, EDID, CEC
4. DM Lite HDCP 2.3 and EDID
5. HDBaseT HDCP 2.3

H. Connectors
1. MIC/LINE CH1-CH2 (2) 3-pin 3.5 mm detachable terminal blocks;
2. Balanced mono microphone/line audio inputs
3. LINE INPUT CH3-CH8 (6) 3-pin 3.5 mm detachable terminal blocks;
4. Balanced mono line-level audio inputs
5. AUX OUT 1-2 (2) 5-pin 3.5 mm detachable terminal blocks;
6. Balanced stereo line-level audio outputs;
7. Output Impedance: <200 Ohms;
8. Maximum Output Level: 4 Vrms balanced
9. HDMI INPUTS 1-6 (6) 19-pin Type A connector, female;
10. HDMI digital video/audio input (DVI and Dual-Mode DisplayPort interface compatible3)
11. DM LITE INPUTS 7-8 (2) 8-pin RJ-45 yellow connectors, female, shielded;
12. DM Lite input ports for connection to DM Lite transmitters5
13. DM LITE OUTPUT 1 (1) 8-pin RJ-45 orange connector, female, shielded;
14. DM Lite output port (HDBaseT standard compliant) for connection to a DM Lite receiver, DMPS Lite™ switcher, or HDBaseT device6;
15. Mirrored with HDMI OUTPUT 1
16. HDMI OUTPUT 1 (1) 19-pin Type A connector, female;
17. HDMI digital video/audio output (DVI compatible4);
18. Mirrored with DM LITE OUTPUT 1
19. DM LITE OUTPUT 2 (1) 8-pin RJ-45 orange connector, female, shielded;
20. DM Lite output port (HDBaseT standard compliant) for connection to a DM Lite receiver, DMPS Lite switcher, or HDBaseT device6;
21. Mirrored with HDMI OUTPUT 2
22. HDMI OUTPUT 2 (1) 19-pin Type A connector, female;
23. HDMI digital video/audio output (DVI compatible4);
24. Mirrored with DM LITE OUTPUT 2
25. LAN (1) 8-pin RJ-45 connector, female;
26. 100BASE-TX/1000BASE-T Ethernet port

27. 100-240VAC 1.8-0.7A 50/60 Hz (1) IEC 60320 C14 mains power inlet;
28. Mates with removable power cord, included
29. NOTE: This power connection powers both the HD-PS622 and the connected DM Lite transmitters and receiver. When connected to the HD-PS622, the DM Lite transmitters and receiver must not be connected to power.7
30. G (1) 6-32 screw, chassis ground lug
31. SERVICE (1) USB 2.0 Type A connector, female;
32. Used for firmware loading, configuration management, or as a USB host port for one TT-100 cable caddy (sold separately);
33. Can also provide up to 5V 500 mA power to a USB powered device

I. Controls and Indicators
1. PWR (1) LED. Amber indicates that the device is booting. Green indicates that the device is operational.
2. AUTO (1) Push button to enable or disable automatic switching and (1) green LED to indicate that automatic switching is enabled.
3. SETUP (1) Red LED and (1) push button for display of IP address on connected HDMI and DM Lite outputs
4. INPUT 1-8 (8) Push buttons for manual input selection and (8) LEDs. Green indicates that the corresponding input is routed to an output. Amber indicates that a source is detected at the corresponding input but is not routed to an output.
5. OUTPUT 1-2 (2) Push buttons for manual output selection and (2) LEDs. Green indicates that a display or other destination device is detected and the corresponding output is transmitting video. Amber indicates that a display or other destination device is detected but no video is routed to the corresponding output.
6. FOLLOW (1) Push button to enable or disable Follow Output mode and (1) LED. Green indicates that Follow Output mode is enabled, which causes the selected HDMI or DM Lite input to be routed to HDMI and DM Lite outputs 1
7. and 2 simultaneously.
8. Ethernet (2) LEDs on RJ-45 LAN connector.
9. Link status LED: Green indicates that a 100BASE-TX link is established. Amber indicates that a 1000BASE-T link is established.
10. Ethernet activity LED: Flashing amber indicates Ethernet activity.
11. DM Lite (2) LEDs on RJ-45 DM Lite connectors. Green indicates that a DM Lite link is established. Flashing amber indicates non-HDCP video and solid amber indicates HDCP video.

J. Power
1. Mains Power 100-240VAC 1.8-0.7A 50/60 Hz
2. NOTE: The AC mains power connection powers both the HD-PS622 and connected DM Lite transmitters and receivers. When connected to the HD-PS622, the DM Lite transmitters and receivers must not be connected to power.7
3. Power Consumption 72 W typical

K. Environmental

1. Temperature 32° to 104° F (0° to 40° C)
2. Humidity 10% to 90% RH (non-condensing)
3. Heat Dissipation 164 BTU/hr typical
4. Acoustic Noise 32 dBA typical

L. Construction
1. Chassis Metal, black finish, vented sides
2. Mounting 1 RU 19-inch rack-mountable (rack ears included)

M. Dimensions
1. Height 1.72 in. (44 mm)
2. Width 17.33 in. (441 mm) without rack ears
3. 19.00 in. (483 mm) with rack ears (included)
4. Depth 10.82 in. (275 mm)

N. Weight
1. 8.0 lb (3.63 kg)

O. Compliance
1. Regulatory Model M202004002
2. Bureau Veritas Listed for US & Canada, IC, CE, FCC Part 15 Class B digital device

2.5 SINGLE CABLE 4K HDMI TRANSMITTER

A. Crestron HD-TX-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)
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
b. Signal transmission up to 230 feet.
c. Minimum cable type supported: UTP/STP CAT5e
3. Controls and Indicators
a. The device shall include the following indicators:
b. One (1) Green LED indicating a valid link to device by same manufacturer

c. One (1) LED indicating that power is provided to device with the following modes:
d. Green - device is operational
e. Amber - device is booting
f. One (1) Green LED indicating device is receiving HDMI signal
g. Two (2) LEDs on RJ-45 connector with the following modes:
h. Green - Connection established to device by same manufacturer
i. Flashing Amber - non-HDCP video
j. 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 4K 4:4:4 60Hz
         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-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
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 M202045001

2.6 SINGLE CABLE 4K HDMI RECEIVER

A. Crestron HD-RX-4KZ-101
   1. Device Architecture
      a. Physical Form factor
         1) Device enclosure to be made of black finished metal with vented sides
         2) Device weight: 11.82 oz (335 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 receiver
         1) Signal transmission up to 230 feet.
         2) Minimum cable type supported: UTP/STP CAT5e
      b. Remote control via control processor by same manufacturer
   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 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
   4. Connectors
      a. The device shall include the following connectors:
         1) 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 transmitter device from same manufacturer
            b. IR output connects to IR emitter and transmits IR signal from source connected to transmitter device from same manufacturer
            c. IR up to 60 kHz
         2) 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 transmitter device from same manufacturer

3) 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. DVI-D with adaptor
   e. EDID
   f. Common resolutions: 1920x1080 60Hz to 4096x2160 DCI 4K 4:4:4 60Hz
   g. Custom resolutions: pixel clock rates up to 600 MHz
4) One (1) RJ45 single cable transmission input with support for the following:
   a. Link port for connection to compatible transmission device by same manufacturer
   b. Remote switching and control via control processor by same manufacturer
   c. Power sharing option for connected remote transmission device
5) One (1) 2.1 x 5.5 mm DC power connector supporting the following characteristic:
   a. 24 VDC 1.25 A power input

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 and Canada, CE, IC, FCC Part 15 Class B digital device
   b. Regulatory Model M202047002

2.7 MEDIA PRESENTATION CONTROLLER: REFERENCED PRODUCT CRESTRON MPC3-102-B

A. Control Engine
   1. Crestron 3-Series; real-time, preemptive multi-threaded/multitasking kernel; transaction-safe extended FAT file system; battery-backed non-volatile real-time clock; supports up to 10 simultaneously running programs (license required [1])

B. Communications
   1. Ethernet
      a. 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), FIPS 140-2 compliant encryption, IEEE 802.1X, SNMP, BACnet/IP [2], IPv4 or IPv6, Active Directory authentication, SMTP e-mail client, HTTPS web server, HTTPS

web browser setup and XiO Cloud client, IEEE 802.3af & 802.3at Type 1 PoE compliant

C. Connectors
   1. LAN PoE
      a. (1) 8-pin RJ45 connector, female;
      b. 100Base-TX Ethernet port;
      c. PoE (Power over Ethernet) PD (Powered Device) port
   2. COM
      a. (1) 3-pin 3.5 mm detachable terminal block;
      b. Bidirectional RS-232 port;
      c. Up to 115.2k baud, hardware and software handshaking support
   3. I/O / IR
      a. (1) 5-pin 3.5 mm detachable terminal block;
      b. Comprises (2) "Versiport" digital input/output or analog input ports (referenced to GND) and (1) IR/Serial port
      c. Digital Input: Rated for 0-24 Volts DC, input impedance 20k Ohms, logic threshold >3.125V low/0 and <1.875V high/1;
      d. Digital Output: 250 mA sink from maximum 24 Volts DC, catch diodes for use with "real world" loads;
      e. Analog Input: Rated for 0-10 Volts DC, protected to 24 Volts DC maximum, input impedance 21k Ohms with pull-up resistor disabled;
      f. Programmable 5 Volts, 2k Ohms pull-up resistor per pin;
      g. IR/Serial output port;
      h. IR output up to 1.2MHz;
      i. 1-way Serial TTL/RS-232 (0-5 Volts) up to 115.2k baud;
      j. (IRP2 emitter sold separately)
   4. NET
      a. (1) 3-pin detachable terminal block;
      b. Cresnet master port
   5. RELAY
      a. (1) 3-pin detachable terminal block;
      b. Comprises (2) normally open, isolated relays;
      c. Rated 1 Amp, 30 Volts AC/DC;
      d. MOV arc suppression across contacts
   6. Ground
      a. (1) 6-32 screw;
      b. Chassis ground lug (flying lead with ring terminal included)

D. Controls & Indicators
   1. Assignable Buttons
      a. (9) Projected capacitive pushbuttons, each may be labeled using one of 25 pre-labeled icon chips or hidden using one of five blackout chips (included), custom

laser-etched icon chips are available using optional MPB3/MPC3-BTN3-B ENGRAVED engravable icon chips (sold separately)

2. Mute
   a. (1) Projected capacitive pushbutton with "mute" icon
3. -/+
   a. (2) Projected capacitive pushbuttons labeled with "-" and "+" icons for volume control
4. Volume Gauge
   a. (1) Blue LED multi-segment bargraph for volume level indication
5. Power
   a. (1) Projected capacitive pushbutton labeled with “power” icon
6. HW-R
   a. (1) Pushbutton (behind front panel) for hardware reset (reboots the processor)
7. SW-R
   a. (1) Pushbutton (behind front panel) for software reset (restarts the software program)
8. Illumination
   a. Each capacitive button is individually backlit white when inactive and blue when active; auto-brightness control adjusts all backlighting in three levels according to the ambient light level; backlighting may be dimmed or extinguished when unit enters idle state
   b. Note: All capacitive buttons are custom programmable

E. Light Sensor
   1. Photosensor detects the ambient light level to enable auto-brightness control

F. Proximity Sensor
   1. Type
      a. Eye-safe 940 nm laser ranging sensor
      b. Range Adjustable from 20 to 90 cm (8 to 35 inches)
      c. Detects bodies within range and wakes the unit from standby or idle state

G. Audio
   1. Key Click
      a. Sounds when any button is pressed, adjustable to one of three volume settings or off

H. Power
   1. Power over Ethernet
      a. IEEE 802.3at Type 1 (802.3af compatible) Class 0 (12.95 Watts) PoE Powered Device
   2. Power Consumption
      a. 4.5 Watts typical, 2.8 Watts idle

I. Environmental
   1. Temperature

a. 5 to 40 °C (41 to 104 °F)
2. Humidity
a. 10% to 90% RH (non-condensing)
3. Heat Dissipation
a. 15.4 BTU/hr typical, 9.6 BTU/hr idle

J. Construction
1. Housing
a. Plastic with metal mounting plate, removable front panel with optional security screw
2. Flush Wall Mount
a. Mounts in a 1-Gang U.S. electrical box (not included), mounts in a 2-gang U.S. electrical box using MPC3-101/102/201-RMB Retrofit Mounting Bracket (sold separately)
3. Lectern Mount
a. Mounts in a 2.85 in. (72 mm) H x 2.04 in. (52 mm) W rectangular cutout using bracket provided

K. Dimensions
1. Height 4.62 in. (117 mm)
2. Width 3.02 in. (77 mm)
3. Depth 2.02 in. (51 mm)
4. Weight
5. 9.59 oz (272 g)

L. Compliance
1. CE, IC, FCC Part 15 Class B digital device; Class 1M laser product, complies with safety regulations of IEC- 60825-1, FDA 21 CFR 1040.11, and FDA 21 CRF 1040.10

2.8 4K STUDIO CAMERA SYSTEM

A. 4K STUDIO CAMERA: REFERENCED PRODUCT BLACKMAGIC DESIGN URSA BROADCAST G2
1. Imaging
a. Lens Mount
1) B4
b. Lens Communication
1) Yes
c. Sensor Resolution
1) Not Specified by Manufacturer
d. Image Sensor
1) 23.1 x 12.99 mm (Medium Format) CMOS
e. Image Stabilization
1) No

f. Built-In ND Filter
    1) Mechanical Filter Wheel with Clear, 2-Stop (1/4), 4-Stop (1/16), 6-Stop (1/64) ND Filters
g. Capture Type
    1) Stills & Video

2. Exposure Control
    a. Shutter Type
        1) Electronic Rolling Shutter
    b. ISO Sensitivity Range
        1) 400 to 3200 (Extended: 100 to 25,600)
    c. Gain
        1) -6 to 18 dB
    d. Advertised Dynamic Range
        1) 13 Stops
3. Video Capture
    a. Internal Recording Modes
        1) Blackmagic RAW 10-Bit
            a. 6144 x 3456 up to 50 fps [65 to 483 Mb/s]
            b. 6144 x 2560 up to 59.94 fps [49 to 359 Mb/s]
            c. 5376 x 3024 up to 59.94 fps [51 to 371 Mb/s]
            d. 3728 x 3104 up to 59.94 fps [36 to 265 Mb/s]
            e. 3840 x 2160 up to 59.94 fps [32 to 190 Mb/s]
            f. 1920 x 1080 up to 150 fps [5.2 to 47 Mb/s]
        2) ProRes 422/ProRes 422 HQ
            a. 3840 x 2160 up to 59.94 fps [73.6 to 110 Mb/s]
            b. 1920 x 1080p up to 59.94 fps [18.4 to 27.5 Mb/s]
            c. 1920 x 1080p up to 120 fps [18.4 to 27.5 Mb/s]
        3) H.265
            a. 3840 x 2160 up to 59.94 fps [3.2 to 7.8 Mb/s]
        4) H.264
        5) 1920 x 1080p up to 59.94 fps [1.8 to 7 Mb/s]
    b. External Recording Modes
        1) No
    c. Fast-/Slow-Motion Support
        1) Yes
    d. Broadcast Output
        1) NTSC/PAL
    e. Built-In Microphone
        1) Stereo
    f. Audio Recording
        1) ProRes: 2-Channel 24-Bit 48 kHz
    g. IP Streaming

1) No

h. Interface
   1) Media/Memory Card Slot
      a. Dual Slot: SD/SDHC/SDXC (UHS-II)
      b. Dual Slot: CFast (CFast 2.0)

i. Video I/O
   1) 1x BNC (12G-SDI) Output
   2) 1x BNC (12G-SDI) Input
   3) 1x BNC (12G-SDI) Output

j. Audio I/O
   1) 1x 1/8" / 3.5 mm TRRS Headphone/Mic Headphone Input/Output on Camera Body
   2) 2x XLR 3-Pin Mic/Line (+48 V Phantom Power) Input on Camera Body

k. Power I/O
   1) 1x XLR 4-Pin Input
   2) 1x XLR 4-Pin (12 to 20VDC) Output
   3) 1x Molex 12-Pin Input

l. Other I/O
   1) 1x USB-C (USB 3.2 / 3.1 Gen 2) Video Output
   2) 1x USB-C Data Input
   3) 1x 2.5 mm Sub-Mini (LANC) Control Output
   4) 1x BNC (Reference, Sync, Timecode) Data Input
   5) 1x Hirose 12-Pin (Camera Interface) Control Output

m. Wireless
   1) Bluetooth Control

n. Mobile App Compatible
   1) Yes: iPadOS Only
   2) App Name: Blackmagic Camera Control App

o. Global Positioning (GPS, GLONASS, etc.)
   1) No

4. Monitor
   1) Display Type
      a. Articulating Touchscreen LCD
   2) Display Size
      a. 4.0"
   3) Secondary Display
      a. Side: LCD Status Display

5. Viewfinder
   1) Type
      a. Optional, Not Included

6. Focus
   1) Focus Type

a. Auto and Manual Focus
2) Focus Mode
a. Automatic, Manual Focus
7. Environmental
1) Operating Temperature
a. 32 to 104°F / 0 to 40°C
2) Storage Temperature
a. -4 to 113°F / -20 to 45°C
3) Operating Humidity
a. 0 to 90%
8. General
1) Battery Type
a. V-Mount
2) Power Consumption
a. 100 W
3) Tripod Mounting Thread
a. 3x 1/4"-20 Female (Bottom)
4) Accessory Mounting Thread
a. 1x ARRI/Hirth Rosette
5) Netflix Approved
a. Yes
6) Material of Construction
a. Magnesium Alloy
7) Dimensions (W x H x D)
a. 10.95 x 9.93 x 5.9" / 27.81 x 25.22 x 15 cm
8) Weight
a. 7.83 lb / 3.55 kg (Body Only)

B. 4.6K SUPER 35MM STUDIO CAMERA VIDEWFINDER: REFERENCED PRODUCT BLACKMAGIC URSA STUDIO VIEWFINDER

1. Connections
a. SDI Video Input
1) 1 x HD/Ultra HD 3G-SDI via BNC.
b. Power Input
1) 1 x 4 pin XLR 12V.
c. Screen Dimensions
1) 7" 1920 x 1200 resolution.
d. Screen Type
1) 7" IPS LCD.
e. Computer Interface

1) 1 x USB type C connector for initial setup and software updates via Blackmagic Camera Setup software.

2. SDI Video Standards
   a. HD Format Support
      1) 720p50, 720p59.94, 720p60
      2) 1080p23.98, 1080p24, 1080p25, 1080p29.97, 1080p30, 1080p50, 1080p59.94, 1080p60
      3) 1080i50, 1080i59.94, 1080i60
   b. SDI Compliance
      1) SMPTE 259M, SMPTE 292M, SMPTE 296M, SMPTE 425M 2084.
   c. Video Sampling
      1) 4:2:2 YUV.
   d. Color Precision
      1) 10-bit.
   e. Color Space
      1) REC 601, REC 709.
   f. Multiple Rate support
      1) SDI switches between 1.5 Gb/s HD and 3.0 Gb/s 60P HD.
3. Monitor Features
   a. Controls
      1) Dial, knobs and customizable function buttons for settings, short cut features and navigating menus.
   b. Handles
      1) Built in grab handles for positioning the monitor independently from the camera.
   c. Position Adjustment Options
      1) Variable tension pivot points for articulated arm and grab handles with forward, backward, up, down, pan and tilt adjustments.
   d. Mounting Options
      1) Quick release V-lock mounting bracket for attaching viewfinder to URSA Mini handle.
   e. Tally
      1) Large LED tally light with customizable perspex camera numbers.
   f. Metadata Support
      1) Detects camera information embedded in the SDI signal including status information, frame guides, focus peaking, tally, and more.
   g. Screen Interface
      1) On screen meters and status information including Camera ID, resolution, frames per second, shutter speed, gain, white balance, camera battery level, and more.
   h. 3D Lookup Table Support
      1) LUT support for loading custom LUTs.

4. Power Requirements
    a. 12V power input via 4 pin XLR connected via URSA Mini 12v power output.
5. Environmental
    a. Operating Temperature
        1) 0° to 40° C (32° to 104° F)
    b. Storage Temperature
        1) -20° to 60° C (-4° to 140° F)
    c. Relative Humidity
        1) 0% to 90% non-condensing

C. 4K STUDIO CAMERA BROADCAST LENS: REFERENCED PRODUCT FUJINON LA16X8BRM-XBIA

1. Sensor Compatibility
    a. 2/3" (16:9)
2. Focal Length
    a. 8 to 128mm
3. Built-In Extender
    a. No
4. Zoom Ratio
    a. 16x
5. Angle of View
    a. 16:9
    b. Wide: 61.86 x 37.25° (H x V)
    c. Tele: 4.29 x 2.41° (H x V)
6. Maximum Aperture
    a. f/1.9 to 2.8
7. Focus Type
    a. Servo
8. Filter Thread
    a. M82 x 0.75 mm
9. Macro
    a. Yes
10. Minimum Object Distance
    a. 2.62' / 0.8 m
11. Optical Image Stabilization
    a. No
12. Dimensions
    a. 3.3 x 6.4" / 85.0 x 163.8 mm (ø x L)
13. Weight
    a. 3.53 lb / 1.6 kg

2.9 STUDIO CAMERA PEDESTAL SYSTEM: REFERENCED PRODUCT LIBEC RSP-750PD

A. RHP75 FLUID HEAD WITH PH-8B EXTENDABLE PAN HANDLES
1. Payload 37.5 lb (17.0 kg)
2. Diameter 100 mm
3. Range Counterbalance: 12.0 to 31.0 lb (5.5 to 14.0 kg)
4. Counterbalance Continuous
5. Drag Mode 7-step
6. Tilt Angle +90 to -70°
7. Bubble Level Illuminated
8. Camera Plate Sliding plate
9. Sliding Range ± 2.2" (55.0 mm) (Standard)
10. Plate Attachment 2 x 3/8" screw
11. Spare Screw 3/8"
12. Temperature Range -40 to 140°F (-40 to 60°C)
13. Weight 8.4 lb (3.8 kg)
14. Packaging Info
15. Box Dimensions (LxWxH) 14.7 x 10.4 x 7.9"

B. PH-8B EXTENDABLE PAN BAR HANDLE FOR RHP75, RHP85, AND LX10 VIDEO HEADS
1. Compatibility Libec RHP75 Video Head
2. Libec RHP85 Video Head
3. Libec LX10 Video Head
4. Material Aluminum alloy with rubberized handle
5. Effective Arm Length 16.0 to 22.0" (40.6 to 55.9 cm)
6. Packaging Info
7. Box Dimensions (LxWxH) 13.7 x 2.8 x 1.6"

C. P110S PNEUMATIC COLUMN PEDESTAL SYSTEM
1. Payload 66 lbs (30kg)
2. Height 32-62" (81-157.5cm)
3. Column Number of columns: 3
4. Upper column: air pressure
5. Middle column: hand-operated
6. Weight 40.5 lbs (18.5kg)
7. Casters Diameter of casters: 4.9" (125mm)
8. Material Corrosion resistant aluminum alloy and resin

2.10 19″ STUDIO CAMERA TELEPROMPTER SYSTEM: REFERENCED PRODUCT AUTOCUE P7008-0902

A. General
    1. Beamsplitter Ratio
        a. 70/30
    2. Beamsplitter Material
        a. Glass
    3. Anti-Reflective Coating
        a. Yes

B. Monitor
    1. Size (Diagonal)
        a. 19" / 48.3 cm
    2. Maximum Brightness
        a. 1500 nits / cd/m2
    3. Resolution
        a. 1280 x 1024
    4. Aspect Ratio
        a. 4:3
    5. Contrast Ratio
        a. 1000:1
    6. Inputs/Outputs
        a. 1x SDI Input
        b. 1x SDI Output
        c. 1x Composite Input
        d. 1x Composite Output
        e. 1x HDMI Unspecified Version Input
        f. 1x VGA Input
    7. Self Reversing
        a. Yes
    8. AC Input Power
        a. 110 to 240 VAC, 50 / 60 Hz
    9. Power I/O
        a. 1x Proprietary Output
    10. Output Voltage
        a. 12 VDC at 3 A
    11. Power Consumption
        a. 35 W
    12. Dimensions
        a. 16.5 x 14" / 420 x 356 mm
    13. Weight
        a. 9.7 lb / 4.4 kg

C. Physical
    1. Material of Construction

a. Metal
2. Height Adjustment
   a. 3.5" / 90 mm
3. Dimensions
   a. 26.6 x 17.9 x 32.0" / 675.0 x 455.0 x 813.0 mm
4. Weight
   a. 26.0 lb / 11.8 kg

2.11 4K 12G-SDI VIDEO SWITCHER: REFERENCED PRODUCT BLACKMAGIC ATEM TELEVISION STUDIO 4K8

A. Connections
1. SDI Video Inputs
   a. 8
2. SDI Video Outputs
   a. 12
3. SDI Rates
   a. 1.5G, 3G, 6G, 12G
4. HDMI Video Outputs
   a. 1
5. Total Audio Inputs
   a. 2 x XLR balanced analog audio,
   b. 1 x BNC 32 Ch MADI digital audio,
   c. 2 x RCA stereo analog audio,
   d. 1 x 5 pin XLR Talkback.
6. Total Audio Outputs
   a. 4 x 1/4 inch Jack analog audio,
   b. 1 x BNC 64 Ch MADI digital audio, up to 50 active,
   c. 1 x 5 pin XLR Talkback.
   d. SDI Audio Inputs
   e. 4 Ch embedded audio on all SDI inputs.
7. SDI Audio Outputs
   a. 16 assignable channels.
8. Timecode Connections
   a. 1 x BNC In, 1 x BNC Out.
9. Reference Input
   a. 1 x BNC In, 1 x BNC Out.
10. Tri-Sync or Black Burst.
11. Video Input Re-Sync
   a. On all 8 inputs.
12. Frame Rate and Format Converters

a. On all 8 inputs.

13. SDI Aux Outputs
    a. 10
14. SDI Program Outputs
    a. 1
15. Webcam Output
    a. 2 x USB-C supporting 720p or 1080p at PGM frame rate.
16. Total Multi Views
    a. 1 x 12G-SDI
    b. 1 x HDMI 2.0
17. Remote
    a. RJ12 supports RS-422
18. Control Panel Connection
    a. Ethernet. Direct connection between panel and chassis, or via network.
19. Internal Timecode Generator
    a. Yes
20. Talkback
    a. RJ45 for 3rd party talkback systems.
21. Tally Output
    a. Added via ethernet connection to Blackmagic Design GPI and Tally Interface product. (Not included).
22. Ethernet
    a. 4 x RJ45 with internet network switch. Supports 10/100/1000/10G BASE-T.
23. Computer Interface
    a. 2 x USB-C supports USB 2.0 for external drive recording, webcam out, software control, software updates and switcher connection.

B. Standards
    1. SD Video Standards
        a. None
    2. HD Video Input Standards
        a. 720p50, 720p59.94, 720p60
        b. 1080i50, 1080i59.94, 1080i60
        c. 1080p23.98, 1080p24, 1080p25, 1080p29.97, 1080p30, 1080p50, 1080p59.94, 1080p60
    3. Ultra HD Video Input Standards
        a. 2160p23.98, 2160p24, 2160p25, 2160p29.97
        b. 2160p30, 2160p50, 2160p59.94, 2160p60
    4. SDI Compliance
        a. SMPTE 292M, SMPTE 296M, SMPTE 424M, SMPTE 425M level A and B, SMPTE 2081-1, SMPTE 2081-10, SMPTE 2082-1 and SMPTE 2082-10.
    5. Video Sampling

a. 4:2:2
6. Color Precision
   a. 10-bit.
7. Color Space
   a. REC 709, REC 2020
8. SDI Auto Switching
   a. Automatically detects between 1.5G-SDI, level A or level B 3G-SDI, 6G-SDI and 12G-SDI.

C. Product Specifics
1. Number of Mix Effects Rows
   a. 1
2. Direct Cross Points
   a. 10
3. Shifted Cross Points
   a. 20
4. Crosspoint Button Type
   a. Tri-Color LED
5. Crosspoint Label
   a. 6 rows 24 character LCD
6. Preview Transition
   a. 1
7. Source Select Bus
   a. 1
8. Dedicated Macro Buttons
   a. 10 plus shift 10
9. Transition Type Buttons
   a. 5
10. Transition Rate
    a. Set via system LCD menu display
11. Key Buttons
    a. 8
12. AUX Buttons
    a. 12
13. Fader Bar
    a. 1
14. Record Buttons
    a. 2
15. Stream Buttons
    a. 2
16. DSK Transition Selectors
    a. 6

17. Fade to Black Buttons
    a. 1
18. System LCD Displays
    a. 1
19. Numeric Keypad
    a. 1
20. 3 Axis Joystick
    a. 1
21. Upstream Keyers
    a. 4
22. Downstream Keyers
    a. 2
23. Advanced Chroma Keyers
    a. 4
24. SuperSource
    a. 1
25. DVEs
    a. 2
26. Linear/Luma Keyers
    a. 7
27. Transition Keyer (Stinger/DVE)
    a. 1 Stinger, 1 DVE.
28. Total Number of Layers
    a. 8
29. Pattern Generators
    a. 7
30. Color Generators
    a. 2
31. Control Panel
    a. Integrated panel with full control of switching and settings.
32. Routable Windows
    a. 16
33. Windows Source Labels
    a. Yes
34. Tally
    a. Red for program and green for preview indication.
35. Talkback Support
    a. Yes
36. Mix Minus Support
    a. Yes

D. Streaming

1. Direct Streaming
    a. Supports direct live streaming using Real Time Messaging Protocol (RTMP) over ethernet or a shared internet connection over USB-C.

E. Recording
1. Direct Recording Video and Audio
    a. Direct recording to optional internal M.2 flash memory or to external media via USB-C expansion ports.
2. Video Recording
    a. HD programs recorded as a H.264 .mp4 file at the streaming quality setting and at the ATEM video HD standard with AAC audio.
    b. Ultra HD programs recorded as a H.265 HEVC file at the streaming quality setting and at the ATEM video Ultra HD standard with AAC audio.
3. Media Format
    a. Supports media formatted ExFAT (Windows/Mac). APFS or HFS+ (Mac).

F. Multi View Monitoring
1. Multi View Monitoring
    a. 1 x multi view via SDI and HDMI configurable to 16, 13, 10, 7 or 4 up views. Includes monitoring of Program, Preview, Inputs, Media Players, DSKs, SuperSource, Clean Feed with optional labels and audio meters.
2. Multi View Video Standard
    a. HD or Ultra HD
3. Display Minimum Resolution
    a. 1366 x 768

G. Media Player
1. Media Players
    a. 2
2. Channels
    a. Fill and key for each media player.
3. Media Pool Still Image Capacity
    a. 20
4. Media Pool Still Image Format
    a. PNG, TGA, BMP, GIF, JPEG and TIFF.
5. Media Pool Clip Capacity
    a. 2 x up to 2160p60.
6. Media Player Clip Length in 720 HD
    a. 720 frames.
7. Media Player Clip Length in 1080 HD
    a. 360 frames.
8. Media Player Clip Length in 2160 HD
    a. 90 frames.
9. Media Pool Video File Format

a. TGA sequence.

10. Media Pool Audio File Format
    a. WAV, MP3 and AIFF.

H. Processing
1. Processing Delay
    a. < 10 lines when genlocked and in the same format as the switcher.
2. Audio Mixer
    a. 58 Channel mixer.
    b. Selectable On/Off/Audio-Follow-Video.
    c. Level and Peak metering.
    d. Master gain control.
    e. 6 band parametric EQ, Dynamics including Expander, Gate, Compressor and Limiter.
3. Camera Control
    a. When used with most Blackmagic Design cameras, ATEM can control focus, iris and zoom of compatible lenses and camera settings including gain, white balance, tint, shutter, ND filter, color corrector, tally and record start/stop.
4. Down Conversion
    a. 1 x multi view

I. Power Requirements
1. Power Supply
    a. 1 x Internal 100 - 240 AC 50/60Hz with IEC C14 socket.
    b. 1 x 4 pin XLR 12V DC In for external power supply or battery use.

J. Environmental Specifications
1. Operating Temperature
    a. 0° to 40° C (32° to 104° F)
2. Storage Temperature
    a. -20° to 60° C (-4° to 140° F)
3. Relative Humidity
    a. 0% to 90% non-condensing

2.12 4K UHD SOLID STATE RECORDER: REFERENCED PRODUCT BLACKMAGIC HYPERDECK EXTREME 4K HDR

A. General
1. Compatibility
    a. Blackmagic Design ATEM Mini

B. Inputs / Outputs
1. USB I/O
    a. 1 x USB-C 3.0 / 3.1/3.2 Gen 1 Female Output

2. Video I/O
    a. 1x BNC (12G-SDI) Input
    b. 2x BNC (12G-SDI) Output
    c. 1x BNC (Component) Input
    d. 1x HDMI 2.0 Input
    e. 1x HDMI 2.0 Output
    f. 1x BNC (3G-SDI) Monitor Output
    g. 1x USB-C Output
3. Audio I/O
    a. 4x XLR 3-Pin Input
    b. 4x XLR 3-Pin Output
    c. 1x 2RCA Input

C. Power
1. Power Source
    a. AC Input (Built-In)
2. AC Input Power
    a. 100 to 240 VAC, 50 / 60 Hz
3. DC Input Power
    a. 12 VDC
4. Power Consumption
    a. 190 W

D. Environmental
1. Operating Temperature
2. 32 to 72°F / 0 to 40°C
3. Operating Humidity
4. 0 to 90% (Non-Condensing)
5. Storage Temperature
6. -4 to 140°F / -20 to 60°C
7. Storage Humidity
8. 0 to 90% (Non-Condensing)
9. Physical
10. Dimensions
11. 13.15 x 8.28 x 5.14" / 33.4 x 21.03 x 13.06 cm
12. Weight
13. 7.94 oz / 225 g

2.13 MULTI-RECORDER CONTROLLER: REFERENCED PRODUCT BLACKMAGIC HYPERDECK EXTREME CONTROL

A. Deck Control Outputs
   1. 8 x RS-422
B. Reference Input
   1. Tri-Sync or Black Burst
C. Reference Output
   1. Follows Reference Input
D. Ethernet
   1. 1 Gb/s
E. Computer Interface
   1. 1 x USB Type-C
F. Control Protocols
   1. Sony
G. Internal Software Upgrade
   1. Loaded at System Start or via Blackmagic HyperDeck Setup Using USB Port
H. Compatible Operating Systems
   1. Mac 10.13 High Sierra, 10.14 Mojave, or later
   2. Windows 8.1 or 10
I. Display
   1. 8-Digit, 7-Segment LED Timecode Display
J. Power Supply
   1. 1 x Internal 100 - 240 VAC
   2. 1 x 4-Pin XLR 12 VDC
K. Operating Temperature
   1. 32 to 104°F / 0 to 40°C
L. Storage Temperature
   1. -4 to 113°F / -20 to 60°C
M. Relative Humidity
   1. 0 to 90% Non-Condensing
N. Rack Compatibility
   1. 3 RU, Half Rack Width
O. Dimensions
   1. 8.3 x 5.1 x 13.8" / 21 x 13 x 35 cm
P. Weight
   1. 3.5 lb / 1.6 kg

2.14 1 TB COMPACT FLASH DRIVE: REFERENCED PRODUCT ANGELBIRD 1 TB AV PRO CF

A. Card Type
   1. CFast 2.0
B. Storage Capacity
   1. 1 TB
C. Bus Type
   1. SATA III
D. Read Speed
   1. Maximum: 560 MB/s
   2. Sustained: 550 MB/s
E. Write Speed
   1. Maximum: 525 MB/s
   2. Sustained: 480 MB/s
F. Operating Temperature
   1. 32 to 158°F / 0 to 70°C
G. Storage Temperature
   1. -40 to 185°F / -40 to 85°C
H. Certifications
   1. CE, RoHS, FCC, UKCA

2.15 4K CAPTURE / PLAYBACK USB-C INTERFACE: REFERENCED PRODUCT BLACKMAGIC ULTRASTUDIO MINI 4K

A. System Connection
   1. USB-C (Thunderbolt 3)
B. Video Inputs
   1. 1x BNC (12G-SDI)
   2. 1x HDMI (2.0b)
   3. 2x Coax (Component)
C. Audio Inputs
   1. 1x XLR 3-Pin
   2. 1x 2RCA Stereo
D. Video Outputs
   1. 2x BNC (12G-SDI) (Program)
   2. 1x BNC (12G-SDI) (Loop Output)
   3. 1x HDMI (2.0b)
   4. 2x Coax (Component)

E. Audio Outputs
   1. 1x 2RCA Stereo Female
   2. 1x 1/4" TRS Female

F. Other I/O
   1. 1x USB-C
   2. 1x DE-9/DB-9 Control

G. Input Video Format
   1. SDI (10-Bit 4:4:4/4:2:2 YUV)
      a. DCI 4K up to 60 fps
   2. SDI (12-Bit 4:4:4/4:2:2 YUV)
      a. DCI 4K up to 30 fps
      b. UHD 4K up to 60 fps
      c. DCI 2K up to 60 fps
      d. DCI 2KPsF up to 30 fps
      e. 1080p up to 60 fps
      f. 1080i up to 60 fps
      g. 720p up to 60 fps
      h. 480i / 525 lines at 59.94 fps
      i. 576i / 625 lines at 50 fps
   3. HDMI (8/10/12-Bit 4:4:4/4:2:2/4:2:0)
      a. DCI 4K up to 60 fps
      b. UHD 4K up to 60 fps
      c. 1080p up to 60 fps
      d. 1080i up to 60 fps
      e. 720p up to 60 fps
      f. 480i / 525 lines at 59.94 fps
      g. 576i / 625 lines at 50 fps

H. Input Audio Format
   1. Analog: 48 kHz

I. Output Video Format
   1. SDI (10-Bit 4:4:4/4:2:2)
      a. DCI 4K up to 60 fps
   2. SDI (12-Bit 4:4:4/4:2:2)
      a. DCI 4K up to 30 fps
      b. UHD 4K up to 60 fps
      c. DCI 2K up to 60 fps
      d. DCI 2KPsF up to 30 fps
      e. 1080p up to 60 fps
      f. 1080i up to 60 fps
      g. 720p up to 60 fps
      h. 480i / 525 lines at 59.94 fps

i. 576i / 625 lines at 50 fps

3. HDMI (8/10/12-Bit 4:4:4/4:2:2/4:2:0)
   a. DCI 4K up to 60 fps
   b. UHD 4K up to 60 fps
   c. 1080p up to 60 fps
   d. 1080i up to 60 fps
      1) 720p up to 60 fps
   e. 480i / 525 lines at 59.94 fps
   f. 576i / 625 lines at 50 fps

J. Output Audio Format
   1. Analog: 48 kHz

K. Embedded Audio
   1. SDI: 16-Channel
   2. HDMI: 8-Channel

L. Standards
   1. Video Standard Compliance
      a. SMPTE 259M/274M/296M/424M/425M-A/425M-B/2048-1/ST-2036/ST-2081-10/ST-2082-10/ST-2108-1
      b. HDR Compatibility
      c. HDR10, Hybrid Log Gamma

M. Hardware
   1. Media Card Reader
      a. 1x SD (Unspecified Type) (UHS-II [312 MB/s])

N. OS Compatibility
   1. macOS 11.1 to 12.0 or Later
   2. Windows 10 to 11 (64-Bit Only)
   3. Linux

O. Power I/O
   1. 1x USB-C Output
   2. 1x Barrel Input

P. Power Consumption
   1. Power Supply: 100 to 240 VAC (75.3 W)

Q. Environmental
   1. Operating Temperature
      a. 37 to 72°F / 5 to 40°C
   2. Storage Temperature
      a. -4 to 113°F / -20 to 45°C
   3. Operating Humidity
      a. 0 to 90% ()

R. General
    1. Certifications
        a. FCC, ICES

S. Dimensions
    1. 7 x 1.8" / 17.8 x 4.6 cm

T. Weight
    1. 2.65 lb / 1.2 kg

2.16 VIDEO CONVERTERS

A. BLACKMAGIC MINICONVERTER SDI DISTRIBUTION 4K
    1. Interfaces
        a. Inputs
            1) 1 x BNC (6G-SDI)
        b. Outputs
            1) 8x BNC (6G-SDI)
        c. Other I/O
            1) 1x USB-A (Firmware)
    2. Standards
        a. Video Standard Compliance
            1) SMPTE 259M/292M/296M/372M/425M
        b. Reclocking
            1) Yes
        c. Transmission
            1) Video Format
                a. SDI (4:2:2 RGB, YUV)
                    NTSC: 23.98/29.97 fps
                    PAL: 25 fps
                    720p: 59.94/60 fps
                    1080i: 50/59.94/60 fps
                    1080PsF: 23.98/24/25/29.97/30 fps
                    1080p: 23.98/24/25/29.97/30/50/59.94/60 fps
                    DCI 2KPsF: 23.98/24/25 fps
                    DCI 2K: 23.98/24/25 fps
                    UHD 4K: 23.98/24/25/29.97/30 fps
                    DCI 4K: 24 fps
            2) Maximum Sampling Rate
                a. 48 kHz / 24-Bit
        d. Power
            1) Power Consumption
            2) Power Supply: 12 to 30 VDC (4.8 W)

e. Environmental
    1) Operating Temperature
    2) 32 to 104°F / 0 to 40°C
    3) Storage Temperature
    4) -4 to 113°F / -20 to 45°C
    5) Operating Humidity
    6) 0 to 90%
f. General
    1) Dimensions
    2) 4.8 x 3.6 x 0.9" / 12.2 x 9.2 x 2.3 cm
    3) Weight
    4) 11.88 oz / 336.79 g

B. BLACKMAGIC MICRO CONVERTER BIDIRECTIONAL SDI/HDMI 12G
1. Inputs / Outputs
    a. Video Inputs
        1) 1x BNC (12G-SDI) Female
        2) 1x HDMI (2.0) Female
    b. Audio Inputs
        1) No
    c. Video Outputs
        1) 1x BNC (12G-SDI) Female
        2) 1x HDMI (2.0) Female
    d. Audio Outputs
        1) No
    e. Other I/O
        1) 1x USB-C Firmware Input (Shared Power)
2. Expansion Slots
    a. No
3. Format Support
    a. Input Video Format
        1) SDI (8/10-Bit 4:2:2 RGB, YUV)
            a. DCI 4K at 23.98/24/25/29.97/30/47.95/48/50/59.94/60 fps
            b. UHD 4K at 23.98/24/25/29.97/30/47.95/48/50/59.94/60 fps
            c. DCI 2K at 23.98/24/25/29.97/30/47.95/48/50/59.94/60 fps
            d. DCI 2KPsF at 25/29.97/30 fps
            e. 1080p at 23.98/24/25/29.97/30/47.95/48/50/59.94/60 fps
            f. 1080PsF at 25/29.97/30 fps
            g. 1080i at 50/59.94/60 fps
            h. 720p at 50/59.94/60 fps
            i. 576i / 625 lines at 50 fps
            j. 480i / 525 lines at 59.94 fps
        2) HDMI (8/10-Bit 4:2:2 RGB, YUV)

a. DCI 4K at 23.98/24/25/29.97/30/47.95/48/50/59.94/60 fps
b. UHD 4K at 23.98/24/25/29.97/30/47.95/48/50/59.94/60 fps
c. 1080p at 23.98/24/25/29.97/30/47.95/48/50/59.94/60 fps
d. 1080i at 50/59.94/60 fps
e. 720p at 50/59.94/60 fps
f. 576i / 625 lines at 50 fps
g. 480i / 525 lines at 59.94 fps

b. Output Video Format
1) SDI (8/10-Bit 4:2:2 RGB, YUV)
a. DCI 4K at 23.98/24/25/29.97/30/47.95/48/50/59.94/60 fps
b. UHD 4K at 23.98/24/25/29.97/30/47.95/48/50/59.94/60 fps
c. DCI 2K at 23.98/24/25/29.97/30/47.95/48/50/59.94/60 fps
d. DCI 2KPsF at 25/29.97/30 fps
e. 1080p at 23.98/24/25/29.97/30/47.95/48/50/59.94/60 fps
f. 1080PsF at 25/29.97/30 fps
g. 1080i at 50/59.94/60 fps
h. 720p at 50/59.94/60 fps
i. 480i / 525 lines at 29.97 fps
j. 576i / 625 lines at 25 fps
2) HDMI (8/10-Bit 4:2:2 RGB, YUV)
a. DCI 4K at 23.98/24/25/29.97/30/47.95/48/50/59.94/60 fps
b. UHD 4K at 23.98/24/25/29.97/30/47.95/48/50/59.94/60 fps
c. 1080p at 23.98/24/25/29.97/30/47.95/48/50/59.94/60 fps
d. 1080i at 50/59.94/60 fps
e. 720p at 50/59.94/60 fps
f. 576i / 625 lines at 50 fps
g. 480i / 525 lines at 59.94 fps

c. Embedded Audio
1) HDMI/SDI

4. Standards
a. Video Standard Compliance
1) SMPTE 259M/292M/296M/424M/425M-A/425M-B
b. HDCP Support
1) Yes, Version 2.2
c. HDR Compatibility
1) Not Specified by Manufacturer
d. HDMI CEC
1) Yes

5. Hardware
a. Tally Light
1) Yes
b. Wireless
1) No

c. OS Compatibility
    1) macOS 10.15.15 or Later
    2) Windows 11.1 or Later
6. Power
    a. Power I/O
        1) 1x USB-C (4.4 to 5.2 VDC) Input
    b. Power Consumption
        1) Device: 5 W
7. Environmental
    a. Operating Temperature
        1) 32 to 72°F / 0 to 40°C
    b. Storage Temperature
        1) -4 to 140°F / -20 to 60°C
    c. Operating Humidity
        1) 0 to 90%
8. General
    a. Dimensions
        1) 3.18 x 2.32 x 0.98" / 80.77 x 58.93 x 24.89 mm
    b. Weight
        1) 6.13 oz / 174 g

2.17 COMPUTER PLAYBACK DEVICE: REFERENCED PRODUCT BLACKMAGIC ULTRASTUDIO MONITOR 3G

A. Video Inputs
    1. 1x Thunderbolt
B. Audio Inputs
    1. No
C. Video Outputs
    1. 1x BNC (3G-SDI)
    2. 1x HDMI
D. Output Video Format
    1. SDI
        a. 1080p at 60 fps
    2. HDMI
        a. 1080p at 60 fps

2.18 GRAPHICS / TELEPROMPTER WORKSTATION: REFERENCED PRODUCT IMAC MQRJ3LL/A

A. Performance
    1. Processor
        a. Apple M3
    2. CPU
        a. 8-Core:
        b. Performance (4 Cores)
        c. Efficiency (4 Cores)
    3. Graphics Type
        a. Integrated
    4. GPU
        a. Apple (10-Core)
    5. Memory Type
        a. Embedded DRAM
    6. Total Installed Memory
        a. 8 GB
    7. Memory Configuration
        a. 8 GB (Onboard)
    8. ECC Memory
        a. No

B. Display
    1. Panel Type
        a. IPS-Type LCD
    2. Display Size
        a. 23.5"
    3. Aspect Ratio
        a. 16:9
    4. Resolution
        a. 4480 x 2520
    5. Touchscreen
        a. No
    6. Finish
        a. Glossy with Antireflective Coating
    7. Maximum Brightness
        a. 500 nits / cd/m2
    8. Refresh Rate
        a. 60 Hz

C. Storage and Expansion
    1. Total Installed Capacity
        a. 256 GB
    2. Storage Drive Type
        a. 1x 256 GB / Integrated NVMe SSD

3. Optical Drive
    a. No

D. Inputs / Outputs
1. Inputs/Outputs
    a. 2x USB-C (Thunderbolt 3 / USB4)
    b. 2x USB-C 3.1/3.2 Gen 2
2. Audio I/O
    a. 1x 1/8" / 3.5 mm Headphone/Microphone Input/Output
3. Network I/O
    a. 1x RJ45 (Gigabit Ethernet)
4. Built-In Speakers
    a. 6
5. Built-In Microphones
    a. 3
6. Media/Memory Card Slot
    a. No

E. Communications
1. Wi-Fi
    a. Wi-Fi 6E (802.11ax) with MU-MIMO Support
2. Bluetooth
    a. 5.3
3. Webcam
    a. User-Facing: 1080p

F. Keyboard & Mouse
1. Keyboard
    a. Wireless Chiclet-Style Keyboard
2. Pointing Device
    a. Wireless Mouse

G. General
1. Security
    a. Fingerprint Reader
2. Power Supply
    a. 143 W with Barrel/Proprietary
3. AC Input Power
    a. 100 to 240 VAC, 50 / 60 Hz
4. Operating Temperature
    a. 50 to 95°F / 10 to 35°C
5. Operating Humidity
    a. 5 to 90%
6. Certifications
    a. ENERGY STAR

7. Dimensions
    a. 21.5 x 18.1 x 5.8" / 546.1 x 459.7 x 147.3 mm
8. Weight
    a. 9.87 lb / 4.48 kg

2.19 LED DISPLAYS

A. 4K 65" LED DISPLAY: REFERENCED PRODUCT PANASONIC TH-65SQE2
    1. Screen size (diagonal)
        a. 65-inch (1638.9 mm)
    2. Aspect Ratio
        a. 16:9
    3. Panel Type
        a. IPS Panel / Edge-LED
    4. Effective display area (W x H)
        a. 56.23 x 31.36 inch (1428.4 x 803.5 mm)
    5. Resolution
        a. 3840 x 2160
    6. Brightness (typ.)
        a. 500 cd/m2
    7. Contrast Ratio
        a. 1200:1 (Typ)
    8. Response Time
        a. 8 ms (G to G)
    9. Terminals
        a. HDMI IN
            1) HDMI TYPE-A Connector x 2
        b. DisplayPort IN
            1) DisplayPort x 1
        c. DisplayPort OUT
            1) DisplayPort x 1
        d. DVI-D IN/AUDIO IN (L/R)
            1) DVI-D 24-pin x 1/ Stereo Mini Jack (M3) x 2 (Shared with PC In)
        e. PC IN/AUDIO IN (L/R)
            1) Mini D-sub 15-pin x 1/ Stereo Mini Jack (M3) x 2 (Shared with DVI-D In)
        f. USB
            1) USB Connector (TYPE A) x 2, DC 5 V/2 A (USB 3.0 supported)
        g. Serial
            1) D-sub 9-pin x 1, RS232C Compatible
        h. IR IN / OUT
            1) Stereo Mini Jack (M3) x 1 / x 1

i. AUDIO OUT
   1) 30 W [15 W + 15 W] 10% THD
j. DIGITAL LINK
   1) RJ45 x 1, 100 BASE-TX, Compatible with long reach mode and PJLink™
k. LAN
   1) RJ45 x 1, 10 BASE-T / 100 BASE-TX, Compatible with PJLink™
l. Slot
   1) Intel® SDM specification
   2) Corresponding size SDM-S / SDM-L, Supply power 12 V / 5.5 A, 3.3 V / 1.1 A

10. Built-in Speaker
    a. 20 W [10 W + 10 W]
11. Power Requirements
    a. 110-127 V AC, 50/60 Hz, 220-240 V AC, 50/60 Hz
12. Power consumption
    a. 480 W
13. Power Off Condition
    a. Approx. 0.3 W
14. Stand-by Condition
    a. Approx. 0.5 W
15. Dimensions (W x H x D) (inch)
    a. 57.4" x 32.9" x 2.91" (1458 x 836 x 74 mm)
16. Bezel width (T/B/L/R)
    a. 0.60 inch (15.2 mm)
17. Operating Time
    a. 24 h/day
18. Wall-hanging pitch (inch)
    a. 15.8″ x 15.8″ VESA Compliant
19. Tilting angle
    a. 0-20 degrees forward/backward with landscape/portrait setting
20. Viewing angle [(T/B)/(L/R)]
    a. 178°/178° (CR≧10)
21. Wall-hanging pitch (mm)
    a. 400 x 400 mm VESA Compliant
22. Operating environment
    a. Temperature 0 °C to 40 °C (32°F to 104°F)
    b. Humidity 20% to 80% (Non-condensation)
    c. Altitude 0~2800 m (7874 ft)
23. Orientation
    a. Landscape/Portrait (Angle adjustment is not possible for portrait installation.)

B. 31″ 12G-SDI BROADCAST MONITOR: REFERENCED PRODUCT LILLIPUT Q31-8K-VPB

1. Display
    a. Panel Type
        1) IPS-Type LCD
    b. Display Size
        1) 31.5" / 80.0 cm
    c. Resolution
        1) 3840 x 2160
    d. Aspect Ratio
        1) 16:9
    e. Viewing Angle
        1) Horizontal: 178°
        2) Vertical: 178°
    f. Touchscreen
        1) No
    g. Maximum Brightness
        1) 350 nits / cd/m2
    h. Contrast Ratio
        1) 1300:1
    i. HDR Compatibility
        1) Hybrid Log Gamma
    j. Pixels Per Inch (ppi)
        1) 139 ppi
    k. Image Controls
        1) Color Temperature Selection, Customizable Aspect Ratios, False Color, Focus Peaking, Image Flip, Picture-in-Picture, Underscan
2. Inputs / Outputs
    a. Video I/O
        1) 4x BNC (12G-SDI) Input
        2) 4x BNC (12G-SDI) Output
        3) 1x HDMI 2.0 Input
        4) 1x HDMI 2.0 Output
        5) 1x SFP+ (12G-SDI) Input
    b. Embedded Audio
        1) Fiber/HDMI/SDI
    c. Audio I/O
        1) 1x 1/8" / 3.5 mm Headphone Input
    d. Built-In Speaker
        1) 1
    e. Power I/O
        1) 1x XLR 4-Pin (15 VDC) Input
    f. Other I/O
        1) 1x DE-15/DB-15 (Tally)

g. Media/Memory Card Slot
    1) No
h. Wi-Fi
    1) No
i. Bluetooth
    1) No
j. Mobile App Compatible
    1) No

3. Format Support
    a. Video Format
        1) HDMI
            a. UHD 4K: 60/50/30/25/24
            b. 1080p: 60/50/30/25/24
            c. 1080i: 60/50
            d. 720p: 60/50
        2) Fiber
            a. UHD 4K: 60/50/30/25/24
            b. 1080p: 60/50/30/25/24
            c. 1080PsF: 30/25/24
            d. 1080i: 60/50
            e. 720p: 60/50
        3) SDI
            a. 8K: 60/50/30/25/24
            b. UHD 4K: 60/50/30/25/24
            c. 1080p: 60/50/30/25/24
            d. 1080PsF: 30/25/24
            e. 1080i: 60/50
            f. 720p: 60/50
4. Power
    a. DC Input Power
        1) 12 to 24 VDC
    b. Battery Type
        1) 1x V-Mount
    c. Power Consumption
        1) 79 W
5. Environmental
    a. Certifications
        1) No
    b. Operating Temperature
        1) 32 to 122°F / 0 to 50°C
    c. Storage Temperature
        1) -4 to 140°F / -20 to 60°C

6. General
    a. Dimensions
        1) 28.2 x 18.2 x 1.9" / 717.5 x 461.7 x 47.4 mm
    b. Weight
        1) 28.7 lb / 13 kg

2.20 4K30P PTZ CAMERA: REFERENCED PRODUCT PANASONIC AW-UE40

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

2.21 40 CHANNEL 25 BUS DIGITAL CONSOLE: REFERENCED PRODUCT MIDAS M32R

A. Processing
   1. Input Channels: 32 input channels, 8 aux channels, 8 FX return channels
   2. Output Channels: 8 / 16
   3. Buses: 16 aux buses, 6 matrices, main LRC: 100
   4. Effects Engine: 8 / 16, (True Stereo / Mono)
   5. Automation: Internal Show Automation (Structured Cues / Snippets): 500 / 100
   6. Scenes: Internal Total Recall Scenes (Incl. Preamplifiers and Faders): 100
   7. Signal Processing: 40-bit floating point
   8. A/D and D/A Conversion:
      a. A/D Conversion (8-channel, 96 kHz Ready): 24-bit, 114 dB dynamic range, A-weighted
      b. D/A Conversion (stereo, 96 kHz Ready): 24-bit, 120 dB dynamic range, A-weighted
   9. Latency
      a. 0.8 ms, (I/O, console input to output)
      b. 1.1 ms, (network latency, stage box in > console > stage box out)

B. Connectors
   1. Preamplifier Midas PRO Series Microphone Preamplifiers (XLR): 16
   2. Talkback Talkback Microphone Input (XLR): 1
   3. RCA RCA Inputs / Outputs: 2 / 2
   4. Audio Out (XLR) XLR Outputs: 8
   5. Monitoring Outputs Monitoring Outputs (XLR / ¼" TRS Balanced): 2 / 2
   6. Auxiliary Aux Inputs/Outputs (¼" TRS Balanced): 6 / 6
   7. Headphones Phones Output (¼" TRS): 1 (Stereo)
   8. Networking AES50 Ports (Klark Teknik SuperMAC): 2
   9. Ultranet P-16 Connector (No Power Supplied): 1
   10. Expansion Expansion Card Interface: 32 Channel Audio Input / Output
   11. MIDI MIDI Inputs / Outputs: 1 / 1
   12. USB USB Type A (Audio and Data Import / Export): 1
   13. USB Type B: 1, rear panel, for remote control
   14. Ethernet RJ45: 1, rear panel, for remote control

C. Microphone Inputs
   1. Design Midas PRO Series
   2. THD+N THD+N (0 dB gain, 0 dBu output): <0.01% unweighted
   3. THD+N (+40 dB gain, 0 to +20 dBu output): <0.03% (unweighted)
   4. Input Impedance Input Impedance (Unbalanced / Balanced): 10 kOhms / 10 kOhms
   5. Maximum Input Level Non-Clip Maximum Input Level: +23 dBu

6. Phantom Power +48 V, (switchable per input)
7. Equivalent Input Noise @ +45 dB gain (150 ohm source): -125 dB (22 Hz - 22 kHz, unweighted)
8. CMRR CMRR @ Unity Gain (Typical): >70 dB
9. CMRR @ 40 dB Gain (Typical): >90 dB

D. Input/Output
1. Frequency Response @ 48 kHz Sample Rate: 0 to -1 dB (20 Hz - 20 kHz)
2. Dynamic Range
   a. Analog In to Analog Out: 106 dB (22 Hz - 22 kHz, unweighted)
   b. A/D, Preamplifier and Converter (Typical): 109 dB (22 Hz - 22 kHz, unweighted)
   c. D/A, Converter and Output (Typical): 109 dB (22 Hz - 22 kHz, unweighted)
3. Crosstalk Rejection: Typically @ 1 kHz 100 dB, adjacent channels
4. Output Level: XLR Connectors (Nominal / Maximum): +4 dBu / +21 dBu
5. Output Impedance
   a. XLR Connectors (Unbalanced / Balanced): 50 ohms / 50 ohms
   b. TRS (Unbalanced / Balanced): 50 ohms / 50 ohms
   c. Phones Output Impedance / Maximum output Level: 40 ohms / +21 dBu (Stereo)
6. Input Impedance: TRS Connectors (Unbalanced / Balanced): 20 kOhms / 40 kOhms
7. Maximum Input Level: Non-Clip Maximum Input Level, TRS Connectors: +21 dBu
8. Output Level: TRS (Nominal / Maximum): +4 dBu / +21 dBu
9. Residual Noise
   a. Residual Noise Level, Out 1-16 XLR Connectors, Unity Gain: -85 dBu 22 Hz - 22 kHz unweighted
   b. Residual Noise Level, Out 1-16 XLR Connectors, Muted: -88 dBu 22 Hz - 22 kHz unweighted
   c. Residual Noise Level, TRS and Monitor out XLR Connectors: -83 dBu 22 Hz - 22 kHz unweighted

E. Display
1. Screens Main Screen: 5" TFT LCD, 800 x 480 resolution, 262 k colors
2. Channel LCD Screen: 128 x 64 LCD with RGB color backlight
3. Main Meter: 18-segment (-45 dB to clip)

F. Power
1. Power Supply Switch-Mode Power Supply: Auto-ranging 100 - 240 VAC (50 / 60 Hz) ±10%
2. Power Consumption 70 W

G. Physical
1. Operating Temperature 41 - 104°F (5 - 40°C)
2. Dimensions 18.8 x 24.3 x 8.2" (478 x 617 x 208 mm)

H. Weight 31.5 lb (14.3 kg)

2.22 PERSONAL MONITOR 16 CHANNEL DIGITAL INTERFACE: REFERENCED PRODUCT BEHRINGER P16-I

A. Input Module
   1. Analog Inputs
      a. Inputs 16 x 1/4" TRS, balanced, line-level
      b. Input level +4 dBu optimal, +22 dBu maximal
      c. Input gain -10 dBV / 0 dBu / +4 dBu / +22 dBu, adjustable
      d. Gain selector 4-position switch (per channel)
   2. Digital Inputs
      a. Optical inputs 2 x standard TOS-link optical connector
      b. Input format ADAT, 16 / 20 / 24-bit 48 kHz (standard)/ 44.1 kHz
      c. 8 channels per ADAT connection
      d. Synchronization From ADAT input A only (external clock)
      e. Indicators 2 x LED's
      f. Input selection Auto select for channels 1 – 8 / 9 – 16

B. Digital Outputs (Ultranet)
   1. Connectors 6 x RJ45

C. Power Supply / Voltage (Fuses)
   1. USA / Canada 120 V~, 60 Hz (T 1 A H 250 V)
   2. UK / Australia / Europe 220-240 V~, 50/60 Hz (T 1 A H 250 V)
   3. Korea / China 220-240 V~, 50/60 Hz (T 1 A H 250 V)
   4. Japan 100 V~, 50/60 Hz (T 1 A H 250 V)

D. Power consumption max. 40 W

E. Mains connection Standard IEC receptacle

F. Dimensions / Weight
   1. Dimensions (H x W x D) appr. 1.7 x 19 x 7.5" appr. 44 x 482 x 190 mm (1U)
   2. Weight appr. 4.6 lbs / 2.1 kg

G. Ultranet Digital Network

H. Digital Processing
   1. A/D conversion 24-bit 48 kHz (standard for analog in) 44.1 kHz (if ADAT 44.1 kHz)
   2. Converter type 24-bit, delta-sigma

I. System
   1. Signal 16 channels, plus bus-power for P16-M
   2. Latency <0.9 ms (from P16-I to P16-M)
   3. Frequency response 20 Hz to 20 kHz (+0 / -3 dB)
   4. Dynamic range typical 92 dB

J. Cabling

1. • Connectors RJ45
2. • Cables Shielded CAT5
3. • Cable length max. 246 ft / 75 m recommended

2.23 PERSONAL MONITOR CONTROL SURFACE: REFERENCED PRODUCT BEHRINGER P16-M

A. Personal Mixer

B. Connections
   1. Phones 1/4" TRS, stereo
   2. Line out 2 x 1/4" TS, unbalanced
   3. Ultranet Thru / In 2 x RJ45
   4. MIDI in 5-pin MIDI connector

C. Controls
   1. Equalizer
      a. Bass ±12 dB @ 100 Hz, shelving
      b. Mid ±12 dB @ 100 Hz, semi-parametric
      c. Frequency 100 Hz to 10 kHz, adjustable
      d. Treble ±12 dB @ 10 kHz, shelving
   2. Output
      a. Limiter Ratio ∞:1
      b. Level -20 to +15 dBu (Phones)

D. Power Supply
   1. Power consumption max. 5 W (with ESPS1 adaptor)
   2. Mains connection External power supply ESPS1 (included) or P16-I / P16-D

E. Dimensions / Weight
   1. Dimensions (H x W x D) appr. 9.4 x 5.0 x 2.2" appr. 238 x 127 x 55 mm
   2. Weight appr. 1.8 lbs / 0.8 kg

F. Ultranet Digital Network

G. Digital Processing
   1. D/A conversion 24-bit, 44.1 / 48 kHz sample rate
   2. Converter type 24-bit, delta-sigma

H. System
   1. Signal 16 channels, plus bus-power for P16-M
   2. Latency <0.9 ms (from P16-I to P16-M)
   3. Frequency response 20 Hz to 20 kHz (+0 / -3 dB)
   4. Dynamic range typical 92 dB

I. Cabling
   1. Connectors RJ45
   2. Cables Shielded CAT5

3. Cable length max. 246 ft / 75 m recommended

2.24 PERSONAL MONITOR SYSTEM HEADPHONES: REFERENCED PRODUCT SENNHEISER HD-280PRO

A. Transducer: Dynamic
B. Ear coupling: Circumaural, Closed
C. Frequency response: 8 Hz - 25 kHz
D. Characteristic SPL: 113 dB (at 1 kHz/1Vrms)
E. THD: <0.1%
F. Nominal impedance: 64 Ohms
G. Weight (without cable): 285 grams
H. Connection cable: 1 meter single-sided coiled cable, OFC copper
I. Connector: 3.5 mm stereo mini jack with screw-on 1/4" adapter

2.25 MIXING CONSOLE 16 CHANNEL: REFERENCED PRODUCT MACKIE 1604 VLZ PRO

A. Sixteen Mic inputs with low noise preamps:
   1. 60 dB gain range
   2. 130 dB dynamic range
   3. +22 dBu line input handling
   4. Distortion under 0.005% (20 Hz - 20 kHz)
B. 16 line inputs, 16 channel inserts
C. Phantom power
D. 60mm logarithmic-taper faders on all channels, groups, and master except mono
E. 6 aux sends, level, pan, -20, Solo & overload LED's on each channel
F. 4 stereo aux returns, 8 direct outs
G. 3-band active EQ with sweepable midrange + 18 dB/oct. 75 Hz Lo Cut filter
H. Control Room/Phones multi-input source matrix
I. Balanced 1/4" inputs & outputs (except inserts)
J. 5 physical configurations via optional rotating I/O pod
K. Steel main chassis, sealed rotary controlsRack Mountable in 11 Spaces

2.26 28 PORT GIGABIT POE+ MANAGED SWITCH: REFERENCED PRODUCT LUXUL AMS-2624P

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

2.27 12 PORT/8 POE+ GIGABIT MANAGED NETWORK SWITCH: REFERENCED PRODUCT LUXUL AMS-1208P

A. Standards

1. IEEE 802.3, IEEE 802.3u, IEEE 802.3z, IEEE 802.3ab, IEEE 802.3af,
2. IEEE 802.1D, IEEE 802.3x

B. Interface

1. RJ-45
2. 10 Base-T: Cat.5 UTP /STP
3. 100 Base-TX: Cat.5 UTP /STP
4. 1000Base-T: Cat.5, Cat.5e or Cat.6 UTP/STP
5. Gigabit Fiber Uplinks on SFP ports
6. Ethernet Cable Recognition for Straight-through or
7. Crossover Cables

C. Surge Protection

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

D. LEDS

1. Front Back
2. Per Unit: Power
3. Per Port: Link/Activity
4. Dual color, user selectable
5. Per Port: Link/Activity

6. 10/100/1000

E. Power

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

F. Power Budget

1. 130 Watts Maximum

G. Max Power Consumption

1. 168W

H. VLAN

1. 802.1Q Max 4094 VIDs
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 and Port-based Priority Queues
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: 2000Mbps (Full-duplex

K. AV Series

1. LEDs on the front, Ports on the back.

L. Layer 3

1. Layer 3 Static Routing

M. Operating Temperature

1. 32°F to 104ºF (0°C to 40°C)

N. Operating Humidity

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

O. Dimensions LxWxH in. (mm)

1. 17.3”(436.30) x 8.25”(209.55) x 1.75”(44.5)

P. Weight lbs (kg)

1. 6.2 (2.8)

Q. Certification

1. FCC, CE, RoHS

2.28 WIFI 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

2.29 POWERED SPEAKERS:

A. POWERED NEAR FIELD MONITORS: REFERENCED PRODUCT KRK ROKIT5
    1. Drivers: Woofer: 5" Glass Aramid Composite Woofer
    2. Tweeter: 1" Neodymium Soft Dome Tweeter with Ferro Fluid
    3. Input: XLR (3-pin), RCA & 1/4" TRS - 10k Ohm, Balanced / Unbalanced
    4. Amplification: 75 Watt Bi-amp Dynamic Power, 18 dB Octave Filters
    5. Freq Response: 53Hz - 20kHz (+/- 1.5 db)
    6. Video Shielding: Yes

2.30 PASSIVE LOUDSPEAKERS

A. FULL RANGE THREE-WAY LOUDSPEAKER: REFERENCED PRODUCT DANLEY SOUND LABS SH69
    1. The loudspeaker shall utilize the Synergy Horn/Tapped Horn patent-pending enclosure covering three pass bands. The coverage pattern shall be 60° horizontal x 90° vertical. The loudspeaker shall have an operating rage of +/- 3 dB 55 Hz – 18 kHz. Sensitivity of 99 dBSPL @ 1m. Output of 126 dBSPL/132 dBSPL Peak. Power handling shall be 1000 Watts continuous, 2000 Watts program. The impedance shall be nominal 4 ohms.
    2. The loudspeaker shall be constructed of 13 ply Baltic birch, water resistant Polyurea coated, properly braced for the intended use and a rugged steel grill. Connectors shall be Neutrik NL4.
B. FULL RANGE TWO WAY PASSIVE LOUDSPEAKER: REFERENCED PRODUCT ELECTROVOICE ZX5-90
    1. Freq. Response (-3 dB):

a. 58 Hz - 18 kHz
2. Freq. Range (-10 dB):
   a. 39 Hz - 20 kHz
3. Rec. Hipass Frequency: 36 Hz
4. Axial Sensitivity:
   a. 98 dB (1W/1m)
5. Max. Calculated SPL:
   a. 132 dB
6. Horizontal Coverage:
   a. 90°
7. Vertical Coverage:
   a. 50°
8. Power Handling (Passive):
   a. 600W Continuous, 2400W Peak
9. LF Power Handling (Biamp):
   a. 500W Continuous, 2000W Peak
10. HF Power Handling (Biamp):
    a. 40W Continuous, 160W Peak
11. LF Transducer:
    a. DVX3150, 15 in (381mm) Driver
12. HF Transducer:
    a. ND2, 1 in (25.4mm) exit Neodymium Compression Driver
13. Crossover Frequency:
    a. 1.5 kHz
14. Nominal Impedance:
    a. 8 Ohms
15. Minimum Impedance:
    a. 6.5 Ohms
16. Connectors:
    a. (2) Neutrik Speakon NL4's
17. Enclosure Material:
    a. Polypropylene Structural Foam
18. Suspension:
    a. Enclosure has locations for 5 Single-Stud Attachment Plates and 10 Forged Steel Eyebolts - 2 on Top, 2 on Bottom, 2 on Side, and 4 on Rear of Enclosure
19. Grille:
    a. Polyester Powder Coated, 16GA Galvanized Steel, with Rotatable Logo
20. Environmental Spec:
    a. IEC 529 IP24 / IP44 (PI Version)
21. Dimensions (H x W x D):
    a. 692mm x 446mm x 411mm (27.26" x 17.57" x 16.16")
22. Net Weight:

a. 22.2 kg (49.0 lbs)

23. Shipping Weight:
    a. 26.0 kg (57.4 lbs)

2.31 LOW IMPEDANCE MULTI-CHANNEL AMPLIFIERS

A. NETWORK AMPLIFIER: REFERENCED PRODUCT ASHLY NXE8004

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 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 <25.9 lbs (11.7kg), 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.

2.32 LOW IMPEDANCE STEREO AMPLIFIERS

A. NETWORK AMPLIFIER: REFERENCED PRODUCT ASHLY NXE1.52

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 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 <22.7 lbs (10.3kg), 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.

B. NETWORK AMPLIFIER: REFERENCED PRODUCT ASHLY NXE8002

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.

2.33 MICROPHONES AND ACCESSORIES:

A. UHF DIGITAL WIRELESS MICROPHONE SYSTEM: REFERENCED PRODUCT SHURE QLXD SERIES

1. System Specifications
   a. RF Carrier Range
      1) 470–937.5MHz, varies by region
   b. Working Range
      1) 100 m (328 ft)
   c. RF Tuning Step Size
      1) 25 kHz, varies by region
   d. Image Rejection
      1) >70 dB, typical
   e. RF Sensitivity
      1) -97 dBm at 10−5 BER
   f. Latency
      1) <2.9 ms
   g. Audio Frequency Response
      1) QLXD1: 20 Hz – 20 kHz (±1 dB)
      2) QLXD2: Note: Dependent on microphone type
   h. Audio Dynamic Range System (Gain @ +10)
      1) >120 dB, A-weighted, typical
   i. Total Harmonic Distortion (-12 dBFS input, System Gain @ +10)
      1) <0.1%
   j. System Audio Polarity
      1) Positive pressure on microphone diaphragm produces positive voltage on pin 2 (with respect to pin 3 of XLR output) and the tip of the 6.35 mm (1/4-inch) output.
   k. Operating Temperature Range
      1) -18°C (0°F) to 50°C (122°F)
   l. Storage Temperature Range
      1) -29°C (-20°F) to 74°C (165°F)
2. UHF DIGITAL RECEIVER: SHURE QLXD4
   a. Dimensions
      1) 41 × 197 × 151 mm (1.63 × 7.75 × 5.94 in.), H × W × D
   b. Weight: 777 g (1.71 lbs), without antennas
   c. Housing: Steel
   d. Power requirements: 12 V DC @ 0.4 A, supplied by external power supply (tip positive)
   e. RF Input

1) Spurious Rejection: >80 dB, typical
2) Connector Type: BNC
3) Impedance: 50 Ω

f. Audio Output
1) Gain Adjustment Range: -18 to +42 dB in 1 dB steps
2) Configuration:
a. 1/4" (6.35 mm): Impedance balanced (Tip=audio, Ring=no audio, Sleeve=ground)
b. XLR: Balanced (1=ground, 2=audio +, 3=audio −)
3) Impedance:
a. 1/4" (6.35 mm): 100 Ω (50 Ω Unbalanced)
b. XLR: 100 Ω
4) Full Scale Output
a. 1/4" (6.35 mm): +12 dBV
b. XLR: LINE setting= +18 dBV, MIC setting= −12 dBV
5) Mic/Line Switch: 30 dB pad
6) Phantom Power Protection
a. 1/4" (6.35 mm): Yes
b. XLR: Yes

g. Networking
1) Network Interface: Single Port Ethernet 10/100 Mbps
2) Network Addressing Capability: DHCP or Manual IP address
3) Maximum Ethernet Cable Length: 100 m (328 ft)

3. UHF DIGITAL HANDHELD TRANSMITTER: SHURE QLXD2
a. Mic Offset Range: 0 to 21 dB (in 3 dB steps)
b. Battery Type: Shure SB900 Rechargeable Li-Ion or AA batteries 1.5 V
c. Battery Runtime (@ 10 mW): Shure SB900: up to 10 hours Alkaline: up to 9 hours
d. Dimensions: 256 mm × 51 mm (10.1 in. × 2.0 in.) L × Dia.
e. Weight: 347 g (12.2 oz.), without batteries
f. Housing: Machined aluminum
g. Audio Input
1) Configuration: Unbalanced
2) Maximum Input Level 1 kHz at 1% THD: 145 dB SPL (SM58)
h. RF Output
1) Antenna Type: Integrated Single Band Helical
2) Occupied Bandwidth: <200 kHz
3) Modulation Type: Shure proprietary digital
4) Power: 1 mW or 10 mW
5)

4. UHF DIGITAL BODYPACK TRANSMITTER: SHURE QLXD1
a. Mic Offset Range: 0 to 21 dB (in 3 dB steps)

b. Battery Type:
   1) Shure SB900 Rechargeable Li-Ion
   2) AA batteries 1.5 V
c. Battery Runtime @ 10 mW:
   1) Shure SB900: up to 10 hours
   2) Alkaline: up to 9 hours
d. Dimensions: 3.38in.×2.57in.×0.92in. (H×W×D)
e. Weight: 138 g (4.9 oz.), without batteries
f. Housing: Cast aluminum
g. Audio Input
   1) Connector: 4-pin male mini connector (TA4M)
   2) Configuration: Unbalanced
   3) Impedance: 1 MΩ
   4) Maximum Input Level 1kHz @ 1%THD: 8.5 dBV (7.5 Vpp)
   5) Preamplifier Equivalent Input Noise (EIN) System Gain Setting ≥ +20: −120 dBV, A-weighted, typical
h. RF Output
   1) Connector: SMA
   2) Antenna Type: ¼ wave
   3) Impedance: 50 Ω
   4) Occupied Bandwidth: <200 kHz
   5) Modulation Type: Shure proprietary digital
   6) Power: 1 mW or 10 mW

B. PASSIVE WIRELESS ANTENNA SPLITTER: REFERENCED PRODUCT SHURE UA844US

1. Carrier Frequency Range: 470-900 MHz
2. Distributed RF Output Level (Gain): –0.5 to 3 dB, 1 dB typical, from antenna input (unused ports terminated with 50 Ω)
3. Output Connector Isolation: ≥25 dB
4. Third Order Intercept Point (3 OIP): 24 dBm, typical
5. DC Input Voltage: 14 to 18 Vdc
6. DC Output Voltage: 14 to 18 Vdc, 4 connectors
7. DC Antenna Voltage: 12 Vdc
8. Impedance: 50 Ω
9. RF Input/Output Antenna Connector Type: BNC

C. GENERAL PURPOSE HANDHELD SWITCHED VOCAL MICROPHONE: REFERENCED PRODUCT SHURE SM58-S

1. Dynamic Element

2. Frequency response: 50-15,000 Hz
3. Type: Unidirectional (Cardioid)
4. Sensitivity: -56dB
5. Stand clip included
6. On-Off Switch

D. LAVALIER WIRELESS MIC ELEMENT: REFERENCED PRODUCT AUDIO TECHNICA AT831b

1. Element: Fixed-charge back plate permanently polarized condenser.
2. Polar Pattern: Cardioid
3. Frequency Response: 40 - 20,000 Hz
4. Low-Frequency Roll-Off: 80 Hz, 18 dB/octave
5. Open Circuit Sensitivity: – 44 dB (6.3 mV); (Phantom / Battery) –45 dB (5.6 mV) re 1V at 1 Pa
6. Impedance: (Phantom / Battery) 200 ohms / 270 ohms
7. Maximum Input Sound Level (Phantom / Battery): 135 dB / 121 dB SPL, 1 kHz at 1% T.H.D.
8. Dynamic Range (typical - Phantom / Battery): 106 dB / 92 dB, 1 kHz at Max SPL
9. Signal - to - Noise Ratio: 65 dB, 1 kHz at 1 Pa
10. Phantom Power Requirements: 9-52V DC, 2 mA typical
11. Battery Type: 1.5V AA/UM3
12. Battery Current/Life: 0.4 mA / 1200 hours typical (alkaline)
13. Switch: Off, on-flat, on-roll-off
14. Weight (less cable and accessories): Microphone - 0.1 oz (2.8 g); Power Module - 5.2 oz (147 g)
15. Dimensions: Microphone - 0.98" (25.0 mm) long, 0.39" (10.0 mm) diameter; Power Module - 3.27" (83.0 mm) H x 2.48" (63.0 mm) W x 0.87" (22.0 mm) D
16. Output Connector (power module): Integral TA4F
17. Cable: Integral 6' (1.8 m), permanently attached between microphone and power module
18. Provide Microphone with the following accessories: AT8417 clothing clip; AT8116 windscreen; protective carrying case

E. MODULAR DUAL-CAPSULE CONDENSER MICROPHONE: REFERENCED PRODUCT ASTATIC e70

1. Operating Principal: Permanently Biased Condenser
2. Polar Pattern: Cardioid and Omnidirectional
3. Frequency Response: 30Hz - 20kHz
4. Sensitivity: -40dBV (10mV) @ 1Pa
5. Impedance: 85 ohms

6. Self Noise: 23dBA
7. Max SPL: 160dB (20dB Pad Engaged)
8. Power Requirements: P48, 2mA

F. 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
3. non-capacitive pad. The microphone will operate from standard 48V phantom power with a current consumption of 8mA.
4. 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.
5.

2.34 RF HEARING ASSISTANCE SYSTEMS:

A. RF HEARING ASSISTANCE TRANSMITTER: REFERENCED PRODUCT LISTEN TECHNOLOGIES LT-800/216

1. The stationary RF transmitter shall be capable of broadcasting on 57 channels. The transmitter shall have an SNR of 70 dB or greater. The output power shall be adjustable to quarter, half or full. Channel tuning shall be capable of being locked. The device shall have an audio frequency response of 50 Hz to 15k Hz, ± 3 dB at 216 MHz. It shall have two (2) mixing audio inputs and a mixed signal output. The device shall have the following audio controls: input level, mix level and an adjustable low pass filter (contour). The device shall have an audio processor that is capable of automatic gain control and limiting.

B. RF HEARING ASSISTANCE RECEIVER: REFERENCED PRODUCT LISTEN TECHNOLOGIES LR-4200-216

1. The RF receiver shall be capable of receiving on 57 wide and narrow band channels. The device shall tune to a single channel and user shall not be able to change the channel. The receiver shall have a signal-to-noise ratio of 70 dB or greater and shall

have an audio frequency response of 50 Hz – 15 kHz (±3 dB). The device shall employ a unique DSP SQTM noise reduction technology. The unit shall have a programmable squelch circuit. The unit shall incorporate a multi-functional display that indicates battery status, inventory number and channel. The device shall have the option of being lanyard or belt clip worn and the lanyard shall have the option of an integrated neck loop. The device shall have a USB connector used for inventory control, set up, charging and firmware upgrades. The device shall incorporate automatic battery charging circuitry and use a non-proprietary lithium ion battery. The device shall have additional charging contacts to allow multiple charging options.

C. CHARGING/CARRYING CASE: REFERENCED PRODUCT LISTEN TECHNOLOGIES LA-380

1. The LA-380-01 Intelligent 12-unit charging/carrying case shall be capable of transport, charging and storing up to 12 intelligent products. The unit shall accept an input voltage of 100 to 240AC, 50/60 H and shall deliver 5.0 VCD, 8 A at 40 watts. The unit shall be capable of being locked. The unit shall have equivalent compliance with UL, CE and RoHS.

D. DUAL EARBUD HEADPHONES: REFERENCED PRODUCT LISTEN TECHNOLOGIES LA-405

1. The LA-405 Universal Stereo Ear Buds shall provide an audio response of 20 Hz to 20 KHz with an impedance of 32 ohms. The device shall be easy to put on, easy to clean and shall provide a cable length of 13 in (33 cm) that reduces cable tangling. The device shall have replaceable foam cushions.

2.35 SINGLE DISC CD PLAYER: REFERENCED PRODUCT DENON DN-500C

A. CD Section

1. Type: Single-mechanism compact disc player
2. Audio channel: 2 channel stereo
3. Quantization: 16-bit Linear
4. Sampling frequency: 44.1kHz at Normal Pitch
5. Oversampling ratio: 8 times
6. Frequency response: 20 to 20,000 Hz
7. Total harmonic distortion: 0.007%
8. Signal–to–noise ratio: 107dB
9. Dynamic range: 98dB
10. Channel separation: 90dB
11. Analog output: RCA jacks

12. Output level: 2.0V at 0dB disc
13. Load impedance: 10kΩ or more
14. Digital output: RCA jack
15. Signal format: SPDIF or IEC-958 type II
16. Variable pitch control: +16% maximum
17. Frame search accuracy: 1/75 second
18. Discs: Standard compact discs (12cm and 8cm)

B. AUX Section

1. Stereo mini jack: Unbalanced jack
2. Reference input level: –16dBV
3. Maximum input level: 0dBV
4. Input impedance: 22kΩ

C. Headphone output

1. Stereo
2. Output level: 20mW
3. Load impedance: 32Ω

D. General

1. Power supply: 120V AC +10%, 60 Hz
2. Power consumption: 15W

E. Environmental Conditions

1. Operational temperature: 5 to 35°C (41 to 95°F)
2. Operational humidity: 25 to 85% (no condensation)

2.36 PORTABLE AUDIO DEVICE INTERFACE: REFERENCED PRODUCT PRO CO IRACK

A. The rack-mounted impedance matching unit shall be suitable for interfacing one (1) unbalanced -10 dBV stereo source to one (1) balanced or floating low-impedance (1.0 kohm nominal) microphone preamplifier input. There shall be one (1) stereo 3.5 mm phone jack marked “AUDIO INPUT”. This input shall be wired to accept a standard 3.5 mm stereo plug and the signals shall be resistively combined via 2.2 kohm resistors to provide a single output. Additionally, there shall be two (2) RCA-type jacks marked “L”

and "R", also resistively combined via 2.2 kohm resistors. The input connectors shall be electrically isolated from the mounting plate. There shall be a transformer isolated, low-impedance output on a screw-type barrier strip. The transformer shall be a Pro Co MBT-1 Microphone Bridging Transformer. The magnetic and the primary electrostatic shield of the transformer shall be connected to the unbalanced input connectors. The secondary electrostatic shield shall be connected to the output barrier strip. There shall be a miniature rocker-type switch marked "GROUND LIFT" to allow the shields to be connected together or isolated as required.

B. The unit shall be suitable for mounting in a 19" (482.6 mm) wide E.I.A. rack enclosure. It shall be constructed of 1/16" (1.59 mm) anodized aluminum and shall be provided with a brushed finish as required. Control functions shall be identified by a laser-engraved legend. The dimensions of the unit shall be approximately 1-1/2" (38.1 mm) D x 19" (482.6 mm) W x 1-3/4" (44.45 mm) H.

2.37 1000VA UPS BACKUP: REFERENCED PRODUCT MID ATLANTIC UPS-1000R

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.

2.38 INTERCOM SYSTEMS

A. INTERCOM POWER SUPPLY: REFERENCED PRODUCT CLEAR-COM PS-704
   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-601 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 CLEARCOM 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 CLEARCOM CC-300
   1. Headphones
      a. Transducer type: neodymium magnet, copper- clad aluminum 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

2.39 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. WELDED METAL DESKTOP RACK: REFERENCED PRODUCT MIDDLE ATLANTIC DTRK SERIES.
   1. EIA compliant 19" desktop/under-desk equipment rack shall have a useable depth of 18-1/2". DTRK shall come equipped with two pairs of steel rackrail with tapped 10-32 mounting holes in universal EIA spacing, black e-coat finish and numbered rackspaces. Sides of DTRK shall feature vertical slotted vent pattern for ventilation. DTRK shall accept patent-pending LeverLock™ tool free and hardware free internal cable and device management system accessories when used with optional LL-DTRK adapter (10 space + only). DTRK shall be of fully welded construction. DTRK shall be finished in an environmentally friendly, durable metallic grey powdercoat. Fully welded construction shall provide a static capacity of 1,200 lbs. and a UL Listed load capacity of 300 lbs. DTRK shall be UL Listed in the US and Canada. DTRK shall be GREENGUARD Indoor Air Quality Certified for Children and Schools. DTRK enclosure shall comply with the requirements of RoHS EU Directive 2002 / 95 / EC compliant. DTRK shall be manufactured by an ISO 9001 and ISO 14001 registered company. DTRK enclosure shall be warrantied to be free from defects in material or workmanship under normal use and conditions for the lifetime of the rack.

C. 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. VT perforation pattern shall be: 5/32" dia. hole, with 3/16" staggered centers Open Area 64%

D. 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.

2.40 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.

2.41 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
   i.

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.

2.42 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: 2 - 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: 2 - 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.

C. WIRE - INSTALLED MICROPHONE LEVEL:
1. West Penn 291
a. Construction
1) Conductor Gauge: 2 - 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: 2 - 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: 2 - 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: 2 - 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: 2 - 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 – SHIELDED CAT5E NETWORK CABLE: REFERENCED PRODUCT WEST PENN 4245F

1. Construction:
   a. Conductor Gauge: 24 AWG Solid
   b. Number of Conductors: 8 (4 Pair)
   c. Insulation: 0.008" Thermoplastic
   d. Shield: Overall 100%Aluminum Foil (F/UTP)
   e. Drain: 24 AWG Tinned Copper
   f. Jacket Material: PVC
   g. Overall Diameter: 0.252" 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 – 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.

I. 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 Outer Jacket
b. Capacitance between one conductor and other conductor tied to shield: 47 pf/FT. Blue Outer Jacket

2. PORTABLE MULTICORE SNAKE – REFERENCED PRODUCT WHIRLWIND WITH CANARE MR202 SERIES 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.

3. 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.
4. Where multiconductor snake cable is indicated, the snake must have a common outer jacket. Individual pairs will not be accepted.

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.

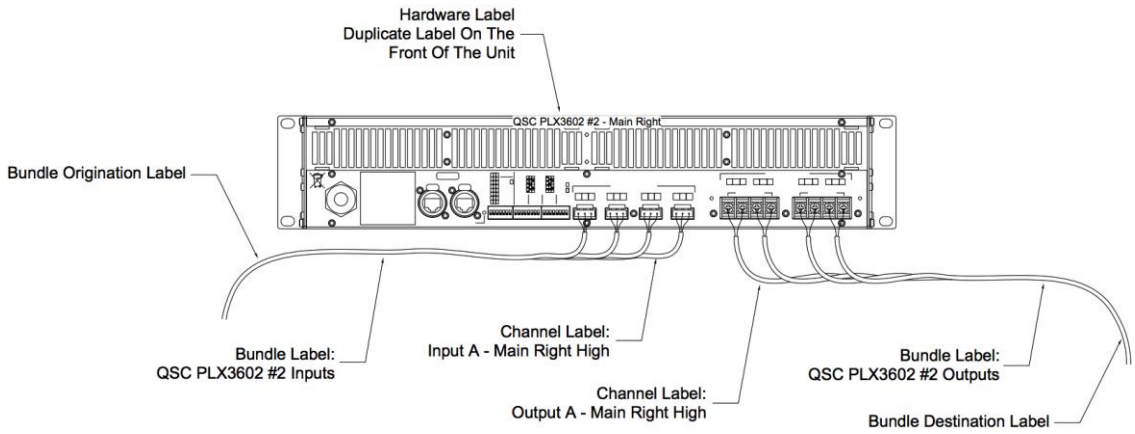
B. On metal panels and plates where possible engrave directly upon the plates and assemblies. Where disassembly of the equipment would be required to achieve engraving the use of adhesive or screw on engraved labels will suffice. Engravings will be paint filled for best contrast with black or white paint.

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 it’s 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. AUTOMIXER SET UP Microphone inputs shall be set for automated functions in groups based on use. NOM attenuation shall be 3dB. Priorities will be assigned as required by use.
    1. Compression shall be applied to all microphones inputs to prevent system overload. Soft knee characteristics shall be utilized. Gain structure as required by the system application for the specific microphone.
    2. Auto level shall be applied to microphone inputs with the intent of providing gain riding within a 10 dB range of the target level. If feedback conditions are encountered in set up do not change NOM settings, Adjust the auto level to compensate.
    3. Final equalization will be done during acceptance testing with a variety of signal sources.

C. HIGH SCHOOL GYMNASIUM SOUND SYSTEM - See section on processor set up above plus the following:
    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. SOUND SYSTEM PROCESSOR PRESETS:
    a. Preset 1 - Game Announcement - Game Console input active with all others muted. All outputs active. Set court levels 10 dB down from bleacher levels.
    b. Preset 2 - Instructional – All inputs active except game console with all outputs active. Wireless mics set to duck the media plate inputs.

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. GYMNASIUM SOUND SYSTEM
1. 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.
2. Loudspeaker phasing: Check each loudspeaker with a phase measuring device for proper polarity.
3. Proceed to equalize all systems to conform to the specified initial performance criteria.
4. 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.
5. 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….)

6. Gain Control Settings: Adjust controls for optimum signal to noise of the all systems relative to the performance requirements of this specification.
7. After initial tests have been made, proceed to equalize the system for feedback control as per normal practice.
8. Verify all systems inputs, outputs, equipment and functions.

B. Video Production Studio:
   1. Cameras – Verification and calibration includes but is not limited to the following:
      a. CCU
      b. Icom
      c. Lensing
   2. Switcher– Verification and calibration includes but is not limited to the following:
      a. Input
      b. Output
      c. DVE
      d. Keying layers Still store
      e. CG
   3. CG– Verification and calibration includes but is not limited to the following:
      a. Configure all software and libraries as required by the owner.
      b. Verify Monitor Output
   4. Teleprompter– Verification and calibration includes but is not limited to the following:
      a. Software
      b. Monitor Output
   5. Video Multiview and Program Monitors
      a. Color correct all monitors to match to SMPTE Colors (within the range of LED capabilities)
      b. Adjust contrast and brightness with SMPTE bars
   6. Audio
      a. Gain structure all normally used inputs to nominal for broadcast 0VU recording level output.
   7. I com and IFB
      a. Verify local I-com channels and operation.
   8. Audio
      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. 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.
d. Gain Control Settings: Adjust controls for optimum signal to noise of the all systems relative to the performance requirements of this specification. Adjust all inputs, equalizers, limiters, etc. to provide equal relative loudness of music and voice sources with typical input levels. Adjust all equalizers, delays, etc. for use as called for within the specification.
e. 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 at the project location and with the project equipment (owner's equipment), consisting of the following hours/periods of instruction total training time not to exceed 36 hours. No training block to be less than 4 hours in duration. All training hours are exclusive of travel time. This time is in addition to training time noted below:

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 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.

3.19 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.

3.20 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.

3.21 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.

3.22 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.

3.23 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. 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.

3.24 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).

1.

END OF SECTION

SECTION 192000 STUDIO LIGHTING SYSTEMS

PART 1 GENERAL

1.1 PROJECT INFORMATION:

A. Owner: Newburgh Enlarged City School District
New CTE Building
201 Fullerton Avenue
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 lighting contractor, the lighting installer or the bidder.

E. Others: Various companies doing construction work under the general contract.

1.2 PROFESSIONAL STANDARDS:

A. The contractor is expected to install all work to the appropriate industry professional standards, manufacturer recommendations, and current applicable codes. If any work required exceeds the skills of the contractor, they will employ appropriate subcontractors for the scope required.

B. The acceptability of materials and workmanship will be determined by the Architect, Consultant, and CM.

C. Any work that might be damaged, be inadvertently painted, or become dirty during construction will be protected by the contractor. All responsibility for protection shall be by the contractor. The contractor will provide final cleaning and or repair of all equipment in their scope to like new condition.

D. The contractor will attend and/or arrange meetings as required to make sure their scope is coordinated with all other trades. The contractor is responsible to make known to all other trades critically dimensioned items and locations to avoid conflicts. Where conflicts occur follow required procedures in the project manual to seek resolution.

E. Where any substandard work is provided by related trades that impedes the work of the contractor, they will notify the CM, Consultant, Architect, or Engineer in writing as called for one the project manila to rectify the issue.

F. Where work is provided by others the contractor is responsible to verify installation conditions that relate to their work. If installation of related work is substandard the contractor shall generate a written RFI through proper channels based upon the project manual. The contractor shall not install their work to any substandard devices, etc. provided by others until such work has been resolved or until the contractor has received written authorization from the construction manager to proceed. If the contractor ignores substandard installation work by others and proceeds to install his devices to these items, then he accepts and bears sole responsibility to repair, reinstall and correct any found deficiencies to the satisfaction of the owner upon final inspections.

G. The contractor will comply with the AHJ (Authority Having Jurisdiction) as it relates to programming any and all emergency interfaces.

H. The contractor is expected to possess knowledge of the equipment of their industry and to provide all small items required to install the specified equipment. Provide small items such as rack rails, DIN rails, rack panels, power cords, connectors, wall-wart power supplies, crimps, Nicopress and other items that may not be called out on drawings or in specs but are required to support primary equipment.

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

1.3 DEFINITIONS:

Code Requirements	Minimum requirements as specified by all applicable and published codes.
Concealed	Work installed in pipe and duct shafts, chases or recesses, inside walls, above ceilings, in slabs or below grade.
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 of holes, marks, and damage left from removals. Consult project manual for 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.

Refer to General Conditions of the Contract for additional definitions.

1.4 INTENT OF DRAWINGS:

A. Throughout the contract documents there are various manufacturers and products referenced. It is understood that these products establish a basis of design that all other "or equal" substitutions must meet or exceed. All submitted devices must be the referenced product or approved equal.

B. The drawings in this package are diagrammatic in nature, unless detailed dimensioned drawings are included. The drawings show the approximate locations of equipment and devices. The final and exact locations of all non-dimensioned devices are subject to the approval of the Owner or the Owner's Representative. Devices with detailed installation dimensions; however, are critically located and must be installed to those indicated dimensions unless alternate instructions have been given to the contractor in writing by the consultant.

C. The contractor(s) shall inspect the entire building(s) with the Owner's representative prior to beginning any work and shall identify the exact locations and installation methods for all devices, conduit and wiring prior to beginning work.

D. Typical details are shown for the installation of various devices. The details do not apply to all situations. Installation methods for all work shall be subject to the Owner's and construction manager's approval. Provide all work and equipment required for a professional, workman-like installation.

1.5 SECTION INCLUDES BUT IS NOT LIMITED TO:

A. All items below relate to work in both studio spaces (green room studio and related control room as well as the photo lab space).

B. Provision of studio lighting system and related work scope as indicated on drawings including controls for lighting fixtures.

C. Wiring, setup, focus and commissioning.

D. Training and closeout documents.

1.6 RELATED SECTIONS & DOCUMENTS:

A. The contractor(s) shall examine the full set of construction drawings and specifications and ascertain all aspects of the scope of work described within this specification. The contractor will be responsible for cooperation with and adherence to the overall scope and intent of the project relative to the work being done by the contractor.

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

1.7 RELATED WORK NOT INCLUDED:

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

1.8 GENERAL REQUIREMENTS:

A. 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.

B. 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.

C. Check each component before installation as well as each portion of the project during installation to ensure that the intent of this specification is achieved.

1.9 BIDDER QUALIFICATIONS – SUBMITTALS:

A. The bidder shall provide references of at least three (3) installations of comparable scope performed by the bidder, including location, system description, and name, address, and telephone number of the architects, consultants, and owners and the names of contract persons for each.

B. The bidder must maintain service facilities and have service available on site within 24 hours. The bidder must be a factory authorized dealer for all products submitted and may be required to submit such proof of factory authorization in writing, or in the form of copies of authorized agreements with the various vendors.

C. The bidder and all persons performing theatrical lighting system related work on this project must be certified (those performing low voltage terminations, system commissioning, 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 or an equivalent factory trained and certified installer (from the equipment supplier) or a crew working under the direct supervision of a certified foreman (of either certification described above). This applies to all theatrical lighting equipment installation and any other assemblies indicated as being provided or installed by the contractor. Proof of current certification MUST be provided in the submittals package (this is typically in the form of a pdf copy of the current and active certification certificates from PLASA). Out of date or expired certifications shall not be recognized as meeting the requirements of ETCP certification.

1.10 INQUIRIES AND COMMUNICATIONS:

A. All questions should be posed in writing as called for in the project manual.

B. Direct communications to the consultant via phone are recommended for initial discussion about intent or site issues. (unless prohibited in the project manual). No action may be taken based on verbal communications, they must be followed up in writing as called for in the project manual.

C. Where discrepancies occur, and pre-bid instructions have not been obtained by written request, the contractor will abide by the owner's decision at no additional cost to the owner.

1.11 COORDINATION:

A. Cooperate with other trades to achieve well-coordinated progress at all times. Notify the owner and consultant as often as necessary with regards to job progress or changes in the installation schedule. No change orders for additional payment will be allowed based upon conflicts with other trades on the project site. All such conflicts will be reported to the architect, construction manager, owner, and consultant in writing. All reasonable attempts will be made to correct any difficulties.

B. Staff the job site adequately at all times to maintain a progress in keeping with the total project progress. No allowances will be made for overtime required to maintain job progress.

C. Provide all materials to be installed by others in a timely fashion based upon the related trades' schedules.

D. The job site will be left in a clean safe condition at the end of any workday. All cleanup and debris removal to a site designated by the owner will be the responsibility of the bidder on a daily basis.

E. All storage of tools and materials will be done by the contractor. No on-site storage security will be provided by the owner.

F. The contractor will attend regular meetings with the architect, owner, general contractor, and the consultant when requested by any of the above, in order to achieve project coordination and progress.

G. The contractor shall be required to share all approved lighting system shop drawings with the EC prior to rough-in. He shall work closely with the electrician in determining final control wiring types, quantities and requirements, related device locations, backbox sizes, conduit routings, etc. before the EC has purchased his supplies and in order to meet the construction schedule.

1.12 DELIVERIES:

A. It is each contractor's responsibility to receive all device shipments, equipment, deliveries, etc. for their own equipment on/at the job site personally. Each contractor

shall be responsible to arrange for storage of all received materials on site until the appropriate time when they shall either turn them over to installing contractor or install them.

B. If the contractor chooses to allow a third party to receive shipments on his behalf the contractor bears sole responsibility for any missing and/or damaged parts.

C. Any equipment that is furnished by the contractor for installation by others shall be turned over to the installing contractor at a time that fits into their production schedule and the project's overall construction schedule.

1.13 STANDARDS REFERENCES:

A. The contractor is responsible for the provision of material and methods installation of equipment conforming to the currently applicable standards of:
   1. ADA - Americans with Disabilities Act
   2. AISC - American Institute of Steel Construction
   3. AISI - American Iron and Steel Institute
   4. ANSI - American National Standards Institute
   5. ASME - American Society of Mechanical Engineers
   6. ASTM - American Society for Testing Materials
   7. AWS - American Welding Society
   8. EIA - Electronic Industries Association
   9. ESTA - Entertainment Services and Technology Association
   10. FCC - Federal Communications Commission
   11. IEC - International Electronics Commission
   12. IEEE - Institute of Electrical and Electronics Engineers
   13. IFI - Industrial Fasteners Institute
   14. ISO - International Organization for Standardization
   15. NACM - National Association of Chain Manufacturers
   16. NEC - The National Electric Code
   17. NEMA - National Electrical Manufacturers Association
   18. NFPA - National Fire Protection Association
   19. OSHA - Occupational Safety and Health Association
   20. SAE - Society of Automotive Engineers
   21. SMPTE - Society of Motion Picture and Television Engineers
   22. TIA - Telecommunications Industry Association
   23. UL - Underwriters Laboratories (Electrical components, devices and accessories shall bear a UL label where applicable. UL listed and labeled as defined by NFPA70, article 100, by a testing agency acceptable to authorities having jurisdiction and marked for intended use.)
   24. USITT - United States Institute for Theater Technology "Recommended Guidelines for stage rigging and stage machinery-specifications and practices".

B. Provide certification and labels where applicable. Comply with federal, state and local regulations and applicable union regulations where required. Provide all equipment with proper labels for sale and use within New York State.

C. Provide only equipment that is standard, new equipment, the latest model of regular stock product and is supplied with all parts regularly used with the equipment offered for the purpose intended. The contractor guarantees that no modification of the equipment has been made contrary to the manufacturer's regular practice.

D. Review all materials and equipment prior to installation and notify owner as to any changes or discrepancies between published specifications and the actual material and equipment to be installed, including discontinued product updates, etc.

1.14 EQUIVALENTS:

A. The successful bidder shall submit any product equivalents prior to award of the contract. When requested, the successful bidder shall also submit information, describing in specific detail, how the equivalent bid material differs from the appearance, quality and performance required by the base specification. Submittal of the manufacturer's advertising cut sheets alone is not acceptable for proof of equivalency.

B. Proof of equivalency may require the bidder to provide physical samples, a full-sized mockup or specific manufacturer information detailing technical equivalency. Proof of equivalency shall be the burden of the submitting contractor/bidder and not that of the consultant. Proof of equivalency relates to all pertinent functions of the specified equipment, regardless of if that information is reflected on any manufacturer’s issued cut sheets.

C. If proposing equivalents that affect the system design as shown on the drawings, the bidder must submit flow charts, and any other drawings necessary to show differences in the system operation from the primary referenced system.

D. The bidder will pay for any and all changes to related work scope required by the equivalent products.
   1. This includes electrical, architectural, structural and other changes that might be needed to implement an equivalent product.
      a. Some products with virtual identical functions have varying power requirements, physical dimensions, etc.

E. The risk of whether bid equivalents will be accepted is borne by the contractor. See section 2.1 “Performance Requirements” for more information.

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

G. Final judgment as to equality will be solely that of the consultant, architect, construction manager and owner.

H. The costs for any changes by other trades required to implement the equivalents proposed will be borne by the contractor.

1.15 SUBMITTALS:

A. Equipment: After bid award but before ordering any equipment or starting any work submit to the owner for approval a list of all equipment to be furnished showing types, models, quantities and manufacturer. Attach catalog sheets for all items submitted.

B. The quantity and form (paper and/or electronic copies) of all submittal material required shall be provided by the contractor to the appropriate parties as is indicated in the contract front end documents (in addition to any requirements listed below). If there are no indications in the contract front-end documents, then the contractor shall submit (1) electronic copy of each area, category, etc. of items as listed below. All submissions are understood to be intended for approval by the construction manager, the architect, owner, general contractor and the consultant prior to any fabrication or installation of any devices.

C. Submit a schedule for submission of drawings for fabrication and site work.

D. Submit a complete submission package with all required paperwork.

E. Submit each of the following as each pertains to this project. Provide a copy for each related person performing indicated work who holds these certifications:
   1. Current training certifications.
   2. Current ETCP certification.
   3. Current manufacturer certifications.

F. Submit material schedules and shop drawings for approval by the architect, consultant and owner prior to any fabrication or installation as follows:
   1. The full set of submitted drawings and data sheets must be presented in a professional manner.
   2. All drawings for submission must be CADD drawn (created with a computer aided drafting program). Hand drawings are not allowed. Illegible drawings shall not be acceptable.
   3. All cut sheets for submission must be high-resolution electronic (pdf) copies of the manufacturer's actual data sheets. Mark up each sheet with highlights or boxes around submitted products, options, etc. No data sheets shall be acceptable that are illegible, poorly photocopied or hand marked up with scribbles, etc.
   4. Drawings of proposed mounting methods for all equipment.
   5. Samples of proposed marking systems for wire and equipment labeling.
   6. Rack layouts, panel layouts and proposed labeling.
   7. Schedule for submission of drawings for fabrication and site work.

G. Quality Assurance

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

1.16 GENERAL SYSTEM DESCRIPTION:

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

PART 2 PRODUCTS

2.1 PERFORMANCE REQUIREMENTS:

A. The requirements of the referenced equipment are not generic in nature. Specific performance, control and routing capabilities are necessary for any alternate or substituted equipment. The details set forth herein and within the functional descriptions of each system are the critical criteria for the selection of each piece of equipment.

B. In bidding equipment from manufacturers other than those referenced be aware that all functional information included in this specification as well as the manufacturer's specifications, physical size, serviceability, acoustic output, warranty terms, product availability and other non-technical issues may be determining factors in product equivalency. Final judgment as to equality will be solely that of the owner, architect and consultant.

C. If the contractor substitutes a piece of equipment that does not meet with all of the critical device functionality of the specified equipment (functionality and feature set as

detailed below, inherent in the specified equipment, available as provided option and/or required based upon the intents of the contract documents), then he will have to replace all substandard equipment or substituted equipment that does not meet, match or exceed the specified equipment with either the specified equipment or an alternate piece(s) of equipment that meets/exceeds the specified equipment's feature set and shall provide all reprogramming, installation, conduit, wire, etc. as is required.

D. All lighting must meet these minimum requirements:
   1. Minimum Foot Candle Requirements: See Section S804 of the New York State Education Department's Manual of Planning Standards – 2014 Draft. Reference Table S804-1.
   2. All luminaires must meet or exceed the minimum initial NEMA LE5 Target Efficacy Rating (TER). See Section S804 of the New York State Education Department's Manual of Planning Standards – 2014 Draft. Reference Tables S804-2 & S804-3.
   3. All LED fixtures shall feature power factor correction (PFC) in their circuitry and/or meet a minimum power factor (PF) of .9. Active PFC is preferred, although passive PFC is acceptable, if the fixtures meet the minimum PF.

E. Equivalents Criteria:
   1. Lighting control system device substitutions require proof that the substituted product meets all performance requirements including but not limited to:
      a. Product warranty period
      b. Physical device size
      c. Device installation options (rack mount, DIN rail mount, etc.)
      d. Physical quantity of inputs, outputs, sourcing & sinking
      e. Output modes (0-10V, 0-15V, 0-2.5V, 0-5V, etc.)
      f. Current rating per channel
      g. RDM discoverability and remote manipulation capabilities
      h. Selectable starting addresses
      i. Signal isolation and fault protection limits
      j. Voltage step selections (.05V, .1V, etc.)
      k. Quantity of DMX universe control
      l. Protocol conversion and compatibility with alternate control schemes (sACN, DMX, RDM, 0-10V, DALI, etc.)
      m. Display, programming buttons & configuration limitations
      n. Panic controls interface
   2. Lighting control console substitutions require proof that the substituted product meets all performance requirements including but not limited to:
      a. Product warranty period and advanced replacements policies
      b. Physical console size
      c. Console fader wing attachment locations and options as well as how these devices interconnect with the console and the monitor mounts, clearances in low-profile rolltop units, ability to configure as the specified system, etc.
      d. Quantity of individual faders

e. Moving light knobs/wheels
f. Remote focus unit device interface without the need for remote or multiple wireless access points, etc.
g. Ability to output to an external monitor
h. Quantity and type of physical external monitor outputs
i. Ability to interface with touch screen monitors
j. Control channel count capacity
k. DMX universe count control capacity
l. Built in touch screen control
m. Drag and drop features on console touchscreen

3. Architectural control system substitutions require proof that the substituted product meets all performance requirements including but not limited to:
   a. Product warranty period
   b. Physical device size
   c. Required device backbox sizes
   d. Architectural control system topology
   e. Preset recall by button stations and LCD displays.
   f. LCD display size, color & programming options
   g. LED indicator light on individual control station devices
   h. Form factor
   i. No required, additional or "buried" accessories or devices in order to obtain system performance requirements.
   j. No spare wire requirements
   k. Ability for each pushbutton station button to trigger the unique preset desired and not simply manufacturer determined or hardware/software restrictive preset order recalls.
   l. Ability for architectural control system to read console snapshots and recall them via presets.
   m. No "room" restrictions in system topology or functionality.
   n. Proximity detector on LCD stations
   o. For all 0-10V, DMX, network or RDM devices the equipment provided must meet or exceed all programmatic, voltage options, etc. of the specified equipment.
4. LED fixture substitutions require proof that the substituted product meets all performance requirements including but not limited to:
   a. Product warranty period and advanced replacements policies
   b. Physical LED strip size, flexibility & durability
   c. PF (power factor)
   d. Light output pattern
   e. Efficacy (lumens per watt)
   f. CRI
   g. PWM frequency adjustability (to high rates)

h. Light output intensity in FC distribution
i. Form factor
j. Wattage of LED's
k. Expected and average LED & related drive electronics lifespan
l. Total length of runs powered by a single, dimmable LED driver/power supply shall meet or exceed specified products.
m. LED driver/power supply(ies) and their ability to dim the LED's smoothly and down to 1% is critical.
n. Ability of LED fixtures/strips to fit in intended locations and with all physical limitations of surrounding structure.
o. Binning tolerances & LED quality control must match or exceed specified product.
p. LED drivers, interfaces, mounting options, etc. shall meet or exceed specified product.
q. No rope lighting or similar products (not even LED rope lighting) shall be considered as an equal to the specified LED strip lighting products nor shall any rope lighting equivalents be approved.
r. Lumen outputs at deep colors
s. Visual representation of white light output of fixture - color temperature variants
t. Power draw requirements.
u. Beam spread characteristics
v. Fixture power supplies must have inherent brown-out protection built in, such as a switching power supply, that shall be self-resettable, not fuse driven and shall not require human interaction in order to operate.
w. Color mixing capabilities without excessive rainbowing effects at beam edges
x. Fixture lens options
y. Total numbering and visual quality of distinct renderable colors
z. Critical accessories and mounting options.
aa. Cooling requirements – convection cooled vs. fan cooled and including fan noise, tonality of fans, etc.

1. LED houselighting 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. Available light output patterns
    e. Lumen package options
    f. Efficacy (lumens per watt)
    g. CRI
    h. PWM frequency adjustability (to high rates)
    i. Light output intensity in FC distribution
    j. Form factor

k. Wattage of LED's
l. Expected and average LED & related drive electronics lifespan
m. LED driver/power supply(ies) and their ability to dim the LED's smoothly and down to <1% is critical (dim to black capabilities). Some general house/work lighting fixtures need only dim down to approx. 10%, based upon specified manufacturer's product.
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. Visual representation of white light output of fixture - color temperature variants.
s. Absence of visual anomalies during static and/or dimmed states (i.e. no flickering, ghosting, jitters, popcorning, etc.)
t. Overall acoustic output of fixture during static and/or dimmed states (i.e. fixtures must not create any discernable acoustic output or tonality of acoustic output while in use)
u. Absence of RF interference during use/standby state
v. Power draw requirements.
w. Beam spread characteristics
x. Critical accessories and mounting options.
y. 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.
z. Fixture installation requirements (installable from below, retrofittable into existing ceiling and holes, etc.)
aa. 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.

2. Wire substitutions require proof that the substituted product meets all performance requirements including but not limited to:
   a. Jacket Type
   b. Number of Conductors
   c. Jacket Shape – i.e. round, twisted, etc.
   d. Number of strands and gauge
   e. Flexibility
   f. Overall physical size of wire

g. Capacitance and resistance conductor-to-conductor as well as single conductor.

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

G. The current manufacturer's data sheet, user's manual and actual technical specifications/capabilities/feature set for each referenced piece of equipment in force at the date of printing of this specification shall be the basis for the specifications of the referenced equipment.

H. Any necessary product accessories such as additional duplex power outlets, power supplies, rack mount kits, connectors, adapters or other small items are the responsibility of the contractor to provide, whether or not they are called out in detail within these specifications. This may include additional electrical work, depending upon the differences between substituted and specified equipment and shall be the sole responsibility of the contractor to provide at no additional cost to the owner.

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

J. Quantities:
   1. Where no quantity is indicated in the written specifications, the contractor shall supply quantities as indicated on drawings.
   2. Items not indicated on drawings but necessary for project completion shall be provided as required for project execution at no additional cost.

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

A. General
   1. The lighting control console shall be a microprocessor-based system specifically designed to provide complete control of stage, studio, and entertainment lighting systems. The console shall be the ColorSource 20 or ColorSource 40 as manufactured by Electronic Theatre Controls, Inc., or equal.
   2. The system shall provide control of 512 DMX512A addresses on a maximum of forty (40) or eighty (80) control channels. Any or all of the DMX512A outputs may be controlled by a channel.
   3. A maximum of 999 cues may be contained in non-volatile electronic memory.
   4. Twenty (20) or forty (40) faders shall provide access to individual intensity channels, intensity for devices as well as playbacks.
   5. Four (4) configurable faders shall provide functionality for output of bump buttons, cue list control or crossfade control.
   6. The console shall have one (1) built-in 7" color multi-touch touchscreen. The touchscreen shall provide the primary interface for system configuration, programming show data and multi-parameter control.

7. Six (6) softkey buttons shall be provided, five of which may be configured by the user.
8. Console shall be equipped with an on-board help system, with on-board tutorial videos.
9. Console shall not require the use of an external monitor for normal use.
10. Console software upgrades shall be made by the user via USB drive. Changing internal components shall not be required.
11. The console shall provide a USB port allowing show data to be saved for archival or transfer to other consoles or a personal computer.
12. Systems that do not provide the above capabilities shall not be acceptable.

B. Controls and Playback
   1. Patching
      a. The console shall provide patching facilities for dimmers and multi-parameter devices via a built in library of fixture definitions. The fixture library shall be updated via software based updates. It shall be possible to create custom fixture definitions using an offline application.
      b. The console shall support patching, address setting, and mode changes using Remote Device Management (RDM) on the local DMX/RDM port.
   2. Channel or Playback Faders
      a. Twenty (20) or forty (40) proportional, fully overlapping faders shall be provided with 45mm potentiometers and bump buttons.
      b. The faders shall provide direct manual control of intensity for all channels. Channel levels can be changed at any time by using the individual channel faders or through the use of the touch screen interface.
         1) Faders shall also control up to ten (10) pages of twenty (20) (or forty (40)) recordable memories or sequences. Memories shall record user-selected channel levels. Sequences shall record user-selected memories or channel levels.
            i) With color mixing systems, output of color from fixtures shall appear to be a combination of the active memories in a color space.
   3. Programming Tools
   4. The console shall provide a 7″ color multi-touch touchscreen with six (6) softkeys, as well as touch-based controls. The LCD shall provide system configuration, programming show data and multi-parameter control.
   5. Touch-based tools shall include:
      a. Forty (40) programmable color chips and color picker.
      b. Touch-based parameter controls.
      c. Virtual Level/Rate wheel.
      d. Virtual keypad for level entry.
      e. Customizable channel display using Stage Map. It shall be possible to rearrange the graphical representations for control channels to closely mimic the positions of fixtures in the venue.

f. Effects (intensity, color, shape, and parameter)
   1) It shall be possible to assign multiple effects to the same channel and parameters. The playback of those effects shall play levels back relative to the combination of the two effects.
g. Fixture selection shall be made via:
   1) Auto fixture selection on fader moves.
   2) Pressing the selection button under channel faders.
   3) Touching the channel icon in the stage map display on the touch screen.
   4) Fixture Tags for Quick Selects
      i) Selection of multiple fixture shall be possible through a special controls dock that groups channels together based on the channel tile positions within a pre-defined area in the topographical view for channels.
      ii) Selection shall be possible through the use of informational tags. Selecting a predefined tag selects all fixtures sharing that same tag. At least two tags may be assigned to any one channel.
      iii) There shall be at least 27 Quick Select groupings.
h. Two independent channels shall be provided with on/off functionality. Independents shall be patched in a location separate from patch.

6. Playback Controls
   a. A cue list of up to 999 cues shall be provided. Cues may be made up of channel levels and parameter settings or contain a reference to a recorded memory. Cues shall be editable and shall be able to be individually deleted and inserted.
   b. Playback Toy for filtered and timed execution of playbacks.
   c. Multiple bump modes (Flash, Solo, SoloChange, Move/GO).
   d. Full history rubberbanding for playbacks.

C. Interface Options
   1. The console shall provide connectors for the following:
      a. 12V AC or DC input for external power supply
      b. DMX512-A/RDM output (one (1) 5-pin XLR connector)
      c. USB connection (one (1) type A connector)

D. Physical
   1. All operator controls and console electronics shall be housed in a single desktop console.
   2. Size and weight:
      a. Twenty (20) fader console shall be equal to or less than 18.31" (465mm) wide 11" (279mm) deep 2.36" (60mm) high (including controls), and6.9 lbs. (3.13 kg.)
      b. Forty (40) fader console shall be equal to or less than 26.31" (668mm) wide 11" (279mm) deep 2.36" (60mm) high (including controls) and 9.55 lbs. (4.33kg).

3. Twenty (20) fader console shall be able to be mounted into a 19" equipment rack with the use of additional mounting hardware.
4. Console power shall be 12V AC or DC via an external power unit. The power unit shall operate with 90-265VAC line voltage, 50 or 60Hz. Console is provided with a universal power supply.

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

A. Display:
   1. Viewable Image Size 22"
   2. Pixel Pitch 0.282mm
   3. Pixels Per Inch 90 @ native resolution
   4. Brightness (typical) 250 cd/m2
   5. Contrast Ratio (typical) 1000:1
   6. Viewing Angle (typical) 160° Vert., 170° Hor. (75U/85D/88L/88R) (CR>10)
   7. Response Time (typical) Rapid Response (5ms)
   8. Display Colors More than 16.7million

B. Synchronization Range:
   1. Horizontal 31.5-82.3KHz (Analog/ Digital)
   2. Vertical 56-75Hz (Analog/Digital)

C. Input Signal:
   1. Video Analog 0.7 Vp-p / 75 Ohms
   2. Sync Separate Sync: TTL Level (positive/negative)

D. Inputs - DVI-D, VGA 15-pin D-Sub and DisplayPort

E. Resolutions Supported - Analog/Digital:
   1. 720 x 400 @ 70 Hz
   2. 640 x 480 @ 60-75 Hz
   3. 800 x 600 @ 56-75 Hz
   4. 832 x 624 @ 75 Hz
   5. 1024 x 768 @ 60-75 Hz
   6. 1152 x 864 @ 70-75 Hz
   7. 1152 x 870 @ 75 Hz
   8. 1280 x 960 @ 60-75 Hz
   9. 1280 x 1024 @ 60-75 Hz
   10. 1360 x 768 @ 60 Hz
   11. 1440 x 900 @ 60-75 Hz
   12. 1440 x 1050 @ 60-70 Hz
   13. 1680 x 1050 @ 60 Hz

F. Native Resolution - 1680 x 1050 @ 60 Hz

G. Additional Features:
   1. Auto brightness (ambient sensor)
   2. Thin-frame (bezel)
   3. Widescreen format
   4. Integrated speakers
   5. Integrated 4-port USB 2.0 hub
   6. Monitor adjustments - Height-adjustable stand (110mm), pivot, tilt, swivel, no-touch auto adjust
   7. Cable management
   8. AccuColor color control
   9. Digital smoothing
   10. Digital controls
   11. DDC/CI, NaViSet software - Plug and Play (VESA DDC 1/2B)
   12. VESA DPMS power management
   13. OSD user controls
   14. ISO 13406-2 Class II, ECMA-370, Windows 7-certified
   15. Dynamic Video Mode, HDCP, ECO Mode
   16. Resettable carbon meter
   17. Resettable cost meter
   18. HDMI-capable via DVI adapter
   19. EPEAT Gold & Silver compliance, Energy Star 5.0, lead-free, RoHS-compliant, TCO 5.1 compliant
   20. Carrying handle
   21. Headphone jack
   22. 3 year warranty

H. Voltage Rating - AC 100-120V / AC 220-240V

I. Power Consumption (typical):
   1. On (w/ USB + audio) - 23W
   2. Power Savings Mode <1W
   3. ECO Mode ON:
      a. With USB & Audio - 17W
      b. Without USB & Audio - 13W

J. Dimensions (W x H x D):
   1. Net (with stand) 20 x 15-19.4 x 8.7 in. / 507.8 x 382 - 492 x 220mm
   2. Net (without stand) 20 x 13.1 x 2.8 in. / 507.8 x 332.1 x 71.8mm

K. Weight:
   1. Net (with stand) - 15.4 lbs. / 7 kg
   2. Net (without stand) - 9.9 lbs. / 4.5 kg

L. VESA Hole Configuration Specifications - 100 x 100mm

M. Environmental Conditions:

1. Operating Temperature - 5-35°C / 41-95°F
2. Operating Humidity - 20-80%
3. Operating Altitude - 2000m / 6562 ft.
4. Storage Temperature -10 - 60°C / 14-140°F
5. Storage Humidity - 10-85%
6. Storage Altitude - 12,192m / 40,000 ft.

N. Limited Warranty - 3 years parts and labor, including backlight.

2.4 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.

2.5 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.
   i) Presets shall have a discrete fade time, programmable from zero to 1,000 hours with a resolution of one millisecond.
   ii) Presets shall be selectable via button, fader, IR transmitter, time clock event, macro activation or switch interface stations.
2) System macros and sequences shall be programmable via LightDesigner system software.
   i) Macro and sequence steps shall provide user selectable steps, and allow the application of conditional logic.
   ii) Macro and sequences shall be activated by button, time clock event or LightDesigner software.
3) System time clock events shall be programmable via LightDesigner system software, the processor user interface, or the internal web server.
   i) Time clock events shall be assigned to system day types. Standard day types include: anyway, weekday, weekend, Sunday, Monday, Tuesday, Wednesday, Thursday, Friday and Saturday. System shall support programming of additional custom or special day types.
   ii) Time clock events shall be activated based on sunrise, sunset, time of day or periodic event. System shall automatically compensate for regions using a fully configurable daylight saving time.

b. Station Button, Button/Fader, and Interface control components shall be designed to operate standard default or custom system functions. Components shall operate default functions unless re-assigned via LightDesigner, the Windows-based configuration program.
   1) Optional button functions include: preset selection, manual mode activation, record mode activation, station lockout, raise, lower, macro activation, cue light, or room join/separate.
   2) Optional fader functions include manual master control, individual zone control, fade rate control or preset master control.

c. Stations (Button and Button/Fader) shall allow programming of station and component electronic lockout levels via LightDesigner.

B. Button/Fader Stations

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

3) Network wiring may be bus, loop, home run, star or any combination of these.
4) Network insulation displacement connectors shall be provided with all stations.

4. Functional
a. The Unison Paradigm Control System shall be designed to allow control of lighting and associated systems via Button, Button/Fader, and Interface, or Astronomical time clock controls. System shall allow the programming of presets, sequences, macros and time clock events.
1) System presets shall be programmable via Button, Button/Fader, Touchscreen, or LightDesigner software.
i) Presets shall have a discrete fade time, programmable from zero to 1,000 hours with a resolution of one millisecond.
ii) Presets shall be selectable via button, fader, IR transmitter, time clock event, macro activation or switch interface stations.
2) System macros and sequences shall be programmable via LightDesigner system software.
i) Macro and sequence steps shall provide user selectable steps, and allow the application of conditional logic.
ii) Macro and sequences shall be activated by button, time clock event or LightDesigner software.
3) System time clock events shall be programmable via LightDesigner system software, the processor user interface, or the internal web server.
i) Time clock events shall be assigned to system day types. Standard day types include: anyway, weekday, weekend, Sunday, Monday, Tuesday, Wednesday, Thursday, Friday and Saturday. System shall support programming of additional custom or special day types.
ii) Time clock events shall be activated based on sunrise, sunset, time of day or periodic event. System shall automatically compensate for regions using a fully configurable daylight saving time.
b. Station Button, Button/Fader, and Interface) control components shall be designed to operate standard default or custom system functions. Components shall operate default functions unless re-assigned via LightDesigner, the Windows-based configuration program.

1) Optional button functions include: preset selection, manual mode activation, record mode activation, station lockout, raise, lower, macro activation, cue light, or room join/separate.
2) Optional fader functions include manual master control, individual zone control, fade rate control or preset master control.

c. Stations (Button and Button/Fader) shall allow programming of station and component electronic lockout levels via LightDesigner.

C. Connector Stations

1. The Lighting Control Stations shall be the Unison Heritage UH Series Control Stations as manufactured by Electronic Theatre Controls, Inc.
2. Mechanical
   a. Unison connector stations shall provide an interface to portable Unison stations.
   b. All connector stations shall be available with white, cream, ivory, gray or black faceplates, fader knobs, and buttons.
      1) Manufacturer's standard colors shall conform to the RAL CLASSIC Standard.
   c. All faceplates shall be designed for flush or surface mounting.
   d. Station faceplates shall be constructed of ABS plastic and shall use no visible means of attachment.
   e. Station faceplates shall be indelibly marked for each function.
   f. The manufacturer shall supply back boxes for flush mounted half gang stations and for all surface mounted stations.
3. Electrical
   a. Unison control station wiring shall be an Echelon® Link power network.
      1) Link power shall utilize low-voltage Class II unshielded twisted pair, type Belden 8471 or equivalent, and one #14 ESD drain wire (when not installed in grounded metal conduit).
      2) Touchscreen and Interface stations shall also require (2) #16 AWG stranded wires for 24Vdc operating power. 24Vdc wiring shall be topology free.
      3) Network wiring may be bus, loop, home run, star or any combination of these.
      4) Network insulation displacement connectors shall be provided with all stations.
4. Functional

a. The Unison Paradigm Control System shall be designed to allow control of lighting and associated systems via Button, Button/Fader, and Interface or Astronomical time clock controls. System shall allow the programming of presets, sequences, macros and time clock events.
   1) System presets shall be programmable via Button, Button/Fader, Touchscreen, or LightDesigner software.
      i) Presets shall have a discrete fade time, programmable from zero to 1,000 hours with a resolution of one millisecond.
      ii) Presets shall be selectable via button, fader, IR transmitter, time clock event, macro activation or switch interface stations.
   2) System macros and sequences shall be programmable via LightDesigner system software.
      i) Macro and sequence steps shall provide user selectable steps, and allow the application of conditional logic.
      ii) Macro and sequences shall be activated by button, time clock event or LightDesigner software.
   3) System time clock events shall be programmable via LightDesigner system software, the processor user interface, or the internal web server.
      i) Time clock events shall be assigned to system day types. Standard day types include: anyway, weekday, weekend, Sunday, Monday, Tuesday, Wednesday, Thursday, Friday and Saturday. System shall support programming of additional custom or special day types.
      ii) Time clock events shall be activated based on sunrise, sunset, time of day or periodic event. System shall automatically compensate for regions using a fully configurable daylight saving time.

b. Station Button, Button/Fader, and Interface control components shall be designed to operate standard default or custom system functions. Components shall operate default functions unless re-assigned via LightDesigner, the Windows-based configuration program.
   1) Optional button functions include: preset selection, manual mode activation, record mode activation, station lockout, raise, lower, macro activation, cue light, or room join/separate.

2) Optional fader functions include manual master control, individual zone control, fade rate control or preset master control.

c. Stations (Button and Button/Fader) shall allow programming of station and component electronic lockout levels via LightDesigner.

D. Contact Interface Station

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

2.6 WI-FI ROUTER/INTELLIGENT WIRELESS MESH SYSTEM: REFERENCED PRODUCT LINKSYS VELOP INTELLIGENT MESH WI-FI SYSTEM ACXXXX

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

B. What's in the Box:
   1. Linksys Velop Dual Band Node
   2. Power supply
   3. Ethernet cable

C. Technical Specifications:
   1. Wi-Fi Technology:
      a. Dual-Band AC1300 (867 + 400 Mbps) ‡ with MU-MIMO and 256 QAM
   2. Key Features:
      a. Dual-Band Wi-Fi Mesh System
      b. Seamless Wi-Fi
      c. Easy App Controls
      d. Intelligent MeshTM Technology - Self-Organizing, Self-Optimizing and Self-Healing
      e. One Wi-Fi Network
      f. Auto Firmware Upgrade
      g. Parental Control
      h. Guest Access
      i. Auto sensing WAN/LAN Ports
      j. Wired/Wireless Backhaul
      k. AP/Bridge Mode Mesh Wi-Fi System
      l. Spot Finder- Mesh system uses signal strength, throughput, and latency to determine the optimal placement during set-up and post set-up.
      m. Auto Wi-Fi Channel

n. Bluetooth 4.1 embedded
o. Speedtest support
p. Amazon Alexa support
q. 3-Year Warranty and Support

3. Network Standards: 802.11b
   a. 802.11a
   b. 802.11g
   c. 802.11n
   d. 802.11ac
4. Wi-Fi Speed:
   a. AC1300 (867 + 400 Mbps)
5. Wi-Fi Bands:
   a. 2.4Ghz + 5GHz
6. Wi-Fi Range:
   a. up to 1500 sq ft
7. Number of Ethernet Ports:
   a. 2x WAN/LAN auto-sensing Gigabit Ethernet ports
8. Other Ports:
   a. power jack
   b. power switch
   c. reset button
9. Antennas:
   a. 3x internal antennas and high-powered amplifiers
10. Processor:
    a. 716 MHz Quad Core
11. Memory:
    a. 256 MB NAND Flash and 256 MB DDR3
12. LEDs:
    a. One LED indicator
13. Wireless Encryption:
    a. WPA2 personal
14. Easy Setup:
    a. Simple and secured App based set-up
    b. Required for set-up:
       1) Internet connection with Modem.
       2) Mobile device with Android 4.4 or iOS 9 and higher, Bluetooth preferred.
15. Minimum System Requirements:
    a. Required for set-up - Simple and secured App based set-up: Mobile devices with Android 4.0.3 or iOS 8 and higher
16. Dimensions (L x W x H):
    a. 3.1" x 3.1" x 5.55" per Node

17. Weight:
    a. 2.076 Lbs.
18. Security Features:
    a. WPA2 personal
19. Regulatory Compliance:
    a. FCC class B
20. Additional Information:
    a. Bluetooth 4.0/LE for secure and easy App based set-up
21. Power Supply:
    a. Input: 100-240V ~ 50-60Hz; Output: 12V, 1.0A

D. Warranty:
    1. Three-year limited

2.7 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.

2.8 MOBILE PRESENTATION CENTER CART: REFERENCED PRODUCT LUXOR PS4000

A. FEATURES:

1. Constructed with black powder coat painted steel frame with laminate work surfaces (available in two colors).
2. Includes four flat shelves.
3. Rolling cart with (4) silent-roll 3" furniture casters, (2) with locking brakes.
4. PS4000C includes optional locking cabinet with interior dimensions of 13 ½″ W x 18 3/8″ H.
5. Optional 3-outlet UL-Listed electric assembly with 15' cord.
6. Color: Walnut or Gray (shelves only).
7. Lifetime warranty.

B. PHYSICAL:

1. Overall: 18" W x 30" D x 40 ¼″ H
2. Top Shelf: 18" W x 14" D
3. Middle Shelf: 18" W x 16" D
4. Clearance between bottom and middle shelf: 19 ¾″
5. Clearance between middle and top shelf: 13 ¼″
6. Second shelf from the top is adjustable in height to 33″, 37″ or 40 ¼″
7. Clearance from bottom to middle shelf is 19 ¾″, middle to top shelf 13 ¼″
8. Middle shelf is adjustable from x 28 ½″ H to 39" H in 1 ¾″ increments
9. Weight: 43 lbs.

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

B. Specifications
1. Rackmount Uninterruptible Power Supply (UPS) shall be Middle Atlantic Products model # UPS- __ R__ (refer to chart). UPS shall be line interactive with AVR. Unit shall measure 19.00″ W x 3.50″ H x 19.00″ D and occupy 2 rackspaces. UPS shall have a rear mounting range of 19″ to 32″ and not require more than one person

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

C. Features:
   1. Pure Sine Wave technology with Automatic Voltage Regulation to improve the quality of power provided to the A/V system
   2. Surge suppression utilizes a clean line-to-neutral design that does not pass noise contamination to ground
   3. Models with bank control available
   4. Individual outlet control available
   5. Internet enabled models available, which include: - Real time UPS monitoring via the Web - Remote management and configuration of UPS via Web Browser or NMS (Network Management System) - Auto-shutdown to protect servers/workstations from data loss due to power failure - Schedule shutdown/start-up/reboot of the UPS - Event logging to trace UPS operational history - Data logging for analyzing power conditions - Event notification via email and SNMP traps - Supports TCP/IP, SNMP/HTTP, NTP, DNS, SMTP protocol - MIB (Management Information Base) provided - Quick installation and user friendly interface - User upgradeable firmware via FTP - Security management provided
   6. Control system integration via RS-232 and USB and analog I/O
   7. Load shedding allows extended run time for system-critical components by disconnecting power to less-critical components
   8. Line Interactive Technology
   9. Power Manager software allows extensive configuration and event notification capabilities

10. Energy Saver design reduces power consumption by up to 75% when compared with traditional UPS designs
11. 9′ SignalSAFE™ power cord minimizes stray magnetic fields
12. UL Listed in the US and Canada

D. Accessories (Provide with all accessories listed on the contract drawings):
   1. UPS-IPCARD - Web based control shall be enabled on non-internet enabled Middle Atlantic Products UPS by UPS-IPCARD, which shall be installed into the Expansion Port on the rear of the UPS. This shall be compatible with UPS firmware v1.65 or greater, and provide full functionality when used on models with firmware v1.75 or greater.
   2. UPS-RLCARD - Remote shutdown of the UPS shall be enabled on non-internet enabled Middle Atlantic Products UPS by UPS-RLCARD, which shall be installed into the Expansion Port on the rear panel of the UPS. This shall be compatible with UPS firmware v1.65 or greater. A user supplied remote push button and external +12VDC source shall be connected to the DB-9 connector on the UPS-RLCARD to activate the remote shutdown feature.
   3. Expansion Battery - Rackmount expansion battery pack shall be Middle Atlantic Products model# UPS-EBPR. Expansion battery pack shall be suitable for use with both UPS-1000R and UPS-2200R. UPS-EBPR shall measure 19.00″ W x 3.50″ H x 19.29″ D and occupy 2 rackspaces. UPS-EBPR shall require 22.66″ useable depth. With __ hot swappable batteries connected to the unit, there is a __ minute run time at half load and a __ minute run time at full load (refer to chart). Rackmount expansion battery pack shall be warrantied for a period of 2 years.
   4. Replacement Battery - Replacement Battery Pack for the UPS shall be Middle Atlantic Products model # UPS-RBP. Replacement battery pack shall be suitable for use with both UPS-1000R__ and UPS-2200R__. Replacement battery shall be warrantied to be free from defects in materials and workmanship under normal use and conditions for a period of 2 years.

E. Technical Specifications:

UPS-1000 Series					
Utility Voltage (AC)	≤ 80	81-105	106-133	133-147	>147
Fans Engaged	front & rear	rear only	none	rear only	front & rear
dBA above Ambient	22dBA	11dBA	0	11dBA	22dBA

UPS-2200 Series					
Utility Voltage (AC)	≤ 80	81-105	106-133	133-147	>147
Fans Engaged	Front & Rear	Rear only	None	Rear Only	Front & Rear
dBA above Ambient	27dBA	14dBA	0	14dBA	27dBA

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

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

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

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

*Assuming a Power Factor of .7

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

*Assuming a Power Factor of .75

2.10 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 :	1 kW
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.

2.11 LED PANEL LIGHT REFERENCED PRODUCT: DRACAST LED2000 PLUS SERIES

A. Light Output @ 3 Ft:
   1. LED2000 PLUS 5600K; 929 FC
   2. LED2000 PLUS 3200K; 794 FC
   3. LED2000 PLUS 3200K - 5600K; 376 - 390 FC
B. Optical System: 2048, 5mm LED bulbs in 32 x 64 arrangement.
C. Light Aperture: 4.75" x 10"
D. Beam Angle: 45 Degrees Beam Angle

E. Weight: 9.5 lbs.
F. Size: 13.9″ x 14.8″ x 2.7″
G. Mounting: Aluminum Yokes Dual locking, 5/8″ Baby Pin Aluminum Mounting Yoke
H. Tilt Angle: +/- 90 degrees
I. Voltage Input : 24VDC
J. Power Consumption: 130 W
K. Power Connection: 4 Pin XLR, 110 - 240 VAC, 50 - 60 Hz, 2.0 A
L. Heat Management: Passive
M. On Board Fan: No
N. Color Temperature: 3200K - 5600K
O. Color Rendition: CRI > 95
P. Dimming: 0 - 100% Continuous
Q. Controls: Local On-Board Manual Controls/5 Pin DMX In/Out
R. Housing Build: Aluminum Alloy
S. Housing Color: Anodized Blue/Black
T. Est. LED Lifetime: 50,000 hour
U. Provide with Baby C clamp, spigot and adapters, 4 Way Barn doors, Safety Cable, Power Cable 4 Pin – Edison, DMX data cables, and all other accessories as listed on the contract drawings.

2.12 LED FRESNEL LIGHT REFERENCED PRODUCT: DRACAST LED2000 LED FRESNEL SERIES

A. Light Output @ 3 Ft:
   1. LED2000 PLUS 5600K; 697 FC
   2. LED2000 PLUS 3200K; 511 FC
   3. LED2000 PLUS 3200K - 5600K; 223 - 530 FC
B. Optical System: 48 surface mounted CREE LED's in 8 x 6 arrangement.
C. Light Aperture: 6.8″
D. Beam Angle: 15 - 60 Degrees Adjustable Beam Angle
E. Weight: 20 lbs.
F. Size: 15.7″ x 20.7″ x 11.5″
G. Mounting: 5/8″ Baby Pin Aluminum Mounting Yoke
H. Tilt Angle: +/- 90 degrees
I. Voltage Input : 24VDC
J. Power Consumption: 200 W

K. Power Connection: 110 - 240 VAC, 50 - 60 Hz, 2.0 A

L. Heat Management: Passive heat sink cooling system

M. On Board Fan: No

N. Color Temperature: 3200K - 5600K (variable or fixed color temperature depending on model)

O. Color Rendition: CRI > 95

P. Dimming: 0 - 100% Continuous

Q. Controls: Local On-Board Manual Controls/3 Pin DMX In/Out

R. Housing Build: Aluminum Alloy

S. Housing Color: Anodized Blue/Black

T. Est. LED Lifetime: 50,000 hour

U. Provide with Baby C clamp, spigot and adapters, 4 Way Barn doors, Safety Cable, Power Cable – Edison, DMX data cables, and all other accessories as listed on the contract drawings.

2.13 FIVE COLOR MIXING LIGHT EMITTING DIODE ASSYMMETRIC CYC FIXTURE: REFERENCED PRODUCT ETC COLORSOURCE CYC LED

A. General
   1. The fixture shall be a color-mixing high-intensity LED illuminator with DMX control of intensity and color. The fixture shall be a ColorSource® CYC as manufactured by Electronic Theatre Controls, Inc. or approved equal.
   2. All LED fixtures shall be provided by a single manufacturer to ensure compatibility
   3. The fixture shall be UL 1573 listed for stage and studio use
   4. The fixture shall comply with the USITT DMX512-A standard

B. Physical
   1. The fixture shall be contained in a rugged all-metal die-cast housing, free of burrs and pits.
   2. The housing shall have a rugged black powder coat finish
      a. White or silver/gray powder coat finishes shall be available as color options
      b. Other powder coat color options shall be available on request
   3. Power supply and electronics shall be integral to each unit.
   4. Fixture housing shall provide built in spill control
   5. Fixture shall operate directly on the ground or by hanging via yoke
   6. The unit shall ship with:
      a. Theatrical style hanging yoke as standard
      b. 5’ power lead with Neutrik® PowerCON™ to Edison connector as standard
   7. Available options shall include but not be limited to:
      a. DMX input via RJ45 connector

8. Light output shall produce an asymmetrical beam
    a. Lensing shall be designed to provide smooth coverage both horizontally and vertically for seamless blending from fixture to fixture
    b. With a minimum setback from the cyclorama of 2', the fixtures shall be able to achieve a 2-to-1 spacing ration and maintain smooth coverage

C. ENVIRONMENTAL AND AGENCY COMPLIANCE

1. The fixture shall be UL and cUL LISTED and/or CE rated, and shall be so labeled when delivered to the job site.
2. The fixture shall be UL LISTED to the UL1573 standard for stage and studio use
3. The fixture shall be rated for IP-20 dry location use.

D. THERMAL

1. The fixture shall be natural convection cooled and shall not use a fan
2. The fixture shall utilize advanced thermal management systems to maintain LED life to an average of 70% intensity after 50,000 hours of use
    a. Thermal management shall include multiple temperature sensors within the housing to include:
        1) The LED array
        2) The control board
3. The fixture shall operate in an ambient temperature range of 0°C (32°F) minimum, to 40° C (104°F) maximum ambient temperature.

E. ELECTRICAL

1. The fixture shall be equipped with 100V to 240V 50/60 Hz internal power supply
2. The fixture shall support power in and thru operation
    a. Power in shall be via Neutrik® PowerCON™ input connector
    b. Power thru shall be via Neutrik ® PowerCON ™ output connector
    c. Fixture power wiring and accessory power cables shall be rated to support linking of multiple fixtures up to the capacity of a 15A breaker
3. The fixture requires power from non-dim source
4. Power supply shall have power factor correction

F. LED Emitters

1. The fixture shall contain 5 different LED colors to provide color characteristics as described in Section H below.

2. All LEDs used in the fixture shall be high brightness and proven quality from established and reputable LED manufacturers.
   a. Fixture shall utilize Luxeon® C™ LED emitters
3. Manufacturer of LED emitters shall utilize an advanced production LED binning process to maintain color consistency.
4. LED emitters should be rated for nominal 50,000 hour LED life to 70% intensity
5. LED system shall comply with all relevant patents
6. Fixtures shall have a flicker free mode that will set the LED refresh rate to 25,000 Hz for flicker free operation on camera

G. CALIBRATION

1. Fixture shall be calibrated at factory for achieve consistent color between fixtures built at different times and/or from different LED lots or bins
   a. Calibration data shall be stored in the fixture as a permanent part of on-board operating system
   b. All arrays, including replacement arrays shall be calibrated to the same standard to ensure consistency
   c. Fixtures not offering LED calibration shall not be acceptable
2. Fixture shall have droop compensation to overcome thermal droop in the LEDs to maintain output levels and color point.

H. COLOR

1. The fixture shall utilize a minimum of 42 LED emitters
   a. These emitters shall be made up of Red, Green, Blue, Indigo and Lime

I. DIMMING

1. The LED system shall use 15-bit nonlinear scaling techniques for high-resolution dimming.
2. The dimming curve shall be optimized for smooth dimming over longer timed fades.
3. The LED system shall be digitally driven using high-speed pulse width modulation (PWM)
4. LED control shall be compatible with broadcast equipment in the following ways:
   a. PWM control of LED levels shall be imperceptible to video cameras and related equipment
   b. PWM rates shall be adjustable by the user via RDM to avoid any visible interference to video cameras and related equipment

J. CONTROL AND USER INTERFACE

1. The fixture shall be USITT DMX512-A compatible via In and Thru 5-pin XLR connectors **or** RJ45 connectors
2. The fixture shall be compatible with the ANSI RDM E1.20 standard
   a. All fixture functions shall accessible via RDM protocol for modification from suitably equipped control console
   b. Temperature sensors within the luminaire shall be viewable in real time via RDM
   c. Fixtures not offering RDM compatibility, feature set access or temperature monitoring via RDM shall not be compatible
3. The fixture shall be equipped with a 7-segment display for easy-to-read status and control
4. The fixture shall be equipped with a three-button user-interface
5. The fixture shall offer multiple control modes including but not limited to:
   a. RGB
   b. 5 channel (IRGBS)
   c. Direct
   d. Single channel
6. The fixture shall operate in Regulated mode for droop compensation
7. The fixture shall offer stand-alone functionality eliminating the need for a console
   a. Fixture shall ship with 12 preset colors accessible as a stand-alone feature
   b. Fixture shall ship with 5 Sequences accessible as a stand-alone feature
   c. Each preset can be modified by the end user
   d. Fixtures can be linked together with standard DMX cables and controlled from designated master fixture
      1) Up to 32 fixtures may be linked
   e. Fixtures in a stand-alone state shall restore to the settings present prior to power cycling, eliminating the need for reprogramming
   f. Fixtures without stand-alone operation features described in a, b, c, d, and e shall not be acceptable.

2.14 INTERIOR SOLID STATE LED LUMINAIRES: REFERENCED PRODUCT GOTHAM ARCHITECTURAL DOWNLIGHTING 6" INCITO LED CYLINDER DOWNLIGHT

A. LUMINAIRES TYPE XX – Pendant Cylinder Downlight
   1. Each luminaire shall consist of an assembly that utilizes LEDs as the light source. In addition, a complete luminaire shall consist of a housing, LED array, and electronic driver (power supply) and integral controls as per this specification.

2. Each luminaire shall be designed to operate at an average operating temperature of 25°C.
3. The operating temperature range shall be 0°C to +25°C.
4. Each luminaire shall meet all parameters of this specification throughout the minimum operational life when operated at the average operating temperature.
5. Provide the specific fixtures as indicated on the contract drawings.
6. Provide sloped ceiling adapters as required by the ceiling section each fixture is mounted into.
7. Provide goof rings as required to infill existing holes. Goof rings shall be manufacturer furnished, professional in appearance and be factory painted to match existing surfaces. Colors TBD by the architect and owner.
8. Provide trim rings in color TBD by the architect/owner and to match the ceiling surface they are mounted into.
9. Nominal luminaire dimensions:
    a. Type XX – Width 15-1/16", Length 10-1/2", Height 8-7/8", Aperture 6-1/4", High ambient (40^0C) height 10-5/8"
    b. Type YY - Width 9-13/16", Length 6-7/16", Height 8" max, Aperture 4-5/16"
    c. Luminaire housing shall be constructed of 16-gauge galvanized steel and have preinstalled telescopic mounting bars with maximum 32" and minimum 15" extension and 4" vertical adjustment.
    d. The luminaire shall be a single, self-contained device, not requiring on-site assembly for installation. The power supply and circuit board for the luminaire shall be integral to the unit and be accessible through aperture.
    e. Luminaires shall be suitable for installation in ceilings up to 1 ½" thick. (specify ceiling thickness adapter to extend frame to accommodate ceiling thickness up to 2")
    f. Sloped ceiling adapter – as per specification for specific degree of slope from 10 to 30 degrees in 5 degree increments.
    g. Toolless adjustments shall be possible after installation.
    h. Cone Finish: anodized reflector in semi-specular, matte diffuse or specular as specified and be self-flanged.
    i. Cone Color shall be as specified, clear, pewter, wheat, gold or white.
    j. Self-flanged cone to have an overlap matching cone color, white or black painted flange shall be optional.
    k. Flangeless cone trims shall be as specified and luminaire shall be provided with mud ring, plaster guard and installation instructions.
    l. The assembly and manufacturing process for the SSL luminaire shall be designed to assure all internal components are adequately supported to withstand mechanical shock and vibration.
10. LED SOURCES:
    a. LED's shall be manufactured by, Nichia, Samsung or Osram.

b. Lumen Output – minimum initial lumen output of the luminaire shall be selected for the particular usage and range from 500 lumens to 6500 lumens as follows for the lumens exiting the luminaire in the 0-90 degree zone - as measured by IESNA Standard LM-79-08 in an accredited lab. Exact tested lumen output shall be clearly noted on the shop drawings.

11. LUMEN OUTPUTS:

a. 4" Luminaires shall provide the following lumen output and wattage consumption performance:

LUMENS	WATTAGE
500	8
750	12
1000	17
1250	18
1500	23
2000	27
2500	35
3000	42

b. 6" Luminaires shall provide the following lumen output and wattage consumption performance according to beam angle:

LUMENS	BEAM ANGLES									
	20	25	30	35	40	45	55	60	65	70
6500	101W	101W	101W	101W	101W					
6000	95W	95W	95W	95W	95W	101W	101W	101W	101W	101W
5500	83W	83W	83W	83W	83W	95W	95W	95W	95W	95W
5000	75W	75W	75W	75W	75W	83W	83W	83W	83W	83W
4500	65W	65W	65W	65W	65W	75W	75W	75W	75W	75W
4000	57W	57W	57W	57W	57W	64W	64W	64W	64W	64W
3500	50W	50W	50W	50W	50W	57W	57W	57W	57W	57W
3000	42W	42W	42W	42W	42W	50W	50W	50W	50W	50W
2500	35W	35W	35W	35W	35W	42W	42W	42W	42W	42W
2000	28W	28W	28W	28W	28W	35W	35W	35W	35W	35W

c. Lumen output shall not decrease by more than 30% over the minimum operational life of 60,000 hours.
d. Individual LEDs shall be connected such that a catastrophic loss or the failure of one LED will not result in the loss of the entire luminaire.
e. LED light engine shall be suitable for field maintenance or service from below the ceiling with plug-in connectors. LED light engine shall be upgradable.
f. Light Color/Quality-
    1. Correlated Color Temperature (CCT) range as per specification, between 2700K, 3000K, 3500K and 4100K shall be correlated to chromaticity as defined by the absolute (X,Y) coordinates on the 2-D CIE chromaticity chart.
    2. The color rendition index (CRI) shall be 83 or greater.
    3. Color shift over 6,000 hours shall be <0.007 change in u' v' as demonstrated in IES LM80 report.

12. Power Supply and Drive
    a. Driver: Acceptable manufacturer: eldoLED
    b. Ten-year expected life while operating at maximum case temperature and 90 percent non-condensing relative humidity.
    c. Driver shall be UL Recognized under the component program and shall be modular for simple field replacement. Drivers that do not meet these requirements will not be accepted.
    d. Electrical characteristics: 120 - 277 volt, UL Listed, CSA Certified, Sound Rated A+. Driver shall be > 80% efficient at full load across all input voltages. Input wires shall be 18AWG solid copper minimum.
    e. Dimming: Driver shall be suitable for full-range dimming. LED dimming shall be equal in range and quality to a commercial grade incandescent dimmer. Quality of dimming to be defined by dimming range, freedom from perceived flicker or visible stroboscopic flicker, smooth and continuous change in level (no visible steps in transitions), natural square law response to control input, inaudible in 26db environment, and stable when input voltage conditions fluctuate over what is typically experienced in a commercial environment. Demonstration of this compliance to dimming performance will be necessary for substitutions or prior approval.
        1. The luminaire shall be capable of continuous dimming without perceivable flicker over a range of 100 – 0.1% of rated lumen output with a smooth shut off function to step to 0%.

f. Driver shall include ability to provide no light output when the analog control signal drops below 0.5V, or the DALI/DMX digital signal calls for light to be extinguished and shall consume 0.5 watts or less in this standby. Control deadband between .5 and .65V shall be included to allow for voltage variation of incoming signal without causing noticeable variation in fixture to fixture output.
g. Driver shall be capable of configuring a linear or logarithmic dimming curve, allowing fine grained resolution at low light levels.
h. Driver must be capable of 20 bit dimming resolution for white light LED driver.
i. Drivers shall track evenly across multiple fixtures at all light levels, and shall have an input signal to output light level that allows smooth adjustment over the entire dimming range.
j. Control Input
    1. 4-Wire (0-10V DC Voltage Controlled) Dimming Drivers
        a. Must meet IEC 60929 Annex E for General White Lighting LED drivers.
        b. Connect to devices compatible with 0 to 10V Analog Control Protocol, Class 2, capable of sinking 0.6 ma per driver at a low end of 0.3V. Limit the number of drivers on each 0-10V control output based on voltage drop and control capacity.
        c. Must meet ESTA E1.3 for RGBW LED drivers
    2. Digital (DALI Low Voltage Controlled) Dimming Drivers
        a. Must meet IEC 62386
    3. Digital Multiplex (DMX Low Voltage Controlled) Dimming Drivers
        a. Must meet DMX / RDM: USITT DMX512A and ANSI E1.20 (Explore & Address)
        b. Capable of signal interpolation and smoothing of color and intensity transitions
k. Flicker: Driver and luminaire electronics shall deliver illumination that is free from objectionable flicker as measured by flicker index (ANSI/IES RP-16-10). At all points within the dimming range from 100-0.1 percent luminaire shall have:
l. Less than 1 percent flicker index at frequencies below 120 Hz.
m. Driver disconnect shall be provided where required to comply with codes.
n. The electronics/power supply enclosure shall be internal to the SSL luminaire and be accessible per UL requirements.
o. The surge protection which resides within the driver shall protect the luminaire from damage and failure for transient voltages and currents as defined in ANSI/IEEE C64.41 2002 for Location Category A, where failure does not mean a momentary loss of light during the transient event.

13. Electrical
    a. Power Consumption: Maximum power consumption, +/- 5% when operating between 120 – 277V (or 346V) shall be met in accordance with 2.2.6.b
    b. Operation Voltage - The luminaire shall operate from a 50 or 60 Hz ±3 Hz AC line over a voltage ranging from 120 VAC to 277 VAC. The fluctuations of line voltage shall have no visible effect on the luminous output. The standard operating voltages are 120 VAC, 277 VAC, 347 VAC.
    c. Power Factor: The luminaire shall have a power factor of 90% or greater at all standard operating voltages and full luminaire output.
    d. THD: Total harmonic distortion (current and voltage) induced into an AC power line by luminaire shall not exceed 20 percent at any standard input voltage and meet ANSI C82.11 maximum allowable THD requirements at full output. THD shall at no point in the dimming curve allow imbalance current to exceed full output THD.
    e. Surge Suppression: The luminaire shall include surge protection to withstand high repetition noise and other interference.
    f. In Rush Current: Meet or exceed NEMA 410 driver inrush standard of 430 Amps per 10 Amps load with a maximum of 370 Amps2 – seconds.
    g. RF Interference: The luminaire and associated on-board circuitry must meet Class A emission limits referred in Federal Communications Commission (FCC) Title 47, Subpart B, Section 15 Non-Consumer requirements for EMI/RFI emissions.
    h. Driver must support automatic adaptation, allowing for future luminaire upgrades and enhancements and deliver improved performance:
        1. Adjustment of forward LED voltage, supporting 3V through 60V.
        2. Adjustment of LED current from 200mA to 1.05A at the 100 percent control input point in increments of 1mA.
        3. Adjustment for operating hours to maintain constant lumens (within 5 percent) over the 50,000 hour design life of the system, and deliver up to 20 percent energy savings early in the life cycle.
    i. Electrical connections between normal power and driver must be modular utilizing a snap fit connector. All electrical components must be easily accessible after installation and be replaceable without removing the fixture from the ceiling.
    j. All electrical components shall be RoHS compliant.
14. Emergency Battery Pack
    a. Shall be factory installed and provide a range of 363 to 1195 lm of light for 90 minutes. Output is based on the size and wattage of the luminaire.
    b. Integral or remote test switch shall be provided as per specification.
15. Photometric Requirements
    a. Luminaire performance shall be tested as described herein.

1. Luminaire performance shall be judged against the specified minimum illuminance in the specified pattern for a particular application.
2. Luminaire lighting performance shall be adjusted (depreciated) for the minimum life expectancy.
3. The performance shall be adjusted (depreciated) by using the LED manufacturer's data or the data from the IESNA Standard TM-21 test report, which ever one results in a higher level of lumen depreciation.
    a. The luminaire may be determined to be compliant photometrically, if:

1) The initial minimum illuminance level is achieved in 100% of the area of the specified lighting pattern
2) The measurements shall be calibrated to standard photopic calibrations.

16. Thermal Management
    a. The thermal management (of the heat generated by the LEDs) shall be of sufficient capacity to assure proper operation of the luminaire over the expected useful life.
    b. The LED manufacturer's maximum junction temperature for the expected life shall not be exceeded at the average operating ambient.
    c. The LED manufacturer's maximum junction temperature for the catastrophic failure shall not be exceeded at the maximum operating ambient.
    d. The luminaire are CSA certified for US and Canadian standards; wet location, covered ceiling.
    e. The Driver manufacturer's maximum case temperature shall not be exceeded at the maximum operating ambient. Thermal management shall be passive by design. The use of fans or other mechanical devices shall not be allowed.
17. Optics
    a. Optical system shall consist of a self-flanged semi-specular, matt diffuse or specular lower reflector as per specification.
    b. Optical design is a patented Bounding Ray design (U.S. Patent No. 5,800,050).
    c. Cone shall provide 45° cutoff to source and source image and have top-down flash characteristic.
    d. Optical distribution for downlight shall be as specified ranging from $10^0 – 70^0$ in 50 increments
18. Luminaire Identification
    a. Each luminaire shall have the manufacturer's name, trademark, model number, serial number, date of manufacture (month-year), and lot number as identification permanently marked inside the each unit and the outside of each packaging box.
    b. The following operating characteristics shall be permanently marked inside each unit: rated voltage and rated power in Watts and Volt-Ampere.

B. WARRANTY

1. The manufacturer shall provide a warranty against loss of performance and defects in materials and workmanship for the Luminaires for a period of 5 years after acceptance of the Luminaires. Warranty shall cover all components comprising the luminaire. All warranty documentation shall be provided to customer prior to the first shipment.

C. INSTALLATION

1. Install fixtures securely, in a neat and workmanlike manner, as specified in NECA 501.
2. Fixture to be recessed mounted in suspended lay-in grid ceiling, dry wall or other ceiling type up to 1 ½" thick. Contractor to verify exact ceiling type prior to ordering luminaires to insure compatibility with ceiling thickness.
3. Flangeless fixtures for recess mounting in drywall shall be provided with mud ring and plaster guard, install per manufacturer's instructions.
4. Install all required hardware and mounting brackets to secure luminaires to structure per local code requirements.
5. Bond luminaires and metal accessories to branch circuit equipment grounding conductor.

D. FIELD QUALITY CONTROL

1. Operate each luminaire after installation and connection. Inspect for improper connections and operation.
2. Test and calibrate all controls associated with luminaires.

E. CLEANING

1. Clean electrical parts to remove conductive and deleterious materials.
2. Remove dirt and debris from lens enclosures
   a. For cleaning acrylic lenses or diffusers, use a feather duster or dry cotton cheesecloth to rid the lens/diffuser of any minor dust. For fingerprints, smudges, or other dirt present, use an ammonia-based cleaner (such as Windex) and wipe carefully with cotton cheesecloth (so as to avoid injury from any prismatic texture of the lens).
   b. Job site contamination may not necessarily be removed using the above recommendations. In that case the lens would need to be replaced.
3. Clean photometric control surfaces as recommended by manufacturer.

F. CLOSEOUT ACTIVITIES

1. Replace any luminaire, related components or associated controls that do not function per specifications or drawing intents.

G. LISTINGS:

1. Product shall be manufactured to conform to requirements of NEC.
2. Luminaire shall be listed for damp locations by an OSHA NRTL.
3. Luminaire shall have locality-appropriate governing mark and/or certification.
4. Codes: Materials and installation shall be in accordance with the latest revision of the National Electrical Code and any applicable Federal, State, and local codes and regulations.
5. UL or CSA US Listing: All fixtures shall be manufactured in strict accordance with the appropriate and current requirements of the “Standards for Safety" to UL 8750 or others as they may be applicable. A listing shall be provided for each fixture type, and the appropriate label or labels shall be affixed to each fixture in a position concealing it from normal view.
6. Luminaire shall be Energy Star certified through testing in EPA–recognized laboratories, with the results reviewed by an independent, accredited certification organization.

H. DEFINITIONS

1. CALiPER - DOE Commercially Available LED Product Evaluation and Reporting program for the testing and monitoring of commercially available LED Luminaires and lights.
2. CCT - Correlated Color Temperature: The temperature in units of kelvin of a blackbody whose chromaticity most nearly resembles that of the light source in question.
3. CD - Candela: SI Unit of luminous intensity, equal to 1 lumen per steradian (lm/sr)
4. Chromaticity - The property of color of light defined by the dominant or complementary wavelength and purity aspects of the color taken together
5. CRI - Color Rendering Index – measure of the degree of color shift of reference objects when illuminated by the light source as compared to a reference source of comparable color temperature.

6. Energy Star - ENERGY STAR is a U.S. Environmental Protection Agency (EPA) voluntary program that sets standards for superior energy efficiency of products. The ENERGY STAR qualification process requires that products be tested in EPA–recognized laboratories, with the results reviewed by an independent, accredited certification organization
7. FC - Footcandle: Unit of illuminance, equal to 1 lm/ft^2
8. L70 - The extrapolated life in hours of the luminaire when the luminous output depreciates 30 percent from initial values.
9. LED - Light Emitting Diode
10. METS - Material Engineering and Testing Services of the Translab
11. MacAdam - Shape on the CIE chromaticity diagram that illustrates how much one can "stray" from the target before perceiving a difference from the target color
12. NEMA - National Electrical Manufacturers Association
13. NRTL - Nationally Recognized Testing Laboratory
14. NVLAP - National Voluntary Laboratory Accreditation Program - A program under the US DOE to accredit independent testing laboratories to qualify
15. PF - Power Factor - The ratio of the real power component to the total (complex) power component.
16. Rated power - Power consumption that the luminaire was designed and tested for at ambient temperature (70°F or 21°C)
17. RoHS - Compliance aims to restrict certain dangerous substances commonly used in electronic equipment, including Lead, Cadmium, Mercury and others.
18. SPD - Surge Protection Device - A subsystem or component(s) that can protect the unit against short duration voltage and current surges
19. SSL - Solid State Lighting
20. THD - Total Harmonic Distortion - The amount of higher frequency power on the power line.

I. REFERENCE STANDARDS:

1. National Energy Policy Act of 2005, Public Law No. 109-58.
2. IESNA LM-63 - ANSI Approved Standard File Format for Electronic Transfer of Photometric Data and Related Information; 2002.
3. NFPA 70 - National Electrical Code; National Fire Protection Association; 2008.
4. IESNA LM-79-08 IESNA - Approved Method for Electrical and Photometric Measurements of Solid-State Lighting Products; 2008
5. IESNA LM-80-08 IESNA - Approved Method for Measuring Lumen Maintenance of LED Light Sources
6. IESNA TM-21-2011 – Projecting Long Term Lumen Maintenance of LED Light Sources
7. UL 1310 and 8750 – Light Emitting Diode (LED) Equipment for Use in Lighting Products

8. OSHA 29CFR1910.7 – luminaires shall be listed by national recognized testing laboratory approved by United Stated Department of Labor, Occupational Safety and Health Administration (OSHA)
9. ANSI C82.11 – Performance requirement for high frequency ballasts.
10. ANSI/IES RP-16-10 – Nomenclature and definitions for illuminating engineering.
11. ANSI C62.41 – Recommended practice in low power circuits.
12. IEC 61347-1 – General and safety requirements for lamp control gear.
13. IEC 61347-2-13 – Particular requirements for electronic control gear for LED modules.
14. IEC 62384 - DC or AC supplied electronic control gear for LED modules – performance requirements.
15. IEC 61000-3-2 - Harmonic current emissions.
16. IEC 61547 - EMC immunity requirements.
17. IEC 62386-101/102/207 – Digital addressable lighting interface (DALI).
18. Federal Communications Commission (FCC) rules – Part 15 Class B: Radio Frequency Devices.
19. Commercial rated
20. Entertainment Services and Technology Association
21. ESTA E1.3 - Entertainment Technology - Lighting Control System - 0 to 10V Analog Control Protocol.

2.15 INTERIOR SOLID-STATE LED LUMINAIRES: REFERENCED PRODUCT GOTHAM ARCHITECTURAL DOWNLIGHTING 6" INCITO LED DOWNLIGHT

A. LUMINAIRES TYPE XX - Open Recessed Downlight

1. Each luminaire shall consist of an assembly that utilizes LEDs as the light source. In addition, a complete luminaire shall consist of a housing, LED array, and electronic driver (power supply) and integral controls as per this specification.
2. Each luminaire shall be designed to operate at an average operating temperature of 25°C.
3. The operating temperature range shall be 0°C to +25°C.
4. Each luminaire shall meet all parameters of this specification throughout the minimum operational life when operated at the average operating temperature.
5. Provide the specific fixtures as indicated on the contract drawings.
6. Provide sloped ceiling adapters as required by the ceiling section each fixture is mounted into.
7. Provide goof rings as required to infill existing holes. Goof rings shall be manufacturer furnished, professional in appearance and be factory painted to match existing surfaces. Colors TBD by the architect and owner.

8. Provide trim rings in color TBD by the architect/owner and to match the ceiling surface they are mounted onto.
9. Nominal luminaire dimensions:
    a. Type XX – Width 15-1/16", Length 10-1/2", Height 8-7/8", Aperture 6-1/4", High ambient (40^0C) height 10-5/8"
    b. Type YY - Width 9-13/16", Length 6-7/16", Height 8" max, Aperture 4-5/16"
    c. Luminaire housing shall be constructed of 16-gauge galvanized steel and have preinstalled telescopic mounting bars with maximum 32" and minimum 15" extension and 4" vertical adjustment.
    d. The luminaire shall be a single, self-contained device, not requiring on-site assembly for installation. The power supply and circuit board for the luminaire shall be integral to the unit and be accessible through aperture.
    e. Luminaires shall be suitable for installation in ceilings up to 1 ½" thick. (specify ceiling thickness adapter to extend frame to accommodate ceiling thickness up to 2")
    f. Sloped ceiling adapter – as per specification for specific degree of slope from 10 to 30 degrees in 5 degree increments.
    g. Toolless adjustments shall be possible after installation.
    h. Cone Finish: anodized reflector in semi-specular, matte diffuse or specular as specified and be self-flanged.
    i. Cone Color shall be as specified, clear, pewter, wheat, gold or white.
    j. Self-flanged cone to have an overlap matching cone color, white or black painted flange shall be optional.
    k. Flangeless cone trims shall be as specified and luminaire shall be provided with mud ring, plaster guard and installation instructions.
    l. The assembly and manufacturing process for the SSL luminaire shall be designed to assure all internal components are adequately supported to withstand mechanical shock and vibration.

10. LED SOURCES:

    a. LED's shall be manufactured by, Nichia, Samsung or Osram.
    b. Lumen Output – minimum initial lumen output of the luminaire shall be selected for the particular usage and range from 500 lumens to 6500 lumens as follows for the lumens exiting the luminaire in the 0-90 degree zone - as measured by IESNA Standard LM-79-08 in an accredited lab. Exact tested lumen output shall be clearly noted on the shop drawings.

11. LUMEN OUTPUTS:

    a. 6" Luminaires shall provide the following lumen output and wattage consumption performance according to beam angle:

LUMENS	BEAM ANGLES									
	20	25	30	35	40	45	55	60	65	70
6500	101W	101W	101W	101W	101W					
6000	95W	95W	95W	95W	95W	101W	101W	101W	101W	101W
5500	83W	83W	83W	83W	83W	95W	95W	95W	95W	95W
5000	75W	75W	75W	75W	75W	83W	83W	83W	83W	83W
4500	65W	65W	65W	65W	65W	75W	75W	75W	75W	75W
4000	57W	57W	57W	57W	57W	64W	64W	64W	64W	64W
3500	50W	50W	50W	50W	50W	57W	57W	57W	57W	57W
3000	42W	42W	42W	42W	42W	50W	50W	50W	50W	50W
2500	35W	35W	35W	35W	35W	42W	42W	42W	42W	42W
2000	28W	28W	28W	28W	28W	35W	35W	35W	35W	35W

b. Lumen output shall not decrease by more than 30% over the minimum operational life of 60,000 hours.
c. Individual LEDs shall be connected such that a catastrophic loss or the failure of one LED will not result in the loss of the entire luminaire.
d. LED light engine shall be suitable for field maintenance or service from below the ceiling with plug-in connectors. LED light engine shall be upgradable.
e. Light Color/Quality-
    1) Correlated Color Temperature (CCT) range as per specification, between 2700K, 3000K, 3500K and 4100K shall be correlated to chromaticity as defined by the absolute (X,Y) coordinates on the 2-D CIE chromaticity chart.
    2) The color rendition index (CRI) shall be 83 or greater.
    3) Color shift over 6,000 hours shall be <0.007 change in u' v' as demonstrated in IES LM80 report.

12. Power Supply and Drive
    a. Driver: Acceptable manufacturer: eldoLED
    b. Ten-year expected life while operating at maximum case temperature and 90 percent non-condensing relative humidity.
    c. Driver shall be UL Recognized under the component program and shall be modular for simple field replacement. Drivers that do not meet these requirements will not be accepted.
    d. Electrical characteristics: 120 - 277 volt, UL Listed, CSA Certified, Sound Rated A+. Driver shall be > 80% efficient at full load across all input voltages. Input wires shall be 18AWG solid copper minimum.

e. Dimming: Driver shall be suitable for full-range dimming. LED dimming shall be equal in range and quality to a commercial grade incandescent dimmer. Quality of dimming to be defined by dimming range, freedom from perceived flicker or visible stroboscopic flicker, smooth and continuous change in level (no visible steps in transitions), natural square law response to control input, inaudible in 26db environment, and stable when input voltage conditions fluctuate over what is typically experienced in a commercial environment. Demonstration of this compliance to dimming performance will be necessary for substitutions or prior approval.
   1) The luminaire shall be capable of continuous dimming without perceivable flicker over a range of 100 – 0.1% of rated lumen output with a smooth shut off function to step to 0%.

f. Driver shall include ability to provide no light output when the analog control signal drops below 0.5V, or the DALI/DMX digital signal calls for light to be extinguished and shall consume 0.5 watts or less in this standby. Control deadband between .5 and .65V shall be included to allow for voltage variation of incoming signal without causing noticeable variation in fixture to fixture output.

g. Driver shall be capable of configuring a linear or logarithmic dimming curve, allowing fine grained resolution at low light levels.

h. Driver must be capable of 20 bit dimming resolution for white light LED driver.

i. Drivers shall track evenly across multiple fixtures at all light levels, and shall have an input signal to output light level that allows smooth adjustment over the entire dimming range.

j. Control Input
   1) 4-Wire (0-10V DC Voltage Controlled) Dimming Drivers
      i) Must meet IEC 60929 Annex E for General White Lighting LED drivers.
      ii) Connect to devices compatible with 0 to 10V Analog Control Protocol, Class 2, capable of sinking 0.6 ma per driver at a low end of 0.3V. Limit the number of drivers on each 0-10V control output based on voltage drop and control capacity.
      iii) Must meet ESTA E1.3 for RGBW LED drivers
   2) Digital (DALI Low Voltage Controlled) Dimming Drivers
      i) Must meet IEC 62386
   3) Digital Multiplex (DMX Low Voltage Controlled) Dimming Drivers
      i) Must meet DMX / RDM: USITT DMX512A and ANSI E1.20 (Explore & Address)
      ii) Capable of signal interpolation and smoothing of color and intensity transitions

k. Flicker: Driver and luminaire electronics shall deliver illumination that is free from objectionable flicker as measured by flicker index (ANSI/IES RP-16-10). At all points within the dimming range from 100-0.1 percent luminaire shall have:
l. Less than 1 percent flicker index at frequencies below 120 Hz.
m. Driver disconnect shall be provided where required to comply with codes.
n. The electronics/power supply enclosure shall be internal to the SSL luminaire and be accessible per UL requirements.
o. The surge protection which resides within the driver shall protect the luminaire from damage and failure for transient voltages and currents as defined in ANSI/IEEE C64.41 2002 for Location Category A, where failure does not mean a momentary loss of light during the transient event.

13. Electrical
    a. Power Consumption: Maximum power consumption, +/- 5% when operating between 120 – 277V (or 346V) shall be met in accordance with 2.2.6.b
    b. Operation Voltage - The luminaire shall operate from a 50 or 60 Hz ±3 Hz AC line over a voltage ranging from 120 VAC to 277 VAC. The fluctuations of line voltage shall have no visible effect on the luminous output. The standard operating voltages are 120 VAC, 277 VAC, 347 VAC.
    c. Power Factor: The luminaire shall have a power factor of 90% or greater at all standard operating voltages and full luminaire output.
    d. THD: Total harmonic distortion (current and voltage) induced into an AC power line by luminaire shall not exceed 20 percent at any standard input voltage and meet ANSI C82.11 maximum allowable THD requirements at full output. THD shall at no point in the dimming curve allow imbalance current to exceed full output THD.
    e. Surge Suppression: The luminaire shall include surge protection to withstand high repetition noise and other interference.
    f. In Rush Current: Meet or exceed NEMA 410 driver inrush standard of 430 Amps per 10 Amps load with a maximum of 370 Amps2 – seconds.
    g. RF Interference: The luminaire and associated on-board circuitry must meet Class A emission limits referred in Federal Communications Commission (FCC) Title 47, Subpart B, Section 15 Non-Consumer requirements for EMI/RFI emissions.
    h. Driver must support automatic adaptation, allowing for future luminaire upgrades and enhancements and deliver improved performance:
        1) Adjustment of forward LED voltage, supporting 3V through 60V.
        2) Adjustment of LED current from 200mA to 1.05A at the 100 percent control input point in increments of 1mA.
        3) Adjustment for operating hours to maintain constant lumens (within 5 percent) over the 50,000 hour design life of the system, and deliver up to 20 percent energy savings early in the life cycle.

i. Electrical connections between normal power and driver must be modular utilizing a snap fit connector. All electrical components must be easily accessible after installation and be replaceable without removing the fixture from the ceiling.
j. All electrical components shall be RoHS compliant.

14. Emergency Battery Pack
    a. Shall be factory installed and provide a range of 363 to 1195 lm of light for 90 minutes. Output is based on the size and wattage of the luminaire.
    b. Integral or remote test switch shall be provided as per specification.
15. Photometric Requirements
    a. Luminaire performance shall be tested as described herein.
        1) Luminaire performance shall be judged against the specified minimum illuminance in the specified pattern for a particular application.
        2) Luminaire lighting performance shall be adjusted (depreciated) for the minimum life expectancy.
        3) The performance shall be adjusted (depreciated) by using the LED manufacturer's data or the data from the IESNA Standard TM-21 test report, which ever one results in a higher level of lumen depreciation.
            i) The luminaire may be determined to be compliant photometrically, if:
        4) The initial minimum illuminance level is achieved in 100% of the area of the specified lighting pattern
        5) The measurements shall be calibrated to standard photopic calibrations.
16. Thermal Management
    a. The thermal management (of the heat generated by the LEDs) shall be of sufficient capacity to assure proper operation of the luminaire over the expected useful life.
    b. The LED manufacturer's maximum junction temperature for the expected life shall not be exceeded at the average operating ambient.
    c. The LED manufacturer's maximum junction temperature for the catastrophic failure shall not be exceeded at the maximum operating ambient.
    d. The luminaire are CSA certified for US and Canadian standards; wet location, covered ceiling.
    e. The Driver manufacturer's maximum case temperature shall not be exceeded at the maximum operating ambient. Thermal management shall be passive by design. The use of fans or other mechanical devices shall not be allowed.
17. Optics
    a. Optical system shall consist of a self-flanged semi-specular, matt diffuse or specular lower reflector as per specification.
    b. Optical design is a patented Bounding Ray design (U.S. Patent No. 5,800,050).
    c. Cone shall provide 45° cutoff to source and source image and have top-down flash characteristic.

d. Optical distribution for downlight shall be as specified ranging from 10^0 – 70^0 in 50 increments

18. Luminaire Identification
    a. Each luminaire shall have the manufacturer's name, trademark, model number, serial number, date of manufacture (month-year), and lot number as identification permanently marked inside the each unit and the outside of each packaging box.
    b. The following operating characteristics shall be permanently marked inside each unit: rated voltage and rated power in Watts and Volt-Ampere.

B. WARRANTY

1. The manufacturer shall provide a warranty against loss of performance and defects in materials and workmanship for the Luminaires for a period of 5 years after acceptance of the Luminaires. Warranty shall cover all components comprising the luminaire. All warranty documentation shall be provided to customer prior to the first shipment.

C. INSTALLATION

1. Install fixtures securely, in a neat and workmanlike manner, as specified in NECA 501.
2. Fixture to be recessed mounted in suspended lay-in grid ceiling, dry wall or other ceiling type up to 1 ½" thick. Contractor to verify exact ceiling type prior to ordering luminaires to insure compatibility with ceiling thickness.
3. Flangeless fixtures for recess mounting in drywall shall be provided with mud ring and plaster guard, install per manufacturer's instructions.
4. Install all required hardware and mounting brackets to secure luminaires to structure per local code requirements.
5. Bond luminaires and metal accessories to branch circuit equipment grounding conductor.

D. FIELD QUALITY CONTROL

1. Operate each luminaire after installation and connection. Inspect for improper connections and operation.
2. Test and calibrate all controls associated with luminaires.

E. CLEANING

1. Clean electrical parts to remove conductive and deleterious materials.
2. Remove dirt and debris from lens enclosures
   a. For cleaning acrylic lenses or diffusers, use a feather duster or dry cotton cheesecloth to rid the lens/diffuser of any minor dust. For fingerprints, smudges, or other dirt present, use an ammonia-based cleaner (such as Windex) and wipe carefully with cotton cheesecloth (so as to avoid injury from any prismatic texture of the lens).
   b. Job site contamination may not necessarily be removed using the above recommendations. In that case the lens would need to be replaced.
3. Clean photometric control surfaces as recommended by manufacturer.

F. CLOSEOUT ACTIVITIES

1. Replace any luminaire, related components or associated controls that do not function per specifications or drawing intents.

G. LISTINGS:

1. Product shall be manufactured to conform to requirements of NEC.
2. Luminaire shall be listed for damp locations by an OSHA NRTL.
3. Luminaire shall have locality-appropriate governing mark and/or certification.
4. Codes: Materials and installation shall be in accordance with the latest revision of the National Electrical Code and any applicable Federal, State, and local codes and regulations.
5. UL or CSA US Listing: All fixtures shall be manufactured in strict accordance with the appropriate and current requirements of the "Standards for Safety" to UL 8750 or others as they may be applicable. A listing shall be provided for each fixture type, and the appropriate label or labels shall be affixed to each fixture in a position concealing it from normal view.
6. Luminaire shall be Energy Star certified through testing in EPA–recognized laboratories, with the results reviewed by an independent, accredited certification organization.

H. DEFINITIONS

1. CALiPER - DOE Commercially Available LED Product Evaluation and Reporting program for the testing and monitoring of commercially available LED Luminaires and lights.

2. CCT - Correlated Color Temperature: The temperature in units of kelvin of a blackbody whose chromaticity most nearly resembles that of the light source in question.
3. CD - Candela: SI Unit of luminous intensity, equal to 1 lumen per steradian (lm/sr)
4. Chromaticity - The property of color of light defined by the dominant or complementary wavelength and purity aspects of the color taken together
5. CRI - Color Rendering Index – measure of the degree of color shift of reference objects when illuminated by the light source as compared to a reference source of comparable color temperature.
6. Energy Star - ENERGY STAR is a U.S. Environmental Protection Agency (EPA) voluntary program that sets standards for superior energy efficiency of products. The ENERGY STAR qualification process requires that products be tested in EPA–recognized laboratories, with the results reviewed by an independent, accredited certification organization
7. FC - Footcandle: Unit of illuminance, equal to 1 lm/ft2
8. L70 - The extrapolated life in hours of the luminaire when the luminous output depreciates 30 percent from initial values.
9. LED - Light Emitting Diode
10. METS - Material Engineering and Testing Services of the Translab
11. MacAdam - Shape on the CIE chromaticity diagram that illustrates how much one can "stray" from the target before perceiving a difference from the target color
12. NEMA - National Electrical Manufacturers Association
13. NRTL - Nationally Recognized Testing Laboratory
14. NVLAP - National Voluntary Laboratory Accreditation Program - A program under the US DOE to accredit independent testing laboratories to qualify
15. PF - Power Factor - The ratio of the real power component to the total (complex) power component.
16. Rated power - Power consumption that the luminaire was designed and tested for at ambient temperature (70°F or 21°C)
17. RoHS - Compliance aims to restrict certain dangerous substances commonly used in electronic equipment, including Lead, Cadmium, Mercury and others.
18. SPD - Surge Protection Device - A subsystem or component(s) that can protect the unit against short duration voltage and current surges
19. SSL - Solid State Lighting
20. THD - Total Harmonic Distortion - The amount of higher frequency power on the power line.

I. REFERENCE STANDARDS:

1. National Energy Policy Act of 2005, Public Law No. 109-58.
2. IESNA LM-63 - ANSI Approved Standard File Format for Electronic Transfer of Photometric Data and Related Information; 2002.

3. NFPA 70 - National Electrical Code; National Fire Protection Association; 2008.
4. IESNA LM-79-08 IESNA - Approved Method for Electrical and Photometric Measurements of Solid-State Lighting Products; 2008
5. IESNA LM-80-08 IESNA - Approved Method for Measuring Lumen Maintenance of LED Light Sources
6. IESNA TM-21-2011 – Projecting Long Term Lumen Maintenance of LED Light Sources
7. UL 1310 and 8750 – Light Emitting Diode (LED) Equipment for Use in Lighting Products
8. OSHA 29CFR1910.7 – luminaires shall be listed by national recognized testing laboratory approved by United Stated Department of Labor, Occupational Safety and Health Administration (OSHA)
9. ANSI C82.11 – Performance requirement for high frequency ballasts.
10. ANSI/IES RP-16-10 – Nomenclature and definitions for illuminating engineering.
11. ANSI C62.41 – Recommended practice in low power circuits.
12. IEC 61347-1 – General and safety requirements for lamp control gear.
13. IEC 61347-2-13 – Particular requirements for electronic control gear for LED modules.
14. IEC 62384 - DC or AC supplied electronic control gear for LED modules – performance requirements.
15. IEC 61000-3-2 - Harmonic current emissions.
16. IEC 61547 - EMC immunity requirements.
17. IEC 62386-101/102/207 – Digital addressable lighting interface (DALI).
18. Federal Communications Commission (FCC) rules – Part 15 Class B: Radio Frequency Devices.
19. Commercial rated
20. Entertainment Services and Technology Association
21. ESTA E1.3 - Entertainment Technology - Lighting Control System - 0 to 10V Analog Control Protocol.

J. PROVIDE
1. Provide all fixtures as specified along with all accessories required, including tile bridges, bracing/blocking, sloped ceiling adapters, goof rings, control wiring, power wiring, etc.
2. Provide spare fixtures, fully tested, set up and ready to be used as replacements. Package in original packing and store per owner's instructions.

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

A. General

1. The Pathport Uno shall be a single-port TCP/IP-compliant gateway node to encode, route and decode DMX data over Ethernet.
2. The node shall support the following protocols for DMX-over-Ethernet transport: Pathport, streaming ACN (Net 3), Strand Shownet, ArtNet. The node shall support, as an output device only, ETC Net2.
3. The node shall incorporate one 5-pin XLR connector mounted on the front face. A female connector shall be used on a nominal output node. A male connector shall be used on a nominal input node.
4. The node shall incorporate one female RJ45 connector mounted on the circuit board for connection to standard Ethernet wiring.
5. The node shall operate as a 10MB device.

B. Appearance
1. The node shall be mounted on a mild steel, single-gang Decora-style faceplate and shall fit a standard, deep back box.
2. Finish shall be matte black or stainless steel.
3. The node shall be of pleasing appearance, suitable for high-visibility architectural locations.
4. There shall be two status LED's on the face: one blue LED shall indicate an active network link; one green LED shall indicate active DMX.
5. There shall be an "identify" function available through management software that shall flash the two LED's together at twice their normal brightness.

C. Power
1. The node shall only operate on IEEE 802.3af Power-over-Ethernet, supplied by an IEEE 802.3af compliant Ethernet switch (by others) or in-line power supply.
2. The node's DMX port shall withstand fault voltages of up to 250VAC without damage.

D. Configuration
1. The node shall be available in DMX input and DMX output versions.
2. The node shall be fully and remotely configurable using Pathport Manager software running on a Java-enabled PC or Mac connected to the Ethernet network. Pathport Manager software shall not be required for regular operation of the node. Configuration shall include but not be limited to:
3. Each node shall accept a user-defined name and IP address.
4. Port direction shall be reversible.
5. DMX output refresh rate shall be user-selectable.
6. Each node shall manage up to 128 DMX universes.
7. Custom channel patches shall be possible, allowing the routing of any input universe or channel to any output location in any order.
8. HTP merging and/or signal prioritizing shall be possible of up to eight input channels to create one output channel.
9. DMX-over-Ethernet transmit and receive protocols shall be user-selectable.

10. Each node's configuration, patching and routing shall be stored locally in the node in non-volatile memory. The node shall recover from power interruption without use of configuration software.
11. Multiple nodes on the same network may be remotely configured over the same Ethernet connection.
12. Each node shall incorporate a four-position jumper switch for hard selection of DMX universes one through four.

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

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

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

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

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

2.18 POWER DISTRIBUTION EQUIPMENT:

A. General
   1. Connectors available are 20A, 50A and 100A grounded stage pin, 20A twist lock and 20A "U" ground (dual rated "T-slot"); other connectors available as specified. Pigtails shall be three-wire type "SOW" rubber jacketed cable sized for the circuit ampacity. Internal wiring shall be sized to circuit ampacity and shall be rated at 125°C.
      a. 20 amp cable mount stage pin connectors shall be 12 gauge 4 way indent crimp (with inspection window) type where the wire is inserted and crimped directly in the socket.
   2. Terminations shall be at one end using feed through terminals individually labeled with corresponding circuit numbers. 20 amp circuits shall use screwless tension clamp or standard screw-type/barrier strip U-style terminals listed for 20 – 8 gauge wire. 50 amp circuits shall use compression terminals listed for 10 – 1 gauge wire and 100 amp circuits shall use compression terminals listed for 8 – 2/0 gauge wire. Terminals that place a screw directly on the wire are not acceptable.
   3. Equipment, except for wall-mounted boxes, shall be supplied with appropriate brackets and hardware for mounting as shown on the drawings. Connector strips shall have brackets on 5' centers. Brackets shall be 1½" x .188" ASTM A 36 steel and hardware shall be ASTM A307 grade 5.
   4. A low voltage distribution system for DMX or Network (or other protocols as specified) shall be available, incorporated in the connector strip, locations and methods to be per print. Connector strips shall have a voltage barrier installed to accommodate these systems. Distributed DMX or Network systems shall use pass through assemblies consisting of a 6" panel with the following: one DMX or Network Output Connector, one DMX or Network Input (Pass Through) connector, one DMX or Network Pass Through (Bypass) Switch, and a label detailing the use of the pass through assembly. The bypass switch shall be used when no DMX or Network devices are present at that location. When activated, the pass through switch shall pass DMX or Network directly through to the next DMX or Network panel on the strip. The pass through switch shall have a mechanical indicator to show the operator that it has or has not been engaged. Low Voltage signals shall

enter the connector strip via a strain relief or connector mounted in a separate DMX or Network terminal box at the specified end of the connector strip.

5. Power distribution equipment shall be Underwriter Laboratories (UL) Listed.

B. Connector Strips

1. Connector Strips shall be fabricated from 18 gauge galvanized steel 6.25″H x 3.3″D with length specified in increments of 6″ and shipped fully wired in a minimum of 6′0″ sections with all splicing hardware included. They shall be finished with fine-textured, scratch-resistant, black powder coat. Circuits shall be labeled on one side of the connector strip with 2″ white lettering on black background labels. Pigtails and outlets shall be spaced on 18″ centers, or as otherwise specified. Outlets shall be mounted on individual 3″ panels and there shall be no external terminal boxes for units with 28 or fewer circuits unless otherwise specified.
    a. Connector strip circuit number labeling:
        1) Circuits shall be labeled on one side of the connector strip with 2″ white lettering on black background labels.

C. Junction Boxes

1. Gridiron Junction Boxes shall be fabricated from 16-gauge cold rolled steel with 14 gauge end panels. They shall be finished with fine-textured, scratch-resistant, black powder coat. For 30 circuits and less they shall be 14″H x 14″W x 4″D and for 31 to 60 circuits they shall be 14″H x 28″W x 4″D. Cover(s) shall be attached with machine screws and Tinnerman retainer nuts. Cover(s) shall be 16-gauge cold rolled steel. Cover(s) shall be hinged and mounting should allow installer to orient the hinged door to open in any direction.

D. Outlet and Pigtail Boxes

1. Outlet and Pigtail Boxes shall be fabricated from 18-gauge cold rolled steel with 16 gauge covers. They shall be finished with fine-textured, scratch-resistant, black powder coat. Circuit numbers shall be 2″ or 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).

F. Floor Pockets

1. The floor pocket shall be a wiring device designed for flush mount installation in the stage floor. The floor pocket cover plate shall be constructed of 3/8″ cast iron with a non-skid tread pattern and four (4) recessed mounting holes. The cover shall be constructed with integral hinges and four (4) cable notches. Secured to

the cover plate shall be an angled sheet-steel mounting panel for receptacles. The floor pocket back box shall have provisions for an integral voltage barrier for low voltage circuits. Circuit designations shall be white on black background labels. The floor pocket cover plate, back box and connector-mounting panel shall be finished in a low gloss black finish. The back box shall be constructed of 16-gauge cold rolled steel and UL listed for use in the United States and Canada.

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

A. Wiring devices shall be fabricated from 16 gauge cold rolled steel, in 6' 0" sections as required. Devices shall be properly cleaned, primed and painted with fine-textured, scratch resistant, black powder coat. Circuit numbers shall be 3/4" Lexan tags with white letters on black background.

B. Individual pigtails and outlets shall be evenly spaced, on 12" centers in connector strips, or as otherwise specified. Where a circuit would fall on a joint it shall be moved 3" towards the junction box end of the strip.

C. All connectors shall be flush mount 20 Amp 2P&G unless otherwise noted.

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

E. Wiring devices shall be UL Laboratories Listed.

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

A. eDIN #1103 Rack Mount Panel Kit:
   1. Features:
      a. Blank steel rack panel with solid bottom pan (on which to mount DIN rail) with a black powder coat finish. Made in single piece construction.
      b. Integral cable management system.
      c. Face dimensions: Standard EIA 19" (482mm) x 3.5" (2RU height that will accommodate all eDIN modules).
      d. Tray dimensions (solid bottom pan) – 17" W x 10" D (430mm x 254mm).
      e. DIN Rail Supplied: Two sections 16.5" (420mm) long each, 5.1 lbs (2.3 kg).
      f. DIN rail made from cold rolled carbon steel sheet with a electrolytic zinc plating or chromated bright surface finish.
      g. DIN rail: Standard 35 mm x 7.5 mm.
      h. DIN rail is a mounting system only and does not carry voltage.
      i. Complies with DIN 50045, 50022 and 50035 Standards.

B. Power Supply:

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

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

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

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

A. WIRE – PORTABLE CONTROL CABLES (those cables for use with DMX512-A and USITT DMX512/1990 Systems):
    1. The data transmission rate (250 kbits/s) used by DMX512 requires the selection of a portable DMX512 cable that does not significantly distort the signal or give rise to spurious signal reflections. Cables intended for use with audio systems (such as microphone cables), while having the convenience of flexibility, availability and relative low cost, may not be suitable for use with DMX512 because of their high capacitance and incorrect characteristic impedance; at DMX512 data rates this will give rise to bit time distortion and signal reflections/overshoot.
    2. Maximum and minimum cable lengths
        a. Maximum and minimum run lengths are specifically omitted due to a number of factors, including signal quality, device operating characteristics including capacitive values, and installation environment. Maximum distance runs without repeaters, therefore, shall be determined by standard industry practices of approx. 330 feet. Regardless of the overall run lengths, the system shall run properly, reliably and without errors, glitches, etc. due to improper use of installed/portable cabling or connectors, terminations, etc.
    3. Construction
        a. Portable DMX512 cables shall use twisted pair conductors. Conductors shall be of stranded construction. The raw cable used for a DMX512 cable assembly shall be declared by its manufacturer as suitable for use with EIA-422/EIA-485/EIA-485-A systems. Shielding shall be on individual pairs or overall shielding of pairs or both. The portable cable itself shall be flexible and

rugged enough for the repeated coiling and uncoiling to which it will be subjected.

1) Cables implementing only the Primary Data Link shall consist of at least one twisted pair and be marked according to ANSI E1.27-1, Clause 7.1.
2) Cables implementing both Data Links shall consist of at least two twisted pairs and be marked according to ANSI E1.27-1, Clause 7.1.
3) Cables implementing only the Secondary Data Link shall not be allowed.

4. Impedance
   a. Portable DMX512 cables shall have a characteristic impedance in the range 100 to 120 ohms. Due to the characteristic impedance of 120 ohms in EIA-485 systems, 120 ohms is preferred.
5. Capacitance
   a. Capacitance between conductors within a shield shall not exceed 19.8 pF/ft (65 pF/m). Capacitance between any conductor and the shield shall not exceed 35 pF/ft (115 pF/m).
6. Dielectric Withstanding Protection
   a. Dielectric rating for portable DMX512 cables shall conform to prevailing electrical codes.
7. Connection Methods - Required Connector
   a. Portable cables shall use 5-pin XLR connectors. The physical pin designations of the 5-pin XLR shall be in accordance with Table 1 (see below).
   b. Any use of alternate connectors shall comply with ANSI E1.11.
8. Electrical Specifications and Physical Layer
   a. General
      1) The physical layer of a DMX512 data link is constrained by earth grounding practices, termination methods, signal levels, EMI, and accidental damage by connection to other devices. Where a conflict exists, DMX512-A shall govern.
   b. DMX512 Portable Cables
      1) General
         i) A DMX512 Portable Cable is a digital data transmission cable designed for the provisional interconnection of two DMX512 devices. Portable cables shall each have two prescribed connectors, a male 5-pin XLR at the end nearest the transmitting device and a female 5-pin XLR at the end nearest the receiving device. Pins shall be designated 1 through 5. There shall be no connection to the shell.
9. Data link common and grounding topologies
   a. In all cases Pin 1 of DMX512 portable cable connectors shall act as Data Link Common. The wire connected to Pin 1 shall be no smaller than the wire used for the twisted pairs in the cable.
10. Each data link shall consist of a separate twisted pair.
11. Terminations

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

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

c. CAT5 Pinout DMX Cabling: *

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

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

The above table is intended for DMX512 cabling only - **NOT** DMX-over-Ethernet cabling. Great care must be taken to prevent the accidental connection of DMX equipment to non-DMX equipment. The connection of DMX equipment to non-DMX equipment such as Ethernet switches or telephone equipment may result in serious equipment damage and/or personal injury, as pins 4 and 5 may carry voltages of up to 48VDC or greater.
Category wire is not recommended for loose or temporary cabling. The use of RJ45 connectors for DMX equipment should be restricted to patch bays in access controlled rooms and should not be used for the direct connection of portable equipment.
Please be aware that some non-standard pin-outs are also in use (i.e. Color Kinetics, etc.) and that custom cabling, connectorizations, etc. may be required in order to interface non-standard pin-outs with the specified system.

2.22 RACKS AND HARDWARE

A. SWING OUT WALL RACK: DWR

1. EIA compliant 19" wall mount rack shall be Middle Atlantic Products model # DWR-__-__ (refer to chart). Overall dimensions shall be 23.4" W x __" H x __" D (refer to chart). Weight capacity shall be __ lbs. Tool-Free Quick-Mount™ system enables one-person installation. Useable depth shall be __" (refer to chart) and shall extend into the back pan 3.5". Center section and back pan shall be 16-gauge steel, phosphate pre-treated and finished in a black textured powder coat. Rackrail shall be constructed of 11-gauge steel with tapped 10-32 mounting holes in universal EIA spacing with black e-coat finish and marked rack spaces. Rack shall be constructed to swing open for component cabling access, center section shall pivot for either left or right opening. Rack shall have a rear knockout panel with 1/2", 3/4", 1", 1-1/2", 2" and 3" electrical knockouts installed in base, and a rear knockout panel with 1/2", 3/4", 1", 1-1/2", 2" and 3" electrical knockouts, four Decora® cutouts, and BNC knockouts for UHF/VHF antennas installed in top. Large laser knockout on back pan shall have a 12-1/2" x 12-1/2" cutout for electrical pull-box. Fan knockouts on top and bottom shall allow for installation of up to four 4-1/2" fans. Rack shall have 2" knockouts, 4" knockouts for Wiremold 4000® Series raceways, and knockouts for UCP Series universal connector panels on the side. Top, bottom and sides shall feature vertical vent pattern. DWR Series enclosures shall satisfy the 2007 & 2010 CBC; 2006, 2009 & 2012 IBC; ASCE 7-05 (2005 Edition) & ASCE 7-10 (2010 Edition) and the 2006 & 2009 editions of NFPA 5000 for use in areas of high seismicity, Seismic Use Group III, Zone 4 or Seismic Design Category (SDC) "D" with lateral force requirements for protecting 140 lbs. of essential equipment in locations with the highest level of seismicity and top floor or rooftop installations with an Importance factor (Ip) of 1.5 when used with DWRSR-ZL Latch. Rack shall be UL Listed in the US and Canada to the UL-2416 (NWIN) Category when used with optional bonding kit, model # PET-K-__. DWR Series shall meet all enclosure requirements towards PCI DSS (Payment Card Industry Data Security Standard) Compliance. Rack shall be GREENGUARD Gold Certified. Rack shall comply with the requirements RoHS EU Directive 2002 / 95 / EC. Rack shall be manufactured by an ISO 9001 and ISO 14001 registered company. Rack shall be warrantied to be free from defects in materials or workmanship under normal use and conditions for the lifetime of the rack.
2. Options
    a. Front doors shall be reinforced 16-gauge steel, model # FD-XX (solid), VFD-XX (vented, 25% open area), LVFD-XX (vented, 64% open area), PFD-XX (plexi), (XX= # of rackspaces of DWR rack)

b. Keyless Latch replaces keylock, fits front & rear doors, shall be models # LATCH
c. Rear rail kit 11-gauge, 10-32 threaded, sold in pairs, hardware included, shall be model # DWR-RRXX
d. Fan kits with two 4-1/2" exhaust fans, fan guards and vent blockers, shall be model # DWR-FK17 (fits DWR-xx-17), DWR-FK22 (fits DWR-xx-22), DWR-FK26 (fits DWR-xx-26), DWR-FK32 (fits DWR-xx-32)
e. Vent Blockers used to promote active thermal management, shall be model # VBK-D17 (fits DWR-XX-17), VBK-SD22 (fits DWR-XX-22), VBK-E20 (fits DWR-XX-26)
f. Optional cover plate / shelf kit shall be model # DWR-CVR • Minimum-clearance latch shall allow side-by-side or corner mounting, shall be model # DWRSR-ZL
g. Optional bonding kit for UL-2416 (NWIN) compliance shall be Middle Atlantic Products PET-K-D/EWR (for backpan to center section), PET-K-D/EWRD (for backpan to center section to front door), PET-K-FD (for front door to center section)

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

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

C. POWERCOOL

1. EIA compliant 19" PowerCool™ Rackmount power distribution and cooling unit shall be Middle Atlantic Products model # PD-COOL-__(refer to chart), with a __ (15, 20 refer to chart) amp capacity, 2 stage, normal mode (Line to Neutral) spike and surge suppression with dry contact and LED status indicators and EMI filtering. PowerCool shall activate at 87°F (30.5°C), reach full speed at 95°F (35°C) and switch off at 85°F (29.4°C). PowerCool shall displace 50 CFM with a maximum decibel level of 29 dB (measurements made 1 meter from source, centered horizontally and vertically). PowerCool shall operate at a static pressure of .031 in. 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.

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

A. Features:
1. LT series shall have an adjustable width of 17.73″ to 21″, a height of 1.75″ and a depth of 1.72″.
2. LT series shall have a light temperature of 2,700-6,500K, and provide __lm (refer to chart).

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

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

B. Technical Specifications:

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

2.24 BILL OF MATERIALS

A. Lighting system equipment, console and all accessories and controls - see drawings for equipment, quantities and required coordination with other related trades.

B. Lighting fixtures: See drawings for quantities, types, lamps, locations, installation requirements, etc. Provide for each studio, independently, as specified.

C. Provide all theatrical fixtures with C-clamp, safety cable, lamp, gel frame and connector as called for on the contract drawings and/or to match existing devices (provide adapters as necessary for all fixtures that require them in order to interface with any existing and reused system equipment). Swap out connectors as required when reusing existing system equipment. Do not provide C-clamps for fixtures mounted directly to Unistrut.

D. Every portable cable shown or referenced on the TL series drawings shall have one 24" piece of black tie-line (Samson black braided tie cord/sash cord or equal - breaking strength 100 lbs./WLL 15 lbs., rip-tie hook & loop black Velcro or equal) choked onto one end (near connector). Provide two full 500'/600' rolls for this project and leave the remainder on site for the owner's future use upon project completion (or at least 1/2 roll, whichever is more). This does not include two-fer cables under 5' long in overall length. Provide 16" tie line for portable cables under 8' in overall length.

E. Theatrical Fixtures: Swap out, at no additional cost to the owner, any different lenses or fixture barrels for the specified fixtures that may be needed due to field conditions, focus plot intents, etc. per the owner’s directive. If there are no specific lenses called out on the drawings, then provide lenses dictated by the field conditions, focus plot, owner and/or the consultant. If the specific fixture barrels called out on the drawings do not provide the intended patterns, etc. that are needed and desired by the focus plot intents of the owner, then provide barrel swaps for all affected fixtures so that the focus plot functions as intended –this will be only one barrel per fixture.

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

G. Provide all DMX terminators as necessary for all DMX controlled equipment.

PART 3 EXECUTION

3.1 GENERAL:

A. All liability for rigging, fastening, wiring and other installation methods shall be borne by the contractor alone. If the contractor has a reason to believe that safety will be

compromised in the installation of any specified equipment in the locations specified, they must note this at the time of bid and offer alternatives in writing.

B. Assess life safety implications of all installation methods and verify there is no compromise of life safety issues.

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

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

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

F. Take all precautions necessary to guard against electromagnetic interference, electrostatic hum and RF interference, especially into the audio and video systems.

G. The contractor shall supply adequate ventilation and will install all equipment for the maximum safety of the operator.

H. The contractor shall verify all on site dimensions prior to the ordering or installation of critically dimensioned equipment and wiring. In a case of discrepancy between these documents and attached drawings, construction documents and actual on-site dimensions, the contractor will notify the owner and consultant in writing before making any changes in intended work. The owner and consultant will determine the correct modification to the work that needs to be done

I. All methods must be cosmetically acceptable to the owner. All equipment shall be installed neatly, with respect to level & plumb, sight lines and finish. All wiring must be neatly run and concealed in an orderly fashion and attached to appropriate support structures.

J. Identify any equipment requiring licensing and initiate licensing procedures for all such equipment.

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

L. All RDM fixtures (remote device management) shall incorporate the latest RDM standard in fixture addressing, remote management, reporting, etc. (must be ANSI E1.37.2 or later compliant).

3.2 WIRING AND RACKS:

A. All CR (communications rack) wiring shall be neatly tie wrap bundled (or as indicated otherwise on contract drawings) with wires parallel and perpendicular to rack sides and backs All wiring shall be properly strain relieved as it exits the rear connection points on the related equipment, shall be routed out to lacing bars, shall be routed out along lacing bars to rack side areas and shall be tie wrapped to the lacing bars. All rack wiring

shall be performed as noted. Loose, haphazard or otherwise poorly managed wiring without proper strain relief shall not be allowed.

B. Provide all internal network/DMX style wiring, etc. Needed inside the relay panel & all required interconnections & feeds to external equipment.

C. Control hookup is provided by the factory technician.

D. Within the dimmer/relay rack all wiring splices must utilize butt style line insulated splices crimped with a controlled cycle termination tool. Referenced style Panduit BSV10X-D or equal. Size splices per gauges of wiring to be spliced. See written specifications for more info.

E. All wiring that is not in conduit shall be plenum rated wiring (Belden 1585A or equal).

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

G. Any wiring splices necessary must utilize butt style inline insulated splices crimped with a properly adjusted controlled cycle termination tool. Referenced style Panduit BSV10X-D or equal. Size splices per gauges of wiring to be spliced & provide as required. No incorrectly sized splices shall be allowed.

H. Any equipment having accessible controls that are not normally used during system operation will have its controls capped or otherwise locked such that they are not adjustable. If no other means is feasible the use of security covers is mandated. Rack doors are not acceptable as means of tamper resistance for controls.

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

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

K. All conduits indicated on the drawings shall terminate directly into racks as shown – top, bottom or at any of the provided knockout locations (unless otherwise and specifically indicated on the drawings as otherwise) and so as not to obstruct access to the racks or adjacent walkways or approaches.

L. Route conduits into racks with as few bends as possible – use sweep elbows where necessaryAll wiring shall be protected in conduit until it has reached the internal space of the indicated rack(s).

M. All lighting system related racks shall be mounted vertically and as intended by the manufacturers. No racks shall be allowed to be mounted horizontally.

N. ELECTRICAL & GROUNDING:

1. Grounding of shields and chassis will adhere to industry standard practice and as required by the dimming & control systems manufacturer.
2. Verify that all hot, neutral and ground conductors are tightened at least 5 days after initial installation and landing of line & load conductors.
3. Any AC service shall be installed to standard Edison U-Ground style outlets at the locations noted on the electrical drawings. Where racks are located the service is to be run to the interior of the rack. Two U-ground outlets will be available for each 20-amp, single-phase circuit unless otherwise indicated or terminated into MPR style devices.
4. Internal rack AC distribution is the responsibility of the contractor. Acceptable methods: Rack mount power strips, rack mounted power distribution devices, Wiremold style outlet strip.
5. Install all internal AC rack power with all switches and controls carrying hazardous voltage housed in steel enclosures within the rack. Provide positive electrical grounding for all steel enclosures. All AC service will incorporate separate hot, neutral and ground for each device. All grounds and neutrals will be appropriately bonded and connected to earth as required by codes and normal practice.

O. CONDUITS:

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

P. JUNCTION/GANG BOXES:

1. Unless otherwise specified all controls, receptacles, user interface stations, plugs and outlets shall be located in an appropriately sized gang box. No multi-gang backboxes with raised, tile ring, extension ring or mud ring style reducers to

obtain the specified faceplate gang size shall be acceptable in lieu of the indicated device backbox.

2. Any junction (i.e. terminal blocks, punch down blocks etc.) shall be housed in metal enclosures with an attached ground. No such connections may be made in ceiling spaces or other areas without the use of a steel enclosure.
3. Any field added junction boxes shall be sized and located for ease of troubleshooting access and all connections within shall be connected on terminal strips, which are clearly identified, in a logical, consistent & permanent manner.

3.3 ASSEMBLY AND PRE-TEST:

A. LIGHTING FIXTURES:

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

B. LIGHTING EQUIPMENT (OTHER THAN FIXTURES):

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

3.4 FINISHES & CLEANING:

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

B. Cover any walls, furniture, finished floors and carpeted areas to catch all metal particles, grit, etc. that may occur during installation.

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

D. Provide thorough cleaning of all work areas including vacuuming, spray cleansers and dust removal as required. Clean all equipment fan filters before final acceptance tests.

E. Provide a thorough cleaning of all lighting system and related devices, including but not limited to, fixtures, housings, racks, cables/cordsets, data lines, reflectors, lenses, modules, mounting pipes, controls, consoles, etc. regardless of status (new or existing to remain/reuse). Cleaning shall be after all dust/dirt creating work has been completed and just prior to walk-through/punch list and turnover to the owner.

F. Maintain clean work areas, removing all debris daily.

3.5 LABELING:

A. All switches, cables, wire, controls and outlets will be permanently and logically marked during installation. Submit to the consultant for approval a listing of intended nomenclature. Where possible engrave directly upon plates and assemblies. Where disassembly would be required the use of adhesive or screw on engraved labels will suffice. Engravings will be paint filled for best contrast with black or white paint.

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

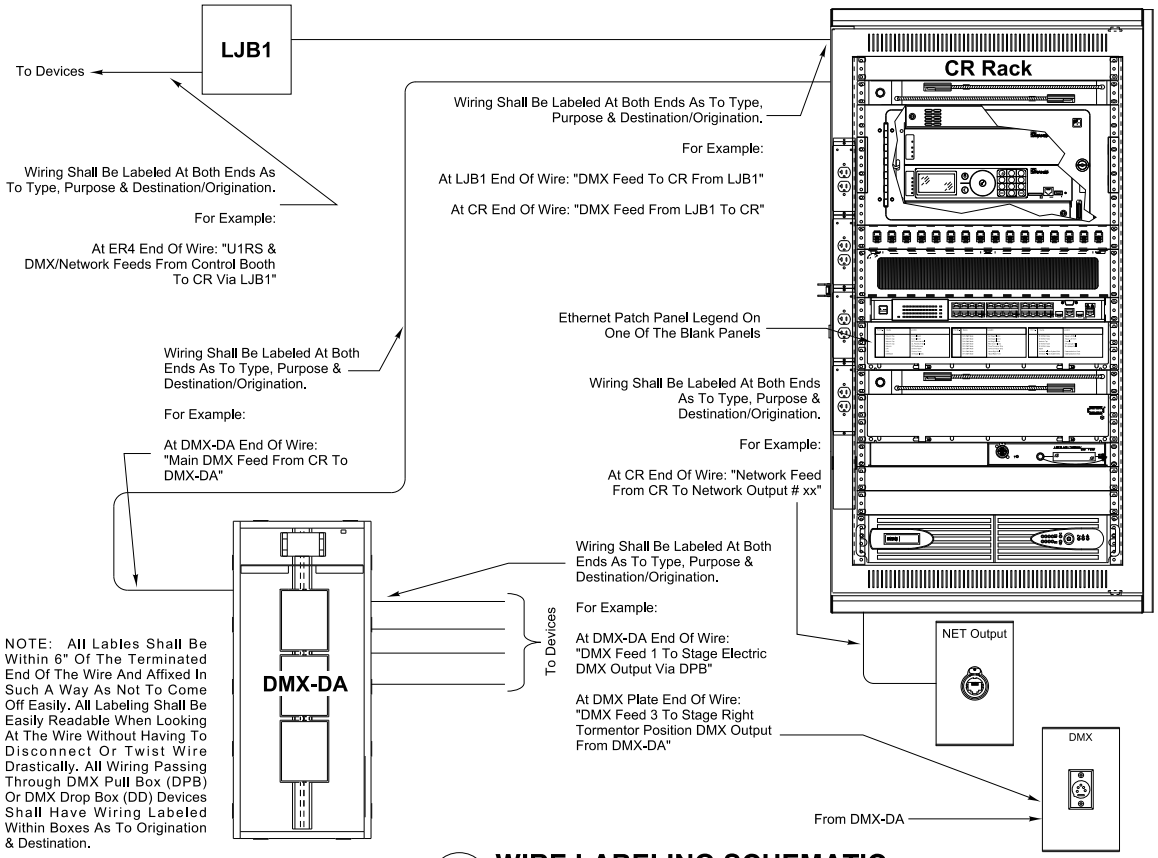
C. Permanently mark cables with an identifying label at each end in a consistent, logical manner.

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

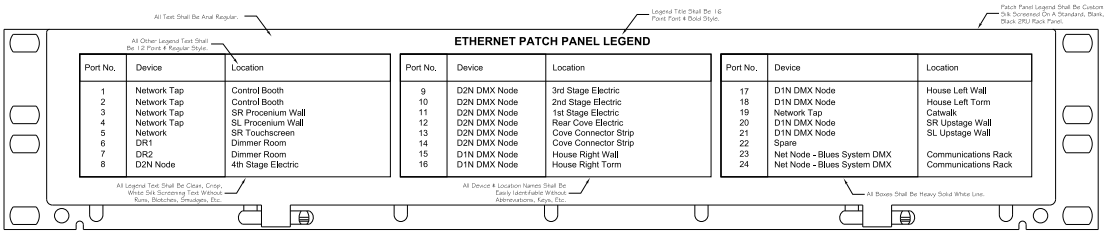
E. The contractor shall provide the owner with a laminated hard copy chart (Microsoft Excel style) of the dimmer channel assignments and locations along with any soft patched devices, DMX assignments, Network assignments, house,

accent and worklighting channel assignments, submaster assignments, etc. to be left at the control console location.

F. The following schematic diagrams have been provided as examples of acceptable and intended wiring & patch panel legend labels to be included for all racks, wiring destinations & originations: (these schematic drawings are diagrammatic only and do not reflect all of the actual parts and/or components, etc. designed into this project.) Contractors (Both EC and lighting contractors) shall use these schematic diagrams as guides and references and label or wire all related and additional devices in a similar manner to those shown here. These diagrams are typical of all lighting related devices, communications racks, etc. designed into this project. The intent is for all portions of this project to be labeled in a concise, intelligent and consistent manner.



1 **WIRE LABELING SCHEMATIC**
SCALE: NONE



Port No.	Device	Location
1	Network Tap	Control Booth
2	Network Tap	Control Booth
3	Network Tap	SR Procenium Wall
4	Network Tap	SL Procenium Wall
5	Network	SR Touchscreen
6	DR1	Dimmer Room
7	DR2	Dimmer Room
8	D2N Node	4th Stage Electric

Port No.	Device	Location
9	D2N DMX Node	3rd Stage Electric
10	D2N DMX Node	2nd Stage Electric
11	D2N DMX Node	1st Stage Electric
12	D2N DMX Node	Rear Cove Electric
13	D2N DMX Node	Cove Connector Strip
14	D2N DMX Node	Cove Connector Strip
15	D1N DMX Node	House Right Wall
16	D1N DMX Node	House Right Torm

Port No.	Device	Location
17	D1N DMX Node	House Left Wall
18	D1N DMX Node	House Left Torm
19	Network Tap	Catwalk
20	D1N DMX Node	SR Upstage Wall
21	D1N DMX Node	SL Upstage Wall
22	Spare	
23	Net Node - Blues System DMX	Communications Rack
24	Net Node - Blues System DMX	Communications Rack

1 **PATCH PANEL LEGEND LABELING SCHEMATIC**
SCALE: NONE

3.6 RIGGING:

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

B. All equipment not described as portable in this specification will be rigidly held in place as per the manufacturer's recommendations or as indicated.

C. All equipment (except luminaires) will be supported at a minimum of three points plus a backup. Each point shall be able to carry the entire rated load with a safety margin of at least five (5) times the rated load. All methods shall incorporate an independent safety backup with a safety margin of at least five (5) times the rated maximum load as installed in case of failure of any rigging component. All safety cables shall be installed so that they have little to no slack in order to reduce shock loading in the event of a catastrophic failure of the primary rigging attachments.

D. Theatrical lighting fixtures will be supported by their primary attachment point, either C clamp or factory supplied or other specified clamp (such as a Megaclaw style clamp for motorized lighting fixtures). A safety cable rated for at least 10 times the rated static weight of the fixture will be utilized as a safety backup in case of a failure of the primary attachment point.

E. All rigging and related fastening methods must be treated as permanent. All threads shall be treated with vibration compounds such as Vibratite or Loctite as per manufacturer's recommendations and shall be visible upon inspection.

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

G. No chain of any type will be acceptable for the hanging or backup support of any equipment except in the case of trim chains.

H. All trim chain shall be Peerless black theatrical chain type or equal.

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

J. No stainless steel or galvanized wire rope shall be secured with Crosby clamps or other threaded type fittings alone. Compression type closures such as Nicopress with thimbles and copper sleeves ONLY must be utilized for all wire rope terminations. Each closure must have a backup closure. All wire rope is to have strain relief thimbles installed where it attaches to other rigging components. The contractor shall never violate the minimum bend radius when using or installing wire rope.

K. All loose ends of the wire rope will be neatly taped down after Nicopress is installed and crimped. No frayed rope ends will be allowed under this specification. This includes safety cables.

L. All Nicopress or equal compression connections and wire rope swaging products utilized on this project shall be required to pass field gauge tests as to their proper terminations and compression (typically referred to as go-no-go gauge tests). Due to the sheer quantity of manufacturer's and the varying types/styles of compression tools in use, this will require the contractor to provide the proper go-no-go gauge during acceptance testing (punch list) for each different compression tool utilized on the project (typically a specific gauge is provided with each tool purchased). This gauge will be turned over to the consultant for use in verifying that the correct compression has been performed on the oval sleeves. It is understood that the consultant cannot test every single oval sleeve but will, instead, check a random percentage of sleeves that will be assumed to be typical of all similar compression fittings on this project. It is the contractor's responsibility to verify, during installation, that every oval sleeve has been compressed properly and that it passes the go-no-go gauge test.

M. All Nicopress 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. Nothing shall be allowed into the interior of any Nicopress or equal compression connection oval sleeves except the wire rope itself. Any taping of wire rope ends shall be performed only after all compression connections are properly swaged.

3.7 ROUGH-IN:

A. Due to small scale of Drawings, it is not possible to indicate all offsets, fittings, changes in elevation, etc. Verify final locations for rough-ins with field measurements and with the equipment being connected. Verify exact location and elevations at work site prior to any rough in work. DO NOT SCALE PLANS. If field conditions, details, changes in equipment or shop drawing information require a significant change to the original documents, contact the owners representative for approval before proceeding.

B. All equipment locations shall be coordinated with other trades to eliminate interference with required clearances for equipment maintenance and inspections.

C. Coordinate work with other trades and determine exact routing of all duct, pipe, conduit, etc., before fabrication and installation. Coordinate with Architectural Drawings. Verify with Owner's Representative exact location and mounting height of all equipment in finished areas, such as thermostats, fixtures, communication and electrical devices, including panels. Coordinate all work with the architectural reflected ceiling plans and/or existing Architecture. Mechanical and electrical drawings show design arrangement only for Diffusers, grilles, registers, air terminals, lighting fixtures, sprinklers, speakers and other items. Do not rough-in contract work without reflected ceiling location plans.

D. Before roughing for equipment furnished by Owner or in other contracts, obtain from Architect and other Contractors, approved roughing drawings giving exact location for each piece of equipment. Do not "rough in" services without final layout drawings approved for construction. Cooperate with other trades to insure proper location and size of connections to insure proper functioning of all systems and equipment.

E. For equipment and connections provided in this contract, prepare roughing drawings as follows:

F. Where more than one trade is involved in an area, space or chase, the contractor shall cooperate and install their own work to utilize the space equally between them in proportion to their individual requirements.

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

H. Existing equipment being relocated: Measure the existing equipment and prepare drawings for installation in new location. Submit as part of submittal package prior to installation. Do not install prior to written approvals.

I. New equipment: Obtain equipment roughing drawings and dimensions, then prepare rough-in drawings. Submit as part of submittal package prior to installation. Do not install prior to written approvals.

3.8 CUTTING AND PATCHING:

A. Each trade shall include their required cutting and patching work unless shown as part of the General Construction work on the architectural drawings. Refer to "General Conditions of the Contract for Construction" for additional requirements. Patch all cut or abandoned holes left by removals of equipment or devices. Patch adjacent existing work disturbed by installation of new work including insulation, walls and wall covering, ceiling and floor covering or other

finished surfaces. Patch openings and damaged areas equal to existing surface finish (i.e. "patch to match existing"). If no instructions exist in the contract documents addressing these issues, then the contractor shall contact the architect and construction manager in writing prior to proceeding with any work in order to obtain written instructions regarding this type of work.

3.9 CONCEALMENT:

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

3.10 PERFORMANCE:

A. The systems will be utilized for lighting various types of performances from solo artists to large groups. The intent is for the preset lighting controls to accommodate most of the general lighting needs. The owner will compile a list of presets to be loaded into the control system. These presets will consist of a prefocused aiming of all lighting instruments.

B. All LED fixtures shall exhibit quiet operation (the preference is for all fixtures to be convection cooled). Audible requirements for ALL LED fixtures is as follows:
   1. No LED fixture shall be allowed that exceeds an NC10 noise curve as measured 4' – 0" from any point of the fixture.
   2. NC measurements shall be dBA and measured in 1/3rd octave resolution.
   3. For fan cooled devices, the fans are normally to be set up and operated in auto mode.
   4. Any fixtures and fixture fans that exhibit that develop a tonality within the first 12 months of use shall be replaced by the contractor at no additional cost to the owner and within a reasonable amount of time (typically less than 2 weeks).

      ** 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.

C. Program all theater lighting presets to maintain the minimum required egress levels of lighting at all times and in all cues based upon life safety code nfpa101 & local building codes. The minimum egress lighting level is .2 fc.

D. Provide the consultant, owner and architect with the following files as it regards the lighting system, control console, paradigm system, misc. Devices and controllers. All project related final lighting system files shall be provided in both compiled and uncompiled (editable) formats and in the current software/firmware format. All files must be named so that identification as to project, file type/intent, etc. Is readily identifiable from the name alone. Provide all files saved to a thumb drive:
   1. ETC Echo config file
   2. ETC concert config file
   3. ETC console config file
   4. All console template files
   5. Network system config files

E. LED fixtures: all fan-cooled LED fixtures must have the ability to be run at full light output (typically full white) for a 4 hour minimum without light output reduction and without the fan speed ramping up to a level noticeable to a listener from a distance of 6' - 0" away. Fan speeds must be assigned to a DMX channel, configured by the setup technician and locked so that they are at the lowest fan speed setting possible while still maintaining full light output out of the fixtures. The cumulative fan acoustic output must be inaudible in the seating area, no matter how many LED fixtures are on. This configuration must be field verified on site for an 8 hour minimum - (2) 4 hour cycles. The total light output shall, at no point in time, be allowed to automatically dip below 90% overall output (unless specifically being dimmed for a theatrical reason) in order to enter a "self-protection" mode or other automated cycle designed to prevent the fixture from overheating. See written specifications for more information and noise curve requirements for all LED fixtures.

F. Provide the owner with a copy of the pathway Pathport manager gateway configuration editor (5.3 or later), via manager software (if applicable) DMX/RDM device configuration softwares and 12 hours of additional training on those platforms (in addition to training noted elsewhere on the drawings or in the written specifications) so that the owner or owner's designated operators will have a full working knowledge of how to address, readdress, maintain, troubleshoot and reconfigure the network gateways located within this system.

G. Post a complete copy set of the lighting system one-line diagram, system as-built drawings, laminated excel spreadsheets of all circuit & DMX/network assignments, etc. as listed on TL flow diagrams) in the CR rack drawer. Provide an additional laminated circuit assignments sheet for the lighting console position.

H. Training & Instruction:
   1. Provide all on-site owner training, software training, architectural system preset programming (including pushbutton & LCD stations), edited DVD training video, bench & field focus of fixtures, etc. As detailed on the bid drawings and in written specifications. (training, DVD, focus and programming time is extensive and detailed). See specs for total quantity of hours of training, focus and software programming requirements that the owner is entitled to as part of this bid

package. All items shall be provided as a part of his bid at no additional cost to the owner after bid. Owner is not obligated to receive all training time; however, all training time, etc. As listed above, in written specifications and on the bid drawings is the sole responsibility and obligation of the contractor to provide. All training shall be at times and in duration as directed by the owner and shall be held on-site at the owner's facilities.

2. Give the owner detailed and specific instructions on powering/depowering and the insertion/removal of PowerCon power connectors for any LED fixtures included in this project. Since the PowerCon connector is a connector without breaking capacity, these connectors should not be inserted or removed under load or when live. Per the manufacturer's instructions, the user is to disconnect the end of the power cable that is plugged into the wall outlet/distribution first and prior to insertion/removal of any PowerCon connectors. Failure to do so may damage, pit or char the contacts inside of the PowerCon connector, rendering them unable to make proper contact and unusable without replacement of the PowerCon connectors. Any such damage to the PowerCon connectors due to failure to disconnect the fixtures from power first will result in factory repairs that will not be covered under warranty.
3. Give the owner detailed and specific instructions on (as well as turning over a copy of the manufacturer's safety notice data sheet) on the hazards that may be associated with the improper use of Neutrik PowerCon True1connectors.

I. LIGHTING SYSTEM NETWORK:

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

defaults (all "as built" system configuration files would then need to be recreated from scratch).

J. Verify the load requirements for all PoE switch outputs and the related devices being powered via the network switch. Provide a switch that is capable of powering all network devices & outputs indicated per the manufacturer's recommendations.

K. Perform all DMX and network programming, device addressing and related software/firmware setup, LED setup, modes and addressing, etc. All LED fixtures, network gateways, 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.

L. Work closely with related trades in setting up, testing, verifying and tweaking the houselighting system, lamps, etc. In order to get consistent and acceptable results. This includes DMX/RDM setup of houselighting fixtures, populating those fixtures into the architectural control system, dimming rack control module and lighting control console, dimmer module curve settings, providing/swapping out indicated modules for modules that will control the associated fixtures better (i.e. ELV's for D20e's, etc. As needed), assisting in visual confirmation of performance acceptability, recording lighting performance visuals for record and any other items as noted in ec houselighting notes or other required coordination. Obtain a written sign-off acceptance by the owner of visual performance of the houselighting system prior to finalizations & programming.

M. All connector strip, outlet box, gateway, etc. Devices must have the proper grommets and strain relief devices in place from the point where the loose or multicable wiring enters the device and at all connection/transition points into the related device. Devices without grommets and strain relief shall not be allowed.

N. Verify the actual electrical loading demands of all devices plugged into indicated UPS devices and provide appropriately sized backup UPS devices as needed, even if that means providing upsized devices beyond what is indicated in order to meet the actual electrical demands of the serviced devices. No UPS device shall be allowed to be loaded past 90% of its rated capacity.

3.11 INITIAL POST COMPLETION TESTS & SET UP:

A. FIXTURE FOCUS & GEL:

1. The lighting plot shown on drawings is not necessarily the plot the contractor will hang. Verify with the owner prior to fixture hang that they do not have an alternate plot they want hung.

2. Theatrical Focus: The contractor shall be responsible to hang and focus all fixtures indicated on the bid drawings. Theatrical focus shall be directed by the owner or by a designated owner's representative.
3. Studio Fixture Focus: The contractor shall be responsible to hang and focus all studio fixtures (and install/set up portable floor lighting kits) indicated on the bid drawings. Studio focus shall be directed by the owner or by a designated owner's representative
4. In the event that there were previously removed theatrical style fixtures that are to be reinstalled, the contractor shall be responsible to rehang and focus all previously removed fixtures in a similar fashion as they were prior to the start of this project or as directed by the owner.

B. Focus Hours Required
1. Focus Day Requirements For <100 Theatrical Fixtures: The contractor shall be responsible for (1) one full day of focus (8 hours) and (2) two full days (16 hours) of programming maximum (in addition to any other programming requirements listed elsewhere in this specification). The contractor shall focus all fixtures with the owner or a designated owner's representative present.
2. Man-Power Requirements (Dead-Hung System): The contractor shall supply (2) two qualified lighting technicians for the day of focus and (3) three walkie-talkies or intercom belt packs, power supplies and all related required cabling. The contractor shall supply a manlift and either extension or stepladders for the day for focus.
3. Intent of Theatrical Focus: The intent of the theatrical focus is for the contractor to hang the fixtures indicated on the drawings to their related and indicated pipe battens, tormentor, Shakespeare or truss locations and then to focus or aim those fixtures in a logical fashion toward the stage or pit areas (depending on fixture location intents) in order to establish a base-line lighting plot for typical events. If a focus plot has been included, then this is what the contractor shall use as a basis for his rough focus. If the owner has a specific focus plot; however, that they wish executed, then the contractor shall focus all fixtures as directed by the owner (the owner's wishes shall supercede all directives here or on the drawings). This includes, but is not limited to, general area washes for the pit and stage areas, even borderlight style colored washes, lectern focus lighting, seamless cyclorama illumination, basic backlighting setups and general area lighting for choral events, orchestral events, lectures, worklight setups and basic stage usage events. The intent for this initial focus and hang is not for the contractor to generate and/or execute a detailed lighting plot for specific theatrical shows and performances. The intent is also not for the contractor to act as a lighting designer or technical lighting advisor. The focus day(s) may also require the contractor to swap

barrels, relocate fixtures, swap color changing devices, etc. as directed by the owner.

4. Specific ladder style to provide depends upon accessibility and physical restrictions present in the auditorium. Typically if a man-lift cannot access FOH rigid cove or motorized FOH truss areas, then a stepladder is used in order to obtain a good "ground-focus" height from which fixtures are then hung and focused (motorized truss fixtures are hung with truss at low trim and then rough focused from an intermediate height. Final focus tweaks are then accomplished by minor adjustments at low trim height until fixtures focus properly at the truss operating height.). Stage fixtures are typically focused from a man-lift, scaffolding or stepladder. Tormentor or Shakespeare position fixtures are typically focused with a stepladder on flat floor areas or with an extension ladder for sloped floor areas. All accessible areas reachable with a man-lift shall utilize a man-lift for both hang and focus as this presents the safest method of installation. Neither the contractor nor any related personnel shall be allowed to "ride" counterweight sets or motorized truss/stage electric sets or climb tormentor or Shakespeare assemblies in order to hang and focus lights in lieu of utilizing ladders or a man-lift to access lighting support positions.

C. ARCHITECTURAL CONTROL STATIONS:

1. All architectural control stations (pushbuton, etc.) shall be named in the Light Designer and Control Designer software so that they reflect the actual room and geographic locations within the room (i.e. Auditorium South Entrance, etc.).
2. Room, entry or other names and designations TBD by owner. The contractor shall obtain these descriptions from the owner in writing prior to ordering these faceplates or programming the architectural control system. All stations shall be labeled with the owner indicated names and with specific nomenclature as indicated on the bid drawings. No device model number names shall be allowed. Names shall be engraved on device plates with a high contrasting color in a legible, large enough font size so that they are easily seen and read. No black on black or self-adhesive tape labels shall be allowed.

D. ARCHITECTURAL SYSTEM PRESETS:

1. Architectural lighting will be included in the preset configurations.

a. The presets to be programmed by the lighting contractor will consist of no more than 10 presets for architectural lighting. The presets will be determined by the owner and consultant.

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

and off. Contractor shall program each station to control presets as directed by the owner.

g. Ipad & Iphone Programming:
   1) The contractor shall fully program and set up the iPad tablet to control both the lighting system console as well as the architectural control system. This includes fader pages, preset button programming, etc. This also includes purchasing the apps, setting up an Apple/Android ID/user account for the owner (if one does not already exist - or interfacing with owner personnel in order to obtain existing account login info), downloading the various control software apps (both architectural system and lighting control console interface apps) and setting up/training the owner on the apps and their use in the aud as a portable lighting system controller (both for the lighting console and the architectural control system).
   2) The contractor shall be responsible to setup and program up to (10) additional wireless devices by owner designated personnel that can control various aspects of the architectural control system or lighting control console. App purchases shall be the responsibility of the device owner for personal devices. The contractor shall simply assist in setting up presets, fader pages, etc.

E. DMX & UNIVERSE SETUP GUIDE:

1. The goal in setting up the DMX addresses for this project is to make things simple for the end user both in operation of the system and in finding fixtures, dimmers, relays, etc. This type of approach will embrace a compact setup/layout. It is our intention to outline a conceptual path forward without actually assigning universes and/or actual addresses. That will still be left up to the contractor to figure out and perform based upon the final fixture count, selections, owner input, etc.
2. The initial objective is as follows:
3. DMX Assignment Order (addressing given/shown on an ascending order priority basis) –
   1) Dimmer rack and dimmed modules (incandescent fixture control)
   2) Beginning with DMX address #1 and continuing in ascending order without gaps in assignments until all dimmer rack/dimmed modules have been addressed.
   3) Relay rack and non-dimmed and/or constant/relay modules (LED & moving head fixture control)
   4) Beginning with the next free address after the last dimmer rack/dimmed module address and continuing in ascending order without gaps in

assignments until all non-dimmed, constant and relay modules have been addressed.

5) Addressing for theatrical fixture lighting devices
6) Beginning with the next free address after the last non-dimmed, constant and relay module address and continuing in ascending order without gaps in assignments until all theatrical fixtures have been addressed.
7) Fixtures should be addressed in the following ascending order: front of house (first cove, second cove, etc.), stage (1st electric, 2nd electric, 3rd electric, etc.), side house lighting (side galleries, Shakespeares, tormentors, balcony pipes, etc.) *.
8) Fixtures should be grouped by type and assigned DMX addresses as such at each location for ease of use (i.e. wash fixtures then ellipsoidal fixtures, then zoomable fixtures, etc.). The exception to this is stage LED strip borderlight style fixtures, which would typically be grouped into a range of DMX addresses so that they can be quickly and easily selected as an entire stage wash.
9) *As an alternative, the owner might select to have the side house lighting (galleries, torms, etc.) occur before the stage assignments.
10) House and work lighting fixtures (incandescent, LED or 0-10V fixture control)
11) All houselighting fixtures (at the top of the address order beyond all other utilized DMX addresses – and within the control system's capabilities).
12) All worklighting fixtures (at the top of the address order beyond all other utilized DMX addresses, including houselighting assignments – and within the control system's capabilities).

4. The intent is that all DMX addressing should occupy as few universes of DMX control as is possible and without the facility's DMX addressing being spread over multiplied universes of control. What should be avoided is assigning each physical location to a different DMX universe (i.e. first electric DMX universe #1, second electric DMX universe #2, … houselighting to DMX universe #7, etc.).
5. A typical layout would look like the following:

DMX Assignment Schedule				
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	RGBL Front of House Cove Wash Fixtures	147	-	176

ColorSource Par	#1 - 6			
Rear Torm - House Left - ETC ColorSource Spot LED	RGBL Rear Torm Spot Fixtures #1 - 3	177	-	191
Rear Torm - House Left - Philips Showline SL Punchlite 220	RGBL Rear Torm Remote Zoom Fixtures #1 - 3	192	-	245
Rear Torm - House Right - ETC ColorSource Spot LED	RGBL Rear Torm Spot Fixtures #1 - 3	246	-	260
Rear Torm - House Right - Philips Showline SL Punchlite 220	RGBL Rear Torm Remote Zoom Fixtures #1 - 3	261	-	314
Front Torm - House Left - ETC ColorSource Spot LED	RGBL Front Torm Spot Fixtures #1 - 3	315	-	329
Front Torm - House Right - ETC ColorSource Spot LED	RGBL Front Torm Spot Fixtures #1 - 3	330	-	344
Stage - First Electric - Philips Showline SL BAR640 Wash Borderlight Fixtures	RGBW Wash Fixtures #1 - 4	345	-	404
Stage - Second Electric - Philips Showline SL BAR640 Wash Borderlight Fixtures	RGBW Wash Fixtures #5 - 8	405	-	464
Stage - Third Electric - Philips Showline SL BAR640 Wash Borderlight Fixtures	RGBW Wash Fixtures #9 - 12	465	-	524
Stage - First Electric - ETC ColorSource Par	RGBL Stage Wash Fixtures #1 - 4 (Stage Electric #1)	525	-	544
Stage - Second Electric - ETC ColorSource Par	RGBL Stage Wash Fixtures #1 - 4 (Stage Electric #2)	545	-	564
Stage - Third Electric - ETC ColorSource Par	RGBL Stage Wash Fixtures #1 - 4 (Stage Electric #3)	565	-	584
Houselighting Fixtures	Rows #1 – 6	585	-	590
Worklighting Fixtures	Stage Hi-Bays	591	-	592
Worklighting Fixtures	Catwalk	593	-	593

N/A	Any required DMX addresses necessary in order to address and control the DMX or 0-10V misc. fixtures, outlets, etc.	As required
This DMX Assignments Chart Is Intended To Be A Starting Point Or Failsafe In Case The Owner Has No Particular Addressing Preferences; However, The TC Shall Consult The Owner Prior To Addressing Any Fixtures With A Printed Copy Of This List And Work Out All Specific Assignments With The Owner Prior To Addressing Any Fixtures As The Owner's Wishes May Differ From What Is Shown Here. Get Owner Approved DMX Assignments In Writing Prior To Assigning Any Fixtures, Dimmers, Misc. Portable Devices, Houselighting Fixtures, Etc.		
DMX Assignments Approval:	Duly Authorized Owner Or Owner's Representative Signature:	
Approved As Indicated:	_____	
Approved With Indicated Changes:	_____	
Written Name:	_____	
Date:	_____ / _____ / _____	

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

3.12 OWNER INSTRUCTION:

A. GREEN ROOM STUDIO: The contractor shall provide a training program at the project location and with the project equipment (owner's equipment), consisting of the following hours/periods of instruction specifically and exclusively regarding the lighting system (total training time not to exceed 36 hours. No training block to be less than 4 hours in duration. This time is in addition to training time noted below):

B. PHOTO LAB: The contractor shall provide a training program at the project location and with the project equipment (owner's equipment), consisting of the following hours/periods of instruction specifically and exclusively regarding the lighting system (total training time not to exceed 36 hours. No training block to

be less than 4 hours in duration. This time is in addition to training time noted below):

C. Additional software training for the owner of up to (12) hours [in addition to training time mentioned above] in making adjustments to basic settings in presets.

D. Additional software training for owner of up to (8) hours [in addition to training time mentioned above] in operating and programming in the Pathport Manager x.x (latest version) software and in operating, configuring, resetting, managing and changing all network and gateway parameters/assignments.

E. All owner instruction to be provided by the contractor as part of this contract shall be scheduled and performed within 12 months of the final system turnover date to the owner.

1. The turnover date is defined as the date of completion of all open punch list items

F. All training hours are exclusive of travel time.

3.13 TRAINING:

A. Training must provide useful information that covers the majority of how a system will be used by the owner. This also applies to documentation and video training.

B. On a job by job basis this training may vary significantly. The hours allotted may be used by the owner as required for any purpose related to the system.

3.14 QUALIFICATIONS OF TRAINERS:

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

3.15 SCHEDULING FOR TRAINING:

A. Initial Training must be scheduled by the contractor with at least two weeks advance notice.

B. If the contractor arrives for a scheduled training session and the owner personnel are not present, then the contractor must notify the owner that a four-hour training segment has been forfeited.

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

3.16 INITIAL TRAINING:

A. Walk through the facility and familiarize the owner with where all primary system equipment is and what it does. This should include any primary and secondary power panels feeding the systems, system disconnects and the identification of individual system breakers.

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

C. Train on how to put together scenes, presets, shows, etc.

D. Train on how to RDM access fixtures, patch dimmers, etc.

E. Train on specialty lighting fixtures such as LED, moving heads, remote zoom fixtures, etc.

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

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

3.17 FOLLOW-UP TRAINING SESSIONS:

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

B. Some operators may want to schedule session on higher level functions. In these instances, the contractor shall provide that advanced training.

C. Training sessions may also be used to change configurations for the owner. Often once a system has been in use for a period of time, configuration changes are requested by the owner for default system presets and controls.

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

3.18 VIDEO RECORDING OF TRAINING WITH OWNER – INITIAL TRAINING – PER STUDIO SPACE:

A. The camera should be placed on a tripod in a location that offers a good view of the console and screens. Lighting must be adequate for the video camera; provide portable lighting as needed.

B. Provide simple explanations of what each piece of equipment does, what would occur if the lighting system were to be shut down, etc.

C. Console initial training shall also be video recorded. During this training an operator from the owner can operate equipment.

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

3.19 VIDEO RECORDING OF DEVICE TRAINING – SECONDARY TRAINING – PER STUDIO SPACE:

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

B. This second video training is to provide multiple levels of information:

1. A walk around of the site should be video recorded that shows the owner where all primary lighting system equipment is located and what all related screens and indicator lights look like when everything is working properly.
2. A walk to the power panels & disconnects feeding the system and what breakers operate various power feeds and what their normal state looks like.
3. A quick start video guide for someone who has to use the system who has no idea how to do anything.
4. Example:

a. How to boot up the console.
b. How to access a show file.
c. How to run a cue.
d. How to navigate screen pages and find magic sheets, etc. and how to operate them.
e. Basics on lighting priority – why lights might still be on from the architectural control system and how to manage these conflicts, etc.
f. How to shut down the console and the lighting system.

5. Additional information for anyone who needs to do the following:

a. Patch lights, including RDM functions. This should include what to do when a fixture won't RDM properly.
b. How to create a lighting cue and edit timing, etc.
c. How to load faders and sub masters.
d. How to save a show to USB.
e. How to load a show from USB.
f. Patching and grouping – how and why to use groups.
g. Color and focus functions – how and why to use.

h. Different in color gamut between manufacturers of LED's.

C. Video recording general requirements (applies to all):

1. Convert each recording to standard formats for playback on Mac/PC based platforms and write to the devices as described below.
2. Edit and title the final video training sessions into logical chapters so that an end user is quickly able to find what they need. The basis for titles, sections, etc. shall be the general content of all video training.
3. Provide an electronic file to the owner and owner's personnel that contains all relevant links to the manufacturer's video training series for basic, intermediate and advanced topics/functions.
4. Provide all training videos in DVD and USB stick formats.
5. On the USB stick, include a PDF document that contains the active links to the manufacturer's video training sessions and relevant sites.
6. In subsequent training sessions with the owner's personnel, higher level functions may be covered. Some owners will not require this, but others will. The contractor is not required to video record subsequent sessions. The owner can record any session they want for future reference using their own equipment.
7. Provide (1) one copy (brand new and not previously used) of Stage Lighting: The Technicians' Guide: An On-the-job Reference Tool with Online Video Resources (provide the latest edition) by Skip Mort. This shall be turned over to the owner.

3.20 WARRANTY AND SERVICE:

A. The contractor guarantees all equipment, materials (excepting incandescent lamps) and workmanship to be free from defects for a period of one year from owner acceptance. This warranty supersedes all manufacturers warranties for the one-year period. Any manufacturer's warranty that exceeds the one-year will continue to be applicable. The contractor will replace any defective materials at no charge to owner. Any equipment replaced during the one-year warranty will have a new one-year warranty to the owner.

B. The contractor guarantees all labeling to be free from defects for a period of two years from the date of owner acceptance. In cases where the label's adhesive fails or the label suffers from degradation causing it to become unreadable, the label will be considered defective and will be replaced at no cost to the owner.

C. LED Fixtures and lamps that fail in the first 90 days will be replaced at no cost unless an electrical fault can be shown to have caused a major lamp outage or fixture failures.

D. The contractor will respond by phone to requests for service within 2 business hours and respond with a technician being sent (if needed) within 1 business day.

E. Any equipment that tends to "drift" or whose performance deteriorates during the warranty period will be considered defective, even if such drifting is normal during break in. This equipment will be readjusted by the contractor at no additional charge to the owner.

F. Provide all service at the owner's location regardless of any manufacturer warranty terms regarding carry in service.

G. During the warranty period if any equipment failed will take more than 24 hours to repair, the contractor will make available and interconnect at no cost to the owner suitable temporary equipment to maintain a fully operational system until repairs are complete.

3.21 DEMONSTRATION AND ACCEPTANCE:

A. CONDITIONS FOR SCHEDULING FINAL ACCEPTANCE:

1. The system is required to be complete and fully tested. Any failure that may have occurred between the contractor's final tests and the date of acceptance will be noted and can be corrected after that date

a. Final setup for the houselighting system must be scheduled so that the owner or owner's representative, consultant, contractor and factory technician are all present. This will also constitute the final acceptance meeting for the houselighting system and all related preset setups. A factory technician must be present at this time or no final setup or final acceptance will be performed. If the factory technician has to return for this meeting, it will be at no additional charge to the owner.

B. PROCEDURE FOR SCHEDULING FINAL ACCEPTANCE:

1. The contractor shall notify the owner and consultant of a proposed date and time for the final acceptance tests. The contractor shall include two alternate dates and times. The dates proposed will be a minimum of fourteen (14) calendar days from the date of the proposal.
2. If none of the dates and times are acceptable, the owner and/or consultant will submit two alternate dates and/or times to the contractor.

C. DATE OF TESTS:

1. Sufficient personnel will be on hand so that final focus/adjustments can be made to the lighting fixtures.

2. The contractor will have the appropriate equipment available to focus/adjust the lights (for example, ladder, manlift, etc.).
3. Tools must be on hand to remove connector plates and provide for other possible inspections.
4. All racks must be able to be opened for inspection.
5. The contractor will demonstrate operation of all major components of the systems including, but not limited to, the following:

a. Demonstrate all system functions and presets.
b. Demonstrate programming input.
c. Demonstrate operations of all devices with the lighting console.

3.22 CONDITIONS OF ACCEPTANCE:

A. It is understood that the consultant cannot inspect every aspect of the installation. The contractor is responsible for installation quality and methods, fabrication quality and methods, and performance of their work. Acceptance of the project will constitute an acceptance of the following:

B. All specified equipment is installed, and the system is operating in an acceptable manner from a functional standpoint (See checklist below for specific functional requirements).

C. Upon completion and acceptance of the project the contractor will provide to the owner a letter stating that all of the equipment and installation methods meet or exceed the specification requirements in all respects, and that the system as installed meets all of the applicable standards and codes required under the specification and meets applicable federal, state and local codes and laws.

D. ACCEPTANCE TESTS CHECKLIST:

1. Prior to acceptance testing there are a number of conditions that need to be verified. There are also site conditions required for the consultant to perform tests as indicated. The contractor shall ensure that every item on this checklist has been performed and verified prior to the consultant's acceptance tests can begin. Scheduling of the consultant to perform final acceptance tests must be coordinated with the owner, the project's construction manager (or clerk of the works), the contractor and the consultant (See paragraphs above for detailed requirements).

2. GENERAL

a. No other contractors may be working within the rooms to be tested during tests.
b. The contractor must verify these conditions can be maintained during testing.

3. STUDIO LIGHTING – TYPICALLY TAKES 2 – 3 HOURS – PER STUDIO SPACE:

a. Required attendance – A technician fully capable of programming and operation on all software including the console, architectural controls and any other software must be on site. Personnel and equipment needed for focus also need to be on site.
b. Any remote programming software that requires an external computer to address the lighting system must be on site, on line and loaded into a laptop provided by the contractor and ready for use if system programming changes are required.
c. All lighting circuits tested and verified functional.
d. Lighting control console set up, monitors in place and on mounts and all cabling and interconnections complete and neatly dressed.
e. All lighting console patching including color and any moving lights must be complete.
f. Architectural presets and control patching complete.
g. All lighting system labeling complete, including wire management, yoke and fixture labeling, portable cabling, etc.
h. All nodes and DMX distribution completely programmed and patched.
i. Remote focusing device (RFU, RFR, iPad or other wireless console control devices) verified and operational.
j. Fixture focus as required within specifications will be done at this time unless the owner chooses to take charge of and responsibility for this at another date.
k. Verification, in the form of signed documents, that all portable equipment has been delivered to the owner per specs and drawings and stored as per the owner's instructions. Portable equipment must be available for visual inspection as well.
l. Network configuration software set up and fully programmed.

3.23 CLOSEOUT DOCUMENTATION:

A. All closeout documentation, including training videos, must provide the owner with usable content. The determination of acceptability will be determined by the Consultant. Poor quality training videos and documents will be rejected.

B. Closeout Documentation is to be submitted within two weeks of system completion.

C. Contractor must submit the following items. All items should be part of the O&M Manual. Provide the quantity and form (paper and/or electronic) of these

closeout documents as is indicated in the contract front-end documentation. Physical copies shall only be required if front-end documentation requires them.

D. System testing documentation as required by final testing and acceptance procedures outlined in this document.
   1. ALL paper copy O&M Manual submissions shall be in heavy-duty, D-Ring style, 3-Ring binders All electronic copies shall be "bound" in an Adobe Acrobat style portfolio (see below for more complete information).
   2. Complete technical manuals for all equipment installed.
   3. List of serial numbers of all equipment installed
   4. Warranty cards for all equipment.
   5. Manufacturer MSDS sheets for all applicable equipment.
   6. Operations & Maintenance Manuals shall include English and Spanish only.
   7. Operations & Maintenance Manual: An operations and maintenance manual (or "Systems Manual") written in English on the safe use of a that particular site's lighting, dimming and controls system(s) shall be provided by the contractor to the owner. (provide separate manual sections for different spaces included in this project – each to be a separate, complete and distinct section in the manual for each differing or multiple system and location). This manual should include the following:

a. Table of contents.
b. A contractor written simplified guide to operating the system Include at minimum:
   1) A contractor written simplified troubleshooting guide or what to check and where to check if no lights will come on. Provide this in a 2-column style format.
   2) How to power up and power down the console, lighting system, etc.
   3) Console touch screen set up and general info on how to access various screens.
   4) A key stroke guide on how to quickly get to menus to patch dimmers, RDM fixtures, address/patch LED's or other moving/specialty lights and accessories to the console.
   5) Constructing and editing cues.
   6) Programming sub masters.
   7) Loading Faders.
   8) How to perform file saves, file loads, etc.
   9) A short list of the required software reset procedures for all lighting system related subsystems.
c. A simplified guide to operating the architectural control system, an understanding of pile on system architecture and where the button stations get their content. If editing has been made available on LCD screens, provide a guide on how to save over presets that affect button stations.

d. Microsoft Excel spreadsheets of all initial lighting system patch data, DMX assignments and fixture types at final set up.
e. Emergency contact number(s) and procedures to follow in the event of a catastrophic system failure.
f. One copy of the "Workbook" version of each of the following training guides used (only provide for levels trained on):
    1) ETC Level 1 console training – Essentials.
    2) ETC Level 2 console training – Enhanced Skills.
    3) ETC Level 3 – Advanced Programming.
g. Maintenance procedures and recommended schedules required for equipment installed that requires regular scheduled maintenance.
h. A DVD (or set of DVDS, depending on requirements listed Under Training Sections above) and a USB thumb drive with all content included on it.

E. O&M Manual pdf requirements: The contractor shall provide a pdf copy (with appropriate titles) for each piece of documentation listed above and bound together in a pdf portfolio/binder, labeled with the owner's name and with the submitting contractor's information. All electronic manuals shall contain only equipment and information that pertains to the project. Where factory manuals are available the contractor shall provide these. Where factory manuals are not available, the contractor shall provide high resolution (150 dpi minimum and fully optimized in Acrobat or equal), full page, properly and consistently oriented pages in a consecutive ascending order. All pdf portfolio and binders produced and submitted shall be professionally put together and presented well. All manuals shall be saved as standard Adobe Portable Document Format (PDF).

END OF SECTION

This page intentionally left blank

SECTION 193000 STUDIO RIGGING & CURTAINS

PART 1 GENERAL

1.1 PROJECT INFORMATION:

A. Owner: Newburgh Enlarged City School District
New CTE Building
201 Fullerton Avenue
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 lighting contractor, the lighting installer or the bidder.

E. Others: Various companies doing construction work under the general contract.

1.2 PROFESSIONAL STANDARDS:

A. The contractor is expected to install all work to the appropriate industry professional standards, manufacturer recommendations, and current applicable codes. If any work required exceeds the skills of the contractor, he will employ appropriate subcontractors for the scope required.

B. The acceptability of materials and workmanship will be determined by the Architect, Consultant, and CM.

C. Any work that might be damaged, be inadvertently painted, or become dirty during construction will be protected by the contractor. All responsibility for protection shall be by the contractor. The contractor will provide final cleaning and or repair of all equipment in their scope to like new condition.

D. The contractor will attend and/or arrange meetings as required to make sure their scope is coordinated with all other trades. The contractor is responsible to make known to all other trades critically dimensioned items and locations to avoid conflicts. Where conflicts occur follow required procedures in the project manual to seek resolution.

E. Where any substandard work is provided by related trades that impedes the work of the contractor, they will notify the CM, Consultant, Architect, or Engineer in writing as called for one the project manila to rectify the issue.

F. Where work is provided by others, the contractor is responsible to verify installation conditions that relate to their work. If installation of related work is substandard the contractor shall generate a written RFI through proper channels based upon the project manual. The contractor shall not install their work to any substandard devices, etc. provided by others until such work has been resolved or until the contractor has received written authorization from the construction manager to proceed. If the contractor ignores substandard installation work by others and proceeds to install his devices to these items, then he accepts and bears sole responsibility to repair, reinstall and correct any found deficiencies to the satisfaction of the owner upon final inspections.

G. The contractor will comply with the AHJ (Authority Having Jurisdiction) as it relates to programming any and all emergency interfaces.

H. The contractor is expected to possess knowledge of the equipment of their industry and to provide all small items required to install the specified equipment. Provide small items such as rack rails, DIN rails, rack panels, power cords, connectors, wall-wart power supplies, crimps, Nicopress and other items that may not be called out on drawings or in specs but are required to support primary equipment.

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

1.3 DEFINITIONS:

Code Requirements	Minimum requirements as specified by all applicable and published codes.
Concealed	Work installed in pipe and duct shafts, chases or recesses, inside walls, above ceilings, in slabs or below grade.
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 of holes, marks, and damage left from removals. Consult project manual for 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.

1.4 INTENT OF DRAWINGS:

A. Throughout the contract documents there are various manufacturers and products referenced. It is understood that these products establish a basis of design that all other "or equal" substitutions must meet or exceed. All submitted devices must be the referenced product or approved equal.

B. The drawings in this package are diagrammatic in nature, unless detailed dimensioned drawings are included. The drawings show the approximate locations of equipment and devices. The final and exact locations of all non-dimensioned devices are subject to the approval of the Owner or the Owner's Representative. Devices with detailed installation dimensions; however, are critically located and must be installed to those indicated dimensions unless alternate instructions have been given to the contractor in writing by the consultant.

C. The contractor(s) shall inspect the entire building(s) with the Owner’s representative prior to beginning any work and shall identify the exact locations and installation methods for all devices, conduit and wiring prior to beginning work.

D. Typical details are shown for the installation of various devices. The details do not apply to all situations. Installation methods for all work shall be subject to the Owner’s and construction manager’s approval. Provide all work and equipment required for a professional, workman-like installation.

1.5 SECTION INCLUDES BUT IS NOT LIMITED TO:

A. All items below relate to work in both studio spaces (green room studio and related control room as well as the photo lab space).
B. Provision of studio rigging systems and related work scope as indicted on drawings.
C. Provision of curtains & tracks.
D. Provision of motorized elements, supports, misc. interface boxes, control system, etc.
E. Set up and commissioning.
F. Training and closeout documents.

1.6 RELATED SECTIONS & DOCUMENTS:

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

1.7 RELATED WORK NOT INCLUDED:

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

1.8 GENERAL REQUIREMENTS:

A. ITEMS TO BE PROVIDED BY OTHERS:

1. Structural steel.
2. Level 5 finished walls.

B. Removals - Offer all existing portable and removed equipment to the owner prior to legally disposing of these items (counterweights, cheeseboroughs, booms, etc.). Obtain written permission from the owner for all existing removed items that they do not desire to retain prior to disposal.

C. Provide all equipment outlined and described within this specification and assemble it into a complete, properly functioning system for use by the owner as described within this specification.

D. It is the contractor's responsibility to clarify any misunderstandings or drawing-to-drawing/drawing-to-spec discrepancies prior to bid. In cases of a difference between stated quantities in drawings, specs or electrical drawings, the higher quantity will prevail.

E. Check each component before installation as well as each portion of the project during installation to ensure that the intent of this specification is achieved.

1.9 BIDDER QUALIFICATIONS – SUBMITTALS:

A. The bidder shall provide references of at least three (3) installations of comparable scope performed by the bidder, including location, system description, and name, address, and telephone number of the architects, consultants, and owners and the names of contract persons for each.

B. The bidder must maintain service facilities and have service available on site within 24 hours. The bidder must be a factory authorized dealer for all products submitted and may be required to submit such proof of factory authorization in writing, or in the form of copies of authorized agreements with the various vendors.

C. The bidder and all persons performing theatrical rigging system related work on this job must be ETCP certified (Entertainment Technician Certification Program) as a theater or arena rigger or under the direct supervision of an ETCP certified foreman. This applies to all theatrical rigging equipment installation and any other assemblies indicated as being provided or installed by the bidder. Proof of current certification MUST be provided in the submittals package (this is typically in the form of a pdf copy of the current and active certification certificates from PLASA). Out of date or expired certifications shall not be recognized as meeting the requirements of ETCP certification.

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

1.10 INQUIRIES AND COMMUNICATIONS:

A. All questions shall be generated as called for in the project manual.

B. Direct communications to the consultant via phone are recommended for initial discussion about intent or site issues. (unless prohibited in the project manual). No action may be taken based on verbal communications, they must be followed up in writing as called for in the project manual.

C. Where discrepancies occur, and pre-bid instructions have not been obtained by written request, the contractor will abide by the owner's decision at no additional cost to the owner.

1.11 COORDINATION:

A. Cooperate with other trades to achieve well-coordinated progress at all times. Notify the owner and consultant as often as necessary with regards to job progress or changes in the installation schedule. All conflicts will be reported to the architect, construction manager, owner, and consultant in writing. All reasonable attempts will be made to correct any difficulties.

B. Staff the job site adequately at all times to maintain a progress in keeping with the total project progress.

C. Provide all materials to be installed by others in a timely fashion based upon the related trades' schedules.

D. The job site will be left in a clean safe condition at the end of any workday. All cleanup and debris removal to a site designated by the owner will be the responsibility of the bidder on a daily basis.

E. All storage of tools and materials will be done by the contractor. No on-site storage security will be provided by the owner.

F. The contractor will attend regular meetings with the architect, owner, general contractor, and the consultant when requested by any of the above, in order to achieve project coordination and progress.

G. The contractor shall be required to share all approved rigging system electrical shop drawings with the EC prior to rough-in. He shall work closely with the electrician in determining final control wiring types, quantities and requirements, related device locations, backbox sizes, conduit routings, etc. before the EC has purchased his supplies and in order to meet the construction schedule. He shall share all approved rigging system shop drawings and work closely with all contractors prior to any rough-ins in coordinating the stringent requirements and clearances required for the rigging systems equipment.

1.12 DELIVERIES:

A. It is each contractor's responsibility to receive all device shipments, equipment, deliveries, etc. for their own equipment on/at the job site personally. Each contractor shall be responsible to arrange for storage of all received materials on site until the appropriate time when they shall either turn them over to installing contractor or install them.

B. If the contractor chooses to allow a third party to receive shipments on his behalf the contractor bears sole responsibility for any missing and/or damaged parts.

C. Any equipment that is furnished by the contractor for installation by others shall be turned over to the installing contractor at a time that fits into their production schedule and the project's overall construction schedule.

1.13 STANDARDS REFERENCES:

A. The contractor is responsible for the provision of material and methods installation of equipment conforming to the currently applicable standards of:

1. ADA - Americans with Disabilities Act
2. AISC - American Institute of Steel Construction
3. AISI - American Iron and Steel Institute
4. ANSI - American National Standards Institute
5. ASME - American Society of Mechanical Engineers
6. ASTM - American Society for Testing Materials
7. AWS - American Welding Society
8. EIA - Electronic Industries Association
9. ESTA - Entertainment Services and Technology Association
10. FCC - Federal Communications Commission
11. IEC - International Electronics Commission
12. IEEE - Institute of Electrical and Electronics Engineers
13. IFI - Industrial Fasteners Institute
14. ISO - International Organization for Standardization
15. NACM - National Association of Chain Manufacturers
16. NEC - The National Electric Code
17. NEMA - National Electrical Manufacturers Association
18. NFPA - National Fire Protection Association
19. OSHA - Occupational Safety and Health Association
20. SAE - Society of Automotive Engineers
21. SMPTE - Society of Motion Picture and Television Engineers
22. TIA - Telecommunications Industry Association

23. UL - Underwriters Laboratories (Electrical components, devices and accessories shall bear a UL label where applicable. UL listed and labeled as defined by NFPA70, article 100, by a testing agency acceptable to authorities having jurisdiction and marked for intended use.)
24. USITT - United States Institute for Theater Technology "Recommended Guidelines for stage rigging and stage machinery-specifications and practices".
25. Wire Rope User's Manual
26. Manual of Steel Construction 15th Edition or later (aka the AISC Steel Construction Manual)

B. Provide certification and labels where applicable. Comply with federal, state, and local regulations and applicable union regulations where required. All equipment will have the proper labels for New York State.

C. Provide only equipment that is standard, new, previously unused equipment of the latest design or of the latest model of regular stock product and is supplied with all parts regularly used with the equipment offered for the purpose intended. No re-furbished or obsolete materials shall be permitted. The contractor guarantees that no modification of the equipment has been made contrary to the manufacturer's regular practice.

D. Review all materials and equipment prior to installation and notify owner as to any changes or discrepancies between published specifications and the actual material and equipment to be installed.

1.14 EQUIVALENTS:

A. The successful bidder shall submit any product equivalents prior to award of the contract detailing the kind, type, brand, manufacturer or equipment included in the base bid. Equivalent products must be highlighted on this list. When requested, the successful bidder shall also submit information, describing in specific detail, how the equivalent bid material differs from the appearance, quality and performance required by the base specification. Submittal of the manufacturer's advertising cut sheets alone is not acceptable for proof of equivalency.

B. Proof of equivalency may require the bidder to provide physical samples, a full-sized mockup or specific manufacturer information detailing technical equivalency. Proof of equivalency shall be the burden of the submitting contractor/bidder and not that of the consultant. Proof of equivalency relates to all pertinent functions of the specified equipment, regardless of if that information is reflected on any manufacturer's issued cut sheets.

C. If proposing equivalents that affect the system design as shown on the drawings, the bidder must submit flow charts, and any other drawings necessary to show differences in the system operation from the primary referenced system.

D. The bidder will pay for any and all changes to related work scope required by the equivalent products.
   1. This includes electrical, architectural, structural and other changes that might be needed to implement an equivalent product.
      a. Some products with virtually identical functions have varying power requirements, physical dimensions, etc.

E. The risk of whether bid equivalents will be accepted is borne by the contractor. See section 2.1 "Performance Requirements" for more information.

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

G. Final judgment as to equality will be solely that of the consultant, architect, construction manager and owner.

H. The costs for any changes by other trades required to implement the equivalents proposed will be borne by the contractor.

1.15 SUBMITTALS:

A. Equipment: After bid award but before ordering any equipment or starting any work submit to the owner for approval a list of all equipment to be furnished showing types, models, quantities and manufacturer. Attach catalog sheets for all items submitted.

B. The quantity and form (paper and/or electronic copies) of all submittal material required shall be provided by the contractor to the appropriate parties as is indicated in the contract front end documents (in addition to any requirements listed below). If there are no indications in the contract front-end documents, then the contractor shall submit (1) electronic copy of each area, category, etc. of items as listed below. All submissions are understood to be intended for approval by the construction manager, the architect, owner, general contractor and the consultant prior to any fabrication or installation of any devices.

C. Submit a schedule for submission of drawings for fabrication and site work.

D. Submit a complete submission package with all required paperwork.

E. Submit curtain material samples (two for each different type of curtain indicated on contract documents), shell material samples and standard color selection charts (charts must be in color and manufacturer's actual cut sheet – no color selection charts in black & white or photocopies of original color selection charts shall be acceptable) for approval by the architect & owner prior to any fabrication or installation. These copies are to be submitted to the architect ONLY. The intent of these is for the charts and samples to be used for the selection of the curtain and shell colors. Submit documentation in the submittal package to the consultant that these have been delivered to the architect & owner.

F. Submit each of the following as each pertains to this project. Provide a copy for each related person performing indicated work who holds these certifications:
   1. Current welding certifications
   2. Current training certifications.
   3. Current ETCP certification.
   4. Current manufacturer certifications.

G. Submit material schedules, shop drawings, bill of materials, rigging system data/cut sheets and any applicable fire rating data or MSDS sheets for all rigging system components and curtains.

H. Submit a complete set of rigging drawings* for each studio space (each sheet bearing the signed stamp of and fully reviewed by a current New York State licensed professional engineer – i.e. a "stamped set" or "NYS PE stamped" set of drawings) of the proposed rigging system and related building components (including, but not limited to, the overhead rigging steel, floor construction and loading under locking rail, etc.).
   1. Technical Drawings:
      a. The full set of submitted drawings and data sheets must be presented in a professional manner.
      b. All shop drawings for submission must be CADD drawn (created with a computer aided drafting program). Hand drawings are not allowed. Illegible drawings shall not be acceptable.
      c. All cut sheets for submission must be clean electronic (pdf) copies of the manufacturer's actual data sheets. Mark up each sheet with highlights or boxes around submitted products, options, etc.
      d. Provide a complete drawing package including attachment details, rigging details, suspension details & mounting and other required miscellaneous details.
      e. Provide complete system drawings including plans, elevations, sections and details.
      f. Provide complete fabrication and attachment method drawings.
      g. Provide a separate cut sheet (manufacturer's data sheet) for every piece of equipment being provided.

         * The intent of the stamped shop drawings is for the contractor to communicate to the consultant the exact proposed locations, materials and fabrication methods of all standard and custom items for all intended rigging system equipment as well as to have all proposed systems approved by a structural engineer as to loading, breaking strengths, embedment depths, loads imposed on building structure, etc.

I. Quality Assurance
   1. 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.

J. 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, seismic requirements, etc. Submission of this package by the contractor is proof that the contractor and his PE have reviewed the entire system design, understand the intents and concur 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 Rigging System:
   1. Pipe Grid system
   2. Fixed & mobile ceiling/grid track system
   3. Curtains
   4. Unistrut support system
   5. Studio cyc system
   6. Studio motorized roll drop background system

PART 2 PRODUCTS

1.17 PERFORMANCE REQUIREMENTS:

A. The requirements of the referenced equipment are not generic in nature. Specific performance, control and routing capabilities are necessary for any alternate equipment.

The details set forth herein and within the functional description of the system are the critical criteria for the selection of each piece of equipment.

B. In bidding equivalent equipment from manufacturers other than those referenced on these contract documents, the contractor must be aware that all functional information included in this specification as well as the manufacturer's specifications, physical size, serviceability, warranty terms, product availability and other non-technical issues may be determining factors in product equivalency. Final judgment as to equivalency will be solely that of the owner, architect and consultant. Equivalent products shall be approved only at the contract bid price and shall not allow for additional costs to the owner, except as described in the contract manual.

C. Substitution Criteria:
   1. Motorized roll drop background 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. dB noise output of hoist.
      h. Noise frequency response curve.
      i. Control interface size, power requirements and ergonomic layout.
      j. Control wiring requirements.
      k. Wireway interface size, location & interface.
      l. User interface panel capabilities, functionality and ergonomics.
      m. Pendant remote capabilities, physical size and operational considerations and ergonomics.
      n. Programmable preset positions available.
      o. Self-contained.
      p. UL or other appropriate agency listings and ratings.
   2. Curtain & Track substitutions require proof that the substituted product meets all performance requirements including but not limited to:
      a. Product warranty period
      b. Flame rating
      c. Available colors & finishes
      d. Sheen of fabric face
      e. Material weight per square yard
      f. Light blocking capabilities
      g. Longevity
      h. UV Resistance
      i. General workability and finished appearance
      j. Track construction, pulleys and material finishes available
      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

3. Hard Cyclorama/Green Screen System & flooring (or Modular Infinity Backgrounds) substitutions shall require proof that the substituted products meets all performance requirements including but not limited to:
   a. Product warranty period
   b. Physical size.
   c. Flame rating.
   d. Mechanical rating of substrate.
   e. Stiffness of materials properly installed.
   f. Smoothness of final finished product.
   g. Thickness of material and the ability to finish to an existing wall.
   h. Radius options, vertical corners, floor coves, etc. availability.
   i. Adherence of paint.
   j. Chroma key green paint color, consistency, application, finish, sheen, coverage and ability to work seamlessly with a chroma keyer.
   k. Available configurations.
   l. Green screen flooring thickness.
   m. Green screen flooring color consistency with green screen paint.
   n. Reflectance of both green screen paint and flooring.
   o. VOC, lead and mercury requirement compliance based upon state codes.
   p. Customization ability (length) by field cutting, etc.
4. 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.
5. Miscellaneous rigging hardware (counterweight or dead hung) substitutions require proof that the substituted product meets all performance requirements including but not limited to:
   a. Product warranty period
   b. Physical size.
   c. Physical weight (self-weight of individual piece).
   d. Stamping or other indications of load rating.
   e. Custom pieces available if need arises.
   f. Critical spacing, line handling or physical size characteristics that may impact installation intents.

g. Load ratings and WLL capacities.
h. Safety factors.
i. Attachment methods.
j. Welding requirements.
k. Physical construction.
l. Rated and expected life duty cycles.
m. Part traceability.
n. Appropriateness or approval for overhead lifting use.

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

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

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

G. Any necessary product accessories such as additional power outlets, power supplies, rack mount kits, connectors, adapters or other small items are the responsibility of the contractor to provide, whether or not they are called out in detail within these specifications. This may include additional electrical work, (also depending upon the differences between any substituted vs. specified equipment), junction boxes, breakers, disconnects, etc. and shall be the sole responsibility of the contractor to provide at no additional cost to the owner.

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

I. Quantities:
1. Where no quantity is indicated in the written specifications, the contractor shall supply quantities as indicated on drawings.
2. Items not indicated on drawings but necessary for project completion shall be provided as required for project execution at no additional cost.

1.18 STANDARDS:

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

adhere to these minimum standards could result in serious injury to operators or bystanders and/or substantial structural damage.

2. These standards apply to rigging hardware only and not to the building or related structure from which the rigging components are supported/suspended.
3. These standards DO NOT apply to raising, lowering, suspending or "flying" of people. None of the items listed within this specification or indicated on the contract documents is intended for the aforementioned rigging or attachment of a person to any portion of the stage rigging or related systems. RIGGING A PERSON TO/FROM THIS SYSTEM IS UNSAFE AND IS NEVER RECOMMENDED.

B. All rigging systems shall be required to be inspected (as a minimum) to the standards set forth in ANSI E1.47 – 2017 (Entertainment Technology – Recommended Guidelines for Entertainment Rigging System Inspections) or the current version of the most recent standard revision.

C. All dead hung rigging system components shall conform (as a minimum) to the standards set forth in ANSI E1.4-1 – 2016 (Entertainment Technology - Manual Counterweight Rigging Systems) or the current version of the most recent standard revision.

D. All parts shall be industry standard load rated types. All hardware shall be rated for maximum possible load with an industry standard safety factor as per the codes and practices noted elsewhere within this specification. A list of load factors for all materials utilized shall be provided to the owner in the form of manufacturer data sheets.

E. The list of major components that follows does not include all required items, only major system components. Field verify dimensions for all items and change as required to fit field conditions for flange sizes, headblock spacing, steel elevations, orientations, etc.

F. Materials shall conform to the following ASTM and ANSI standard specifications:
   1. A-47 Specification for malleable iron casting.
   2. A-48 Specification for gray iron casting.
   3. A-120 Specification for black and hot-dipped zinc-coated (galvanized) steel pipe for ordinary use.
   4. B18.2.1&2 Specification for square and hex bolts and nuts.

G. In order to establish minimum standards of safety, the following factors shall be used:
   1. Cables and fittings - 10:1 Safety Factor.
   2. Cable bending ratio - Sheave tread diameter is 30 times cable diameter or as recommended by wire rope manufacturer, whichever is more restrictive.
   3. Maximum fleet angle - 1-1/2 degrees.
   4. Steel - 1/5 of yield.
   5. Bearings - Two times required load at full speed for 2000 hours.
   6. Bolts - Minimum SAE J429 Grade 5 (ISO R898 Class 8.8), zinc plated.
   7. Motors - 1.0 Service Factor.
   8. Gearboxes - 1.25 Mechanical Strength Service Factor.

H. COMPONENTS:

1. All system components shall be designed, engineered and manufactured to withstand all design loads without deformation or damage to components and shall meet the requirements of the "Design Factors" section of the current ANSI codes for counterweight rigging systems.
2. All housings and mounting components shall use materials having ductile properties that will deform plastically without fracturing.
3. Unless specifically noted otherwise, fasteners shall have a minimum SAE J429 Grade 5 or ISO R898 Class 8.8 rating. Bolts in tension shall have nuts of equivalent rating. Fasteners shall be self-locking or secured by alternate means (moused) to prevent loosening. Fasteners shall be installed in accordance with the manufacturer's instructions. Attachments made through slotted, elongated or oversized holes (more than 1/16" over the fastener diameter) shall use flat washers.
4. The maximum allowable fleet angle for lift lines and purchase line shall be in accordance with the requirements of the "Design Factors" section of the current ANSI codes for counterweight rigging systems, unless the grooves in the block, and the bearings, are designed to accept a greater side thrust without harming the wire rope.
5. All welding shall be performed in accordance with current AWS standards as well as in compliance with any additional local, state or other standards. All field welds shall be certified and verified as required in the contract documents – at the bidder's expense.
6. No quick links or quick link style sleeved and threaded coupler style links shall be allowed for overhead lifting under any circumstances – even if the parts are load rated.

1.19 MISCELLANEOUS RIGGING HARDWARE:

A. LIFT CABLES (WIRE ROPE):

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

5. In applications where reverse bends are incorporated, the wire rope service life shall be decreased as determined by a qualified person.

B. CABLE & CHAIN FITTINGS & TERMINATIONS:

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

C. EYE BOLTS:

1. All eyebolts shall be The Crosby Group or equal.
2. All eyebolts shall be:
   a. Drop forged steel and hot dipped galvanized steel in construction or machinery type - quenched and tempered.
   b. Fatigue rated.
   c. Load rated.
   d. Recommended for straight and in-line pulls only.
   e. Where circumstances require angular loading, only shoulder eye or machinery bolts shall be used. For angular lifts, the contractor shall adjust size of eye bolts in order to maintain the proper working load limit and safety factor based upon manufacturer's standard deratings due to imposed angular forces/loads. Direction of pull of 45° will cause the adjusted working load to be 30% of the rated working load. Direction of pull of 90° will cause the adjusted working load to be 25% of the rated working load.
   f. Regular nut eye bolts are not allowed and are strictly prohibited.
   g. The shoulder shall always be secured flush against the load surface.

D. SHACKLES:

1. All shackles shall be The Crosby Group or equal.
2. All shackles shall be:
   a. Drop forged and hot dipped galvanized steel in construction.
   b. Screw pin or bolt type only.

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

E. TURNBUCKLES:

1. All turnbuckles shall be The Crosby Group or equal.
2. All turnbuckles shall be:
   a. Drop forged and hot dipped galvanized steel in construction.
   b. Fatigue rated.
   c. End fittings quenched and tempered.
   d. Bodies heat treated by normalizing.
   e. Feature UNC threads with modified UNJ threads on end fittings for improved fatigue properties.
   f. Recommended for straight and in-line pulls only.
   g. Meet the performance requirements of Federal Specifications FF-T-791b, Type 1, Form 1 – Class 2/4/7/8 (except for those provisions required of the contractor).

h. Provided with a redundant fixing means (moused), after pin insertion (this is to keep any and all threaded pins from backing out over time or due to vibration or rotation during use). The fixing method shall be performed in accordance with the manufacturer's recommendations. Mouse with galvanized wire or black nylon wire ties after final adjustment to prevent loosening.
i. Turnbuckles shall not feature hook end fittings. Hook end fittings are not allowed and are strictly prohibited.

F. GENERAL FITTINGS REQUIREMENTS:

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

G. 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.

H. 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.

I. 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.

J. 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.

1.20 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.

1.21 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.

1.22 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

.

1.23 METAL FRAMING SYSTEM: REFERENCED PRODUCT UNISTRUT METAL FRAMING

A. All contractor provided metal framing, metal channel or miscellaneous support systems indicated on the drawings shall be Unistrut Framing Systems 1 5/8" width series channel and related nuts & hardware as manufactured by Unistrut Corporation or equal.

B. Framing Members:
   1. Unistrut channel members and continuous inserts shall be fabricated from cold-formed to size from structural grade, low carbon strip steel.
   2. Welding: All spot-welded combination members (except P1001T) shall be welded on 3" (76 mm) maximum centers.
   3. Curved channel: All curved Unistrut channel noted on the drawings shall be curved to the radius specified by the manufacturer. No contractor bent or curved channel shall be acceptable.
   4. Raw steel shall conform to the following ASTM specifications:

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

C. Nuts & 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.

D. 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.

E. 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

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

a) Formulated as a “heavy metal” free coating (trace elements only).
b) Outgassing in service: Essentially none at 350° for 24 hours.

1.24 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.

1.25 CROSS GRID CONNECTOR ASSEMBLY: REFERENCED PRODUCT SAPSIS RIGGING GRID LOCK PIPE CLAMP

A. The cross-grid connector shall be a right angle, low profile connector assembly consisting of two pieces. These pieces shall be capable of joining two 1 ½” pipe battens oriented at a right angle to each other without the need to slide them on from the pipe ends.

B. Each cross-grid connector clamp shall be made from a single piece of 7-gauge steel flat bar (3/16”) that has been factory formed to fit firmly around a standard 1 ½” pipe batten. Clamp sections shall be fastened together with four 3/8” load rated (Grade 5 minimum) hex head bolts with matching locknuts. When the clamps are fastened together, they shall force the pipe battens together and greatly restrict rotational and lateral pipe movement.

C. Cross grid connector assemblies shall have an RWL of 1800 lbs. minimum.

1.26 CURTAIN TRACKS: REFERENCED PRODUCT ADC MODEL 140 RIG-I-FLEX WALK-ALONG TRACK

A. Curtain tracks shall be of 11-gauge extruded aluminum I-Beam construction consisting of a center rib and top, intermediate and bottom flanges. Each curtain carrier shall be spaced on 12” centers and shall be of steel construction to include two nylon-tired ball-

bearing wheels rolling on two separate parallel treads. Each curtain carrier shall consist of a free-moving plated swivel to accommodate curtain snap hook. Live-end and Dead-end pulley blocks shall be equipped with sleeve-bearing wheels adequately guarded. Nylon snap-on spacers shall be attached to wheel supports of curtain carriers. The manufacturer shall furnish two end stops for placement at track ends and a tension floor pulley for increasing cord tension. Track shall be rigidly supported from ceiling clamps or hanging clamps. Stretch-resistant operating cord (Model 1728 for hand operating tracks and Model 3529 for machine operated tracks) shall have synthetic or wire center and shall be of 1/4" or 3/16" diameter. Curves require ball-bearing spindles and ball-bearing idlers. 1-1/4" I.D. stiffening pipe or the equivalent shall be used to support both straight and curved areas of all suspended curved tracks.

B. All track, suspension hardware, carriers, jack chains, etc. shall be flat black.

1.27 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.

1.28 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.

1.29 BUILT-IN ABS/FIBERGLASS HARD CYC & VINYL FLOORING: REFERENCED PRODUCT PROCYC SYSTEM 3EZ AND PROMATTE IV FLOORING

A. System shall come complete from the manufacturer with all panels, legs, bracing, fasteners, seam tape, misc. hardware, etc. needed in order to construct and set up the hard cyc cove system. Contractor must provide joint compound, fasteners for attachment to floor/walls, all required tools and either spray foam or dry mortar for "ground packing" of cyc ground row cove components.

B. Construction: Material – Panels shall be manufactured from a high-impact ABS (Lustran ABS 752 Acrylonitrile Butadiene Styrene - Extrusion Grade or equal natural colored) plastic and fiberglass combination that is easily field trimmable to exact lengths needed. All field-trimmed pieces shall be capable of reattachment via standard ABS or PVC glues. Material shall meet or exceed those physical, general, thermal and mechanical properties of Lustran ABS 752 resin.

C. Flammability: Hard cyc material shall meet or exceed the UL94 flame class and burn rates with an HB rating or greater.

D. Contractor shall provide ProMatte IV vinyl flooring (Chroma Key green colored) to match the Chroma Key green paint referenced below. Flooring shall be 25/1000's of an inch thick. Provide enough flooring to cover area indicated on the drawings, including required 2" overlap material at all edges. Provide with easy removal double-sided tape for installation. Install as directed by manufacturer's installation instructions sheet.

E. Contractor shall perform the following steps in setting up, installing and preparing hard cyc system for finishes (these steps are the minimum required – contractor must perform all recommended steps per the manufacturer's recommendations, even if not listed here):

1. Uncrate & setup ProCyc system (to existing structure, if necessary).
2. Sand the entire surface of the ProCyc units (as well as any related surfaces).
3. Sand all edges to prep for mudding & taping.
4. Prep all surfaces.
5. Apply fiberglass mesh joint tape.
6. Mud all joints (use plaster bonding agent such as Wall Grip, Z-Prime II, XIM or Plaster Weld) with multiple coats of a 90-minute joint compound (Hamilton 90 or Durabond 90), sand in between coasts, etc. (no EZ sand or light variety muds shall be allowed). Top coat (third coat) may be done with similar joint compound or a topping mud.
7. Sweep & vacuum all dust, debris, etc.
8. Wipe entire surface with a clean, damp cloth.
9. Apply one heavy coat of ProCyc grey bonding primer (use only 3" wide rollers on corner units to prevent lines and streaking).
10. Apply two heavy coats of finish color (ProCyc Virtual Green Chroma Key Green). It is critical that the contractor obtain an even final finish coating in order for keyer to work properly.
11. Use disposable surgical booties over shoes for all prep work, set setup, etc. when doing shoots in order to prolong the life of flooring and to minimize damage to the flooring surface.
12. Upon completion of ProCyc setup, contractor shall install ProMatte flooring as directed by the manufacturer in order to cover the floor area detailed on the drawings.

13. All items shall be painted with or shall match the Chroma Key Green colored paint from ProCyc. No substitute paints, locally obtained or national hardware chain mixes shall be acceptable.

F. Contractor shall verify with owner and video keying system that painted surfaces are sufficiently even in paint coverage so that keying system works properly. If surface coverage is questionable, then contractor shall provide additional coats as needed in order to obtain an even surface coverage that allows keying system to work properly.

G. Contractor shall provide owner with an extra, unopened 2-gallon pail each of Virtual Green Chroma Key Green & grey bonding primer paint from ProCyc for future use after all surfaces have been painted and verified. Hard cyc surface may be repainted hundreds of times without need for removal of original coats. All paint provided, both initial cyc coats and extra paint, should be from the same batch/color run in order to provide the most consistent coloring possible.

H. All paint and primer shall be VOC compliant for all 50 states and shall be lead and mercury free.

I. Provide the owner with two cases of Dynarex DYNA2131cs or equal disposable shoe covers (booties) for use with the ProMatte flooring. Booties shall be blue, breathable shoe covers made of a spun, bonded polypropylene with sewn seams, non-skid bottom and an elastic opening. Booties shall be latex free. 150 pairs per case – typical. Owner shall be instructed that these booties should be used by all personnel who walk on the ProMatte flooring for any reason. This will extend the life of the flooring and minimize the need to clean it. All cleanup of ProMatte flooring shall be accomplished with the use of a dry cloth and a standard household cleaner shall as Formula 409. No harsh chemicals, bleach, ammonia, etc. shall be used on the flooring as these may adversely affect or damage the finish.

1.1 MOTORIZED ROLLER MOUNTED BACKGROUND SYSTEM: REFERENCED PRODUCT PHOTOTECH, INC. ROLLEASY MW (SEE CONTRACT DRAWINGS FOR COMPLETE INFO)

A. Motorized roll drop system capable of handling rolls of fabric and/or paper up to 12’ wide.

B. Provide complete with all required brackets, accessories, connectors, power power/control box, remote control device, rollers, roller storage system, etc. as specified.

C. All mounting brackets, power/control distro box and all mounting hardware, etc. must be inherently or painted flat black.

D. Remote control system shall feature a black, heavy duty plastic controller box with (4) independent rocker switches (1 per roller drive motor).

E. Motorized unit operates on standard 120VAC power.

F. All units are fused and grounded.

G. Provide with all backdrop rolls, accessories, etc. as indicated on the contract drawings.

1.2 TRACKABLE GRID SYSTEM: REFERENCED PRODUCT MANFROTTO SKYTRACK SYSTEM (SEE CONTRACT DRAWINGS FOR COMPLETE INFO)

A. Tracks shall be black anodized aluminum. Standard lengths shall be available (without splices) of up to 5 meters.

B. Rails shall be approx. 34.5 mm wide and 61 mm tall.

C. Rails shall be capable of 440 lbs. maximum loading per 1 meter section of track when attached on 1,000 mm centers. (220 lbs./meter for 1,500 mm mounting centers and 110 lbs./meter for 2,000 mm mounting centers). All mountings shall be to overhead structure, pipes, etc. or equal.

D. The Sky Track system features a wide variety of mounting bracket options in order to mount this system to pipe battens, walls, ceilings, tubes, sloped overhead slabs, etc.

E. All attachment hardware, brackets, extensions, joining clamps, alignment connectors, sliding carriages, operating poles, pantographs, etc. shall be provided in anodized black. All spigots shall be their natural color.

F. Provide all spigot and spigot adaptors as required to mount all lighting fixtures to the Manfrotto track system, along with the specified quantity of spares.

G. Provide all spare tracks, accessories, etc. as indicated on the contract documents.

1.3 STUDIO 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. STUDIO PANELS:

1. Studio panel curtains shall be sewn with only full widths of fabric. No partial or multi-panel curtains shall be acceptable. Studio panels 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 Studio panel curtains shall incorporate a 50% additional fullness.

4. SEW-ON VELCRO –

   a. 1.5" - DuraGrip Brand Sew-On Hook - Black
   b. Made from 100% Nylon 8 mil Monofilament with 280 hooks/sq. inch, binder coat prevents unraveling when cut.
   c. Cycle Life: 20,000 operations min.
   d. Shear Strength: 14.15 per square inch (avg.)
   e. Peel Strength: 0.68 per inch of width (avg.)
   f. Selvage: 3/32" max.

5. PRESSURE-SENSITIVE VELCRO –

   a. 2" - Velcro® brand Pressure Sensitive Adhesive Hook: Rubber - Black
   b. 6 mil Monofilament and are binder coated to protect against fraying when cut. They also offer excellent durability and have a high cycle life. The rubber-based pressure sensitive adhesive is designed for a medium temperature range that performs well on many substrates, especially uneven or rough surfaces.
   c. Adhesive shall be Industrial Strength extreme, UV resistant and offer superior holding power without the needs of mechanical fasteners or epoxy resins.
   d. Operating Temperature Range: -40 F to 120 F
   e. Closure Shear Strength: 14.0 psi

f. Closure Peel Strength: 1.2 psi
g. Closure Tension Strength: 6.5 psi

E. STUDIO WALK-ALONG CURTAINS:

1. Studio walk-along curtains shall be fabricated similar to a traveler curtain.
2. Walk-along curtain panels shall be sewn from materials as indicated on the curtain schedule.
3. The walk-along curtains shall incorporate a 50% additional fullness.
4. Walk-along curtains located on tracks shall have a plated S hook inserted in each grommet and closed at the grommet. Each S hook shall then be attached to a length of jack chain to the carriers. Gap between carriers and curtain top shall not exceed 24". Curtains specified with added fullness shall have box pleats sewn on 12" centers.

F. 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).

G. MATERIAL TYPES:

1. CURTAIN LINING DETAILS (UNLESS OTHERWISE NOTED ELSEWHERE)

a. ALL CURTAINS UNLINED

2. IFR VELOUR STAGE CURTAINS: REFERENCED PRODUCT KM FABRICS CRESCENT VELOUR

a. Unit Weight: 18 - 20 oz. (per linear yard)
b. Color TBD by architect/owner.
c. Inherently Flame Resistant.
    1) Meets the minimum requirements of flame resistance established by the following: NFPA 701 – Small Scale; NFPA 701 – Test Method #1; California Title 19; SC-191- 53 Class 1 California; NFPA 260A/UFAC Class 1; IMO a.471 (XII) – A.563(14) for Cruise Ships; CAN/ULS-S109- 03 Canadian flame test for fabrics; State of California – F-59901
    2) This fabric was manufactured and tested under the supervision of a General Applicator registered as #GA-0358.01 by the Fire Marshall of the State of California.
    3) This fabric is registered with the Fire Department of the City of New York as #5138.
    4) Woven with non-combustible filament, it is inherently and permanently flame resistant for the life of the fabric. This flame resistance will NOT wash out by water washing.
    5) Unlimited dry cleaning. Flame resistance is permanent for the life of the fabric; however, atmospheric conditions can and may alter the effectiveness of the flame resistance. Annual testing for flame resistance is recommended.
d. Fiber Content: 100% polyester.
e. Noise Reduction Coefficient: 0.95.
f. Sound Absorption Average: 0.96.

3. IFR VIDEO KEYING FABRIC: REFERENCED PRODUCT SUPREME FABRIC BY FRED KRIEGER FABRICS

a. Unit Weight: 14 oz. (per linear yard)
b. Color: Digital blue; digital green; chroma key blue; chroma key green.
c. Inherently Flame Resistant.
    1) Meets the minimum requirements of flame resistance established by the following: NFPA 701 (small scale test).
    2) This fabric has been approved for this use 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. Color is established by UV resistant dye.
e. Fiber Content: 100% inherently FR polyester.

PART 2 EXECUTION

1.4 GENERAL:

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

B. All liability for rigging, fastening, and other installation methods shall be borne by the contractor alone. The fact that the specification calls for any equipment to be installed does not constitute an approval by the consultant or owner of any method for accomplishing the mounting or installation of the device or the suitability of the device for mounting in the manner, which the contractor has proposed in shop drawings. If the contractor has a reason to believe safety will be compromised in the installation of any of the specified equipment, they must note this at the time of bid and offer alternatives in writing.

C. Assess life safety implications of all installation methods and verify there is no compromise of life safety issues.

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

E. Maintain M.S.D.S. for all materials used where applicable and submit same to architect.

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

G. The contractor will verify all on site dimensions prior to ordering or installation of critically dimensioned equipment and wiring or any of the rigging system equipment. In a case of discrepancy between these documents and attached drawings, construction documents, and actual on-site dimensions the contractor will notify the owner and consultant before making any changes in intended work. The owner and consultant will determine the correct modification to the work to be done. No additional payments will be made for material or equipment improperly ordered or sized due to site variations.

H. Any equipment, hardware, wiring harnesses, or other items not specifically included in this specification but required for the system to function as called for within this document will be the responsibility of the contractor at no extra cost to the owner.

I. Provide all hardware and all other required parts to provide a complete system to the extent that such items are not provided by others.

J. All methods must be cosmetically acceptable to the owner. All equipment will be installed neatly, with respect to level, sight lines, and finish. All wiring must be neatly run and concealed in an orderly fashion and attached to appropriate support structures.

K. Moderate changes or moves necessary to accommodate other equipment, coordination with other trades, or for pleasing appearance will be made without claim for additional payment.

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

M. If specific elevations of dead hung sets are not indicated on the contract documents, it is the responsibility of the contractor to obtain these elevations in writing from the consultant prior to any set installation. Any installation of sets without proper knowledge and written documentation of the actual and exact set trim heights intended will result in the contractor rehanging all such improperly installed sets to the intended trim heights. The contractor shall be solely responsible for all removal and reinstallation labor, hardware, etc. as is needed in order to rehang all improperly installed sets at the intended trim heights.

1.5 WIRING AND RACKS:

A. The contractor shall field verify all locations where contractor provided wiring shall be run in order to determine each space's "plenum status." If any wiring noted on the drawings must be run through an air plenum space, then the contractor must provide plenum rated wiring for all such locations, even if the wiring noted on the drawings is non-plenum rated or spaces have ducted air. The contractor shall provide plenum rated wiring matching the specified wiring as closely as is possible. This applies to both EC provided wiring and other wiring to be installed by theatrical or A/V specialty prime contractors and subcontractors.

B. All wiring shall be neatly tie wrap bundled (or as indicated otherwise on contract drawings) with wires parallel and perpendicular to device sides (i.e. no random angle wiring).

C. All related SO style or other control and power wiring related to the motorized units shall be strain relieved to structure (unless otherwise indicated).

D. Wiring Standards - Plenum Rated Cable: Unless specifically noted on the drawings, all low voltage wiring is to be CL2/CL3 wiring. Where specific plenum conduits exist, it has been noted to use a plenum rated cable. Where wiring runs occur in concealed spaces – walls, ceilings, etc. - and are not enclosed in conduit the EC must verify the space is not being used as a plenum path. Any areas encountered that are plenums must have plenum cable or the wiring must be contained in conduit rated for the plenum application. Field verify conditions prior to ordering or installing cabling.

E. All conduits indicated on the drawings shall terminate directly into racks, control panels, motor control junction boxes, wireways, etc. as shown – top, bottom or at any of the provided knockout locations (unless otherwise and specifically indicated on the drawings as otherwise) and so as not to obstruct access to the racks or adjacent walkways or approaches. Route conduits into devices with as few bends as possible – use sweep elbows where necessary. No loose or dangling or drooping wiring/cabling draped, dropped or festooned into the devices from dead-ended conduits or overhead cable tray systems shall be acceptable. All wiring shall be protected in conduit until it has reached the internal space of the indicated device(s).

F. ELECTRICAL & GROUNDING:

1. Grounding of shields and chassis will adhere to industry standard practice and as required by the rigging and motorized systems manufacturer.
2. Verify that all hot, neutral and ground conductors are tightened at least 5 days after initial installation and landing of line & load conductors.
3. Any AC service shall be installed by the EC to standard Edison U-Ground style outlets at the locations noted on the electrical drawings. Where racks are located the service is to be run to the interior of the rack. This service should be capable of powering all system equipment at 100% of rated power.
4. Internal rack AC distribution is the responsibility of the contractor. Acceptable methods: Rack mount power strips, rack mounted power distribution devices, Wiremold style outlet strip. All shall be provided by the contractor as needed.
5. Install all internal AC rack/device power with all switches and controls carrying hazardous voltage housed in steel enclosures within the rack. Provide positive electrical grounding for all steel enclosures. All AC service will incorporate separate hot, neutral and ground for each device. All grounds and neutrals will be appropriately bonded and connected to earth as required by codes and normal practice.

G. CONDUITS (OR ASSOCIATED RACEWAY/WIREWAY):

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

H. JUNCTION/GANG BOXES:

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

1.6 ASSEMBLY AND PRETEST:

A. All rigging equipment shall be assembled per manufacturer's instructions and tested prior to installation.

B. All controls and motorized elements shall be tested prior to installation.

1.7 FINISHES & CLEANING:

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

B. Cover any walls, furniture, finished floors and carpeted areas to catch all metal particles, grit, etc. that may occur during installation.

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

D. Provide thorough cleaning of all work areas including vacuuming, spray cleansers and dust removal as required. Clean all equipment fan filters before final acceptance tests.

E. Maintain clean work areas, removing all debris daily.

F. Finishes:
1. All welds (and the surrounding area) must be touched up by the contractor to match adjacent undisturbed finishes. No bare metal, unfinished welds, weld spatter or other welding debris, weld "heat" or scorch marks, etc. shall be allowed.
2. All finishes which are disturbed during shipping and installation shall be touched up to match the original.

G. Provide a thorough cleaning of all rigging system equipment and related devices, including but not limited to, blocks, pulleys, sheaves, battens, arbors, guide system, locking rail, FOH devices, catwalk pipes, rigid coves/positions, motorized devices/remotes/controls, misc. related cabinets, cable trays, pantographs, etc. regardless of status (new or existing to remain/reuse). Cleaning shall be after all dust/dirt creating work has been completed and just prior to walk-through/punch list and turnover to the owner.

H. No curtains shall be installed prior to the stage floor being swept and wet mopped by the rigging installer in order to remove all dirt, dust, misc. spilled items, etc. Alternatively, the rigging installer may cover the entire stage floor with a single layer (overlapped 12" as needed) of new, clean, heavy-duty, clear plastic prior to the installation of stage drapery (the rigging installer shall also be responsible for the removal and legal disposal of this covering as well as obtaining written permission by the owner, architect and/or construction manager to install it). Any curtains installed so that portions of the curtain drag across or touch the floor or become dusty, cob-webbed or soiled by any means during construction and prior to turning the room over to the owner shall be completely cleaned, repaired (if damaged) and retrimmed by the rigging contractor at no additional cost to the owner. The rigging contractor shall clean all dirt, dust, etc. from curtains that may have accumulated on them just prior to turning the room over to the owner.

I. The rigging contractor shall wipe clean (with a clean, damp cloth) all pantograph tracks, motorized truss, tormentor, Shakespeare, gallery, catwalk, rigid cove or any other pipe batten, pipe-style or ladder assemblies, motor control or operator control panels, stage pipe battens, remote control devices, locking rail, arbors, rope locks, index lighting system, floor blocks, tension floor pulleys, etc. just prior to turning the systems over to the owner. Upon cleaning, all items shall appear in as new condition and without scratches, blemishes, dirt, dust, debris, chalking, paint marks, etc. on them.

1.8 LABELING:

A. All labeling and signage shall comply with the requirements of the following recognized national standards, where such requirements can be implemented with rigging components, assemblies and systems:
   1. ANSI Z535.1-2006, Safety Color Code
   2. ANSI Z535.2-2006, Environmental and Facility Safety Sign
   3. ANSI Z535.3-2006, Criteria for Safety Symbols
   4. ANSI Z535.4-2006, Product Safety Signs and Labels

B. All signs or labels shall be in English. If operating personnel are not familiar with English, additional signs or labels in the appropriate language shall be permitted.

C. The working load limit, manufacturer's name or grade reference mark shall be permanently displayed on each piece of equipment and hardware. Chain, rope and wire rope shall be exempt from this requirement. If the hardware or equipment is size-specific

(e.g. wire rope clips), then the size shall be displayed on the product. Where permanent labeling or marking of individual components is impractical, then the load, manufacturer, or grade reference information shall be indicated in the system reference documents.

D. Pipe Grid Rigging Systems: There shall be labels attached to the pipe grid battens as indicated as to the intended per/LF. loading capacities for the pipe grid systems (this is typically noted as 20 lbs./LF, 40 lbs./LF, etc.).

E. Load Types Defined:
   1. Dead loads are those static forces that are relatively constant for an extended period of time. This includes typical structural elements like the pipe batten, trim chains, lift lines, turnbuckles and shackles, etc. These are items that are structurally related to the working mechanics of the sets.
   2. Live loads are typically unstable loads or loads that are moving. These are also sometimes called dynamic loads and typically include items such as fixtures, clamps, power supplies, curtains, speakers, hanging mics, etc. These are items that are taken off and put on battens on a semi-regular basis as the look, theme or focus of each show is restruck.
   3. Cyclic loads are typically moving loads that are associated with a motor. These loads would include those presented by the use of curtain draw machines, motorized winches, motorized trusses, moving lights, etc.

F. Any equipment requiring lubrication shall be identified in the maintenance manual stating quantity, type of lubricant and frequency of lubrication. Lubrication points shall be clearly indicated. Lubrication points shall be accessible without major disassembly of the related component.

G. A wall plaque/sign shall be placed on stage indicating standard rigging system operations and methods, as well as load capacities for the sets, basic system operation etc. See paragraphs below for additional and job specific safety signage requirements.

H. 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.

I. SIGNAGE:

   1. Provide safety signs for loading areas as indicated on the contract documents. See the TR series drawings for sample safety signage, verbiage, quantities, etc. Obtain owner desired installation location sign-offs, in writing, prior to installing signage. Signage information is to be job specific. Signage should include procedures for loading and unloading sets, curtains, electrics, etc. as well as standard safety and operational procedures. Specific load ratings shall be detailed for the system designed as indicated on the bid documents and may not exactly reflect the

information on the signage sample pictured below. Signage sample, text and title below is for illustrative purposes ONLY and does not include all job specific information or weight related data for this system that should appear on each sign. Signage sizes may be longer than noted below if more room for pertinent safety text is required; however, the signage size indicated is the MINIMUM size allowed. Signage to be printed with permanent, non-smudging ink. No smudges or high gloss surface treatments will be allowed. Contractor is to obtain specific weight related information and pertinent operational procedures for this system from bid drawings and manufacturer's recommendations and is to obtain weight stacking information from the architect and the designed load capacities of the stage floor at each weight stacking location. Spare weight stacking locations are TBD by the owner, architect or owner's representative. Contractor is to submit sample signage to the consultant for approval of text and information prior to ANY sign fabrication, ordering or installation. These signs are in addition to standard safety and operational signage that should be included. Contractor is to obtain exact signage locations and mounting heights from the architect, owner and any applicable codes relating to safety signage placement. Signs should be placed in locations where they will not be obstructed and are highly visible and readable. FOAM CORE SIGNAGE IS NOT ACCEPTABLE.

2. Provide custom "Rigging Inspections" signs that detail the ANSI E1.47-2017 "Entertainment Technology-Recommended Guidelines for Entertainment Rigging Systems" recommendations. Signage shall be similar to other safety signage for this project and per contract document details.
3. A sign shall be posted in an accessible location providing the name, address and phone number of the primary system contractor, manufacturer and supplier (if not already listed) of the system equipment.

1.9 RIGGING:

A. The following minimum standards apply in addition to the standards referenced elsewhere within this specification. These guidelines do not negate the standards referenced elsewhere within this specification. The standards indicated are minimum standards and do not supersede the requirements of the structural engineer to meet appropriate codes and standards.

B. All equipment not described as portable in this specification will be rigidly held in place.

C. All equipment will be supported at a minimum of three (3) points plus a backup. The contractor shall be responsible to provide backups as required, even if those backups do not appear in plans or on the detail drawings.

D. Each point shall be able to carry the entire rated load with a safety margin of at least five (5) times the rated load. All methods shall incorporate an independent safety backup with a safety margin of at least five (5) times the rated maximum load as installed in case of failure of any rigging component.

1. In the case of counterweight rigging systems, utilize industry standard practices for lift lines gauges and conform to all applicable codes.

E. All rigging and related fastening methods must be treated as permanent. All threads shall be treated with vibration compounds such as Vibratite or Loctite as per manufacturer's recommendations.

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

G. No chain of any type will be acceptable for the primary hanging or backup support of any equipment, unless specifically noted on the drawings. (Trim chains and fire curtain chains excepted)

H. No fabric devices, polyester roundslings, ratchet straps, webbing, wire mesh slings, wire rope core windings with fabric jackets, natural or synthetic corded or devices incorporating cam or buckle parts shall be considered as acceptable methods of hanging of any equipment excepting curtains.

I. No stainless-steel rope shall be secured with threaded compression type fittings alone. Compression type closures such as Nicopress with copper sleeves only must be utilized. All wire rope where connected to turnbuckles, trim chain or eyes will have strain relief/minimum bend radius thimbles installed. A go-no-go calibration toll must be on the job site and closures checked during installation.

J. All loose ends of the wire rope shall be neatly taped down after Nicopress is installed and crimped. No frayed rope ends shall be allowed under this specification.

K. The contractor shall be responsible for how installed devices (even those provided by others but intended to be used in conjunction with the related rigging equipment) affect any rigging related system he has provided and installed (i.e. rigid coves, pipe battens, FOH cove positions, balcony pipes, tormentors, catwalk battens, etc.). If devices provided by others causes battens or related structure, strut channel systems, etc. to bend, twist, warp, rotate, etc., then the contractor shall be responsible for all additional or replacement hardware, return visits and labor necessary in order to remedy any unnatural, abnormal or otherwise unacceptable anomalies and in order to bring the related rigging equipment pipes, strut channel, structure, etc. back into a standard, flush/plumb/level and non-rotating condition.

L. All Nicopress or equal compression connections and wire rope swaging products utilized on this project shall be required to pass field gauge tests as to their proper terminations and compression (typically referred to as go-no-go gauge tests). Due to the sheer quantity of manufacturer’s and the varying types/styles of compression tools in use, this will require the contractor to provide the proper go-no-go gauge during acceptance testing (punch list) for each different compression tool utilized on the project (typically a specific gauge is provided with each tool purchased). This gauge will be turned over to the consultant for use in verifying that the correct compression has been performed on the oval sleeves. It is understood that the consultant cannot test every single oval sleeve but will, instead, check a random percentage of sleeves that will be assumed to

be typical of all similar compression fittings on this project. It is the contractor's responsibility to verify, during installation, that every oval sleeve has been compressed properly and that it passes the go-no-go gauge test. Improperly swaged oval sleeves pose a serious risk to stage personnel. Improperly swaged oval sleeves shall be replaced by the contractor as required, even if that means that the associated wire rope and other related hardware must also be replaced.

M. All Nicopress 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. 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.

1.10 ROUGH-IN:

A. Due to small scale of Drawings, it is not possible to indicate all offsets, fittings, changes in elevation, etc. Verify final locations for rough-ins with field measurements and with the equipment being connected. Verify exact location and elevations at work site prior to any rough in work. DO NOT SCALE PLANS. If field conditions, details, changes in equipment or shop drawing information require a significant change to the original documents, contact the owners representative for approval before proceeding.

B. All equipment locations shall be coordinated with other trades to eliminate interference with required clearances for equipment maintenance and inspections.

C. Coordinate work with other trades and determine exact routing of all duct, pipe, conduit, etc., before fabrication and installation. Coordinate with Architectural Drawings. Verify with Owner's Representative exact location and mounting height of all equipment in finished areas, such as thermostats, fixtures, communication and electrical devices, including panels. Coordinate all work with the architectural reflected ceiling plans and/or existing Architecture. Mechanical and electrical drawings show design arrangement only for Diffusers, grilles, registers, air terminals, lighting fixtures, sprinklers, speakers and other items. Do not rough-in contract work without reflected ceiling location plans.

D. Before roughing for equipment furnished by Owner or in other contracts, obtain from Architect and other Contractors, approved roughing drawings giving exact location for each piece of equipment. Do not "rough in" services without final layout drawings approved for construction. Cooperate with other trades to insure proper location and size of connections to insure proper functioning of all systems and equipment. Obtain written authorization from the Owners representative or other contractor for any "rough ins" that, due to project schedule, are required before approved coordination drawings are available. Any work installed without written authorization or approved coordination drawings, causing a conflict will be relocated by the electrical contractor at no expense to the Owner.

E. For equipment and connections provided in this contract, prepare roughing drawings as follows:
   1. Existing equipment being relocated: Measure the existing equipment and prepare drawings for installation in new location.
   2. New equipment: Obtain equipment roughing drawings and dimensions, then prepare rough-in drawings.

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

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

1.11 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.

1.12 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.

1.13 PERFORMANCE:

A. All battens of similar trim (both high and low trims) must be even with each other +/- 1/16".

B. All studio battens shall be trimmed in such a way so that trim heights match those shown on contract drawings.

C. 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.

D. No battens shall be allowed to have threaded ends or threaded couplings at all.

E. No battens shall be allowed to have plug welded splices at all.

F. 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).

G. 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.

H. 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).

I. Final curtain presentation requirements:
   1. All curtains must be hung properly and per industry standards and shall not feature excessively long jack chains, tie offs, etc.
   2. All 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.

3. The bottom edge of all curtains shall be level with the studio floor for its entire length across the stage and shall not deviate from stage level more than 1/8″.
4. 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 a 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.

1.14 INITIAL POST COMPLETION TESTS & SET UP:

A. Verify that all studio supports have been properly installed, safety cabled, etc.

1.15 OWNER INSTRUCTION:

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

1.16 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.

1.17 QUALIFICATIONS OF TRAINERS:

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

1.18 SCHEDULING FOR TRAINING:

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

1.19 INITIAL TRAINING:

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

1.20 FOLLOW-UP SESSIONS:

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

1.21 VIDEO RECORDING OF TRAINING WITH OWNER – INITIAL TRAINING – FOR EACH STUDIO SPACE:

A. The camera should be placed on a tripod in a location that offers a good view of the rigging system, locking rail, arbors and any related equipment or controls. Lighting must be adequate for the video camera; provide portable lighting as needed.

B. Provide simple explanations of what each piece of equipment does, what would occur if a piece of rigging equipment failed, if the motorized portions (if present) were to be shut down, etc.

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

1.22 VIDEO RECORDING OF DEVICE TRAINING – SECONDARY TRAINING – FOR EACH STUDIO SPACE:

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

B. This second video training is to provide multiple levels of information:
   1. A walk around of the site should be video recorded that shows the owner where all primary lighting system equipment is located and what all related screens and indicator lights look like when everything is working properly.
   2. A walk to any power panels & disconnects feeding the system (motorized equipment, index lighting, etc.) and what breakers operate various power feeds and what their normal state looks like.
   3. For all motorized elements note the control boxes, their use and how to check for trouble status in controls.
   4. This video should include a discussion of the ANSI/ESTA standards for inspections, the frequency of inspections and the necessity to contact the installer if any motorized elements malfunction in any way.
   5. A quick start video guide for someone who has to use the system who has no idea how to do anything.

C. Video recording general requirements (applies to all):
   1. Convert each recording to standard formats for playback on Mac/PC based platforms and write to the devices as described below.
   2. Edit and title the final video training sessions into logical chapters so that an end user is quickly able to find what they need. The basis for titles, sections, etc. shall be the general content of all video training.

3. Provide an electronic file to the owner and owner's personnel that contains all relevant links to the manufacturer's video training series for basic, intermediate and advanced topics/functions.
4. Provide all training videos in DVD and USB stick formats.
5. On the USB stick, include a PDF document that contains the active links to the manufacturer's video training sessions and relevant sites.
6. In subsequent training sessions with the owner's personnel, higher level functions may be covered. Some owners will not require this, but others will. The contractor is not required to video record subsequent sessions. The owner can record any session they want for future reference using their own equipment.
7. Provide (1) one copy (brand new and not previously used) of the Stage Rigging Handbook (provide the latest edition) by Jay O. Glerum. This shall be turned over to the owner and used as the instructional text for training of the designated operators of the stage rigging equipment. This book shall remain with the owner as a reference manual.

1.23 WARRANTY AND SERVICE:

A. The contractor guarantees all equipment, materials, and workmanship to be free from defects for a period of one (1) year from owner acceptance. This warranty supersedes all manufacturers warranties for the one (1) year period. Any manufacturer's warranty that exceeds the one (1) year will continue to be applicable. The contractor will replace any defective materials at no charge to owner. Any equipment replaced during the one (1) year warranty will have a new one (1) year warranty to the owner.

B. The contractor guarantees all labeling to be free from defects for a period of two years from the date of owner acceptance. In cases where the label's adhesive fails, or the label suffers from degradation causing it to become unreadable, the label will be considered defective and will be replaced at no cost to the owner.

C. The contractor will respond by phone to requests for service within two (2) business hours and respond with a technician being sent (if needed) within one (1) business day.

D. Any equipment that tends to "drift" or whose performance deteriorates during the warranty period will be considered defective, even if such drifting is normal during break in. This equipment will be readjusted by the contractor at no additional charge to the owner.

E. Provide during the warranty period one (1) service inspection for preventive maintenance, at six (6) months after acceptance. This will include but not be limited to a full system operational and safety check and tightening of manila operating lines as required.

F. Provide all service at the owner's location regardless of any manufacturer warranty terms regarding carry in service.

G. INSPECTIONS:

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

1.24 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 test:
    a. The contractor shall inspect, completely verify and submit signed documentation that all system components meet all applicable current ANSI, ESTA & PLASA rigging standards as well as all of the performance criteria set forth within this specification.

B. PROCEDURE FOR SCHEDULING FINAL ACCEPTANCE:

1. The contractor shall notify the owner and consultant of a proposed date and time for the final acceptance tests. The contractor shall include two alternate dates and

times. The dates proposed will be a minimum of fourteen (14) calendar days from the date of the proposal.

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

C. DATE OF TESTS:

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

1.25 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. No rehearsals or other activities may take place during tests.

3. RIGGING SYSTEM – TYPICALLY TAKES 1 - 2 HOURS – FOR EACH STUDIO SPACE.

   a. Required attendance – Adequate Personnel from the rigging contractor to operate sets, answer specific system installation questions and verify all installation details.
   b. Curtains and all required lighting fixtures installed to battens.
   c. All sets installed level, true and plumb.
   d. All curtain tracks checked for end stops and binding on tracks.
   e. All cable drops for electrics properly dressed and not tangling during travel.
   f. Verification that all portable equipment has been delivered to the owner per specs and drawings. Portable equipment must be available for visual inspection as well.
   g. All Nicopress or equal compression sleeves have been properly swaged and tested by the contractor with a go-no-go gauge and found to comply with recognized standards and specification requirements.
   h. All curtains hung, clean, wrinkle-free & crease-free and with the proper documentation on site as to their flame-retardant characteristics.
   i. All shackles and turnbuckles properly moused with all wire ties clipped short and clean (with no protruding ends).
   j. All batten end caps installed.
   k. All standard and custom safety signage correct, site specific and properly installed in all locations called for in the written specifications.
   l. All cyc cove sections properly installed, finished, primed and painted.
   m. All ProMatte flooring properly installed.

1.26 CLOSEOUT DOCUMENTATION:

A. Contractor must submit the following items. All items should be part of the O&M Manual. Provide the quantity and form (paper and/or electronic) of these closeout documents as is indicated in the contract front-end documentation. Physical copies shall

only be required if front-end documentation requires them. If the owner requests physical copies, these shall be provided at an additional expense to the owner.

B. System testing documentation as required by final testing and acceptance procedures outlined in this document.

C. ALL paper copy O&M Manual submissions shall be in heavy-duty, D-Ring style, 3-Ring binders (provide size most appropriate for the quantity of paperwork included) with front plastic display pocket and internal side pockets. NO PAPER FOLDERS SHALL BE ALLOWED. All electronic copies shall be "bound" in an Adobe Acrobat style portfolio (see below for more complete information).

D. Complete technical manuals for all equipment installed.

E. List of serial numbers of all equipment installed and the specific location of each piece of equipment.

F. Warranty cards for all equipment or classes of equipment (if warranty cards exist, otherwise provide copies of the manufacturer's warranty policies).

G. Curtain flame resistance certificates.

H. Manufacturer MSDS sheets for all applicable equipment.

I. Operations & Maintenance Manuals shall NOT include any alternate languages or language sections unless specifically requested by the owner (i.e. French, Dutch, German, Spanish, Japanese, etc.)

J. Operations & Maintenance Manual: An operations and maintenance manual (or "Systems Manual") written in English. This manual should include, but is not limited to, the following (these items shall also be included in the system training and videotaping):
   1. A custom compiled simplified guide to standard rigging procedures, including, but not limited to, the following items:
      a. Industry standard procedures for the handling, loading and unloading of weights, battens, arbors and other pipes
      b. Make a clear effort to inform the owner (both during formal training and in the O&M Manuals) and to direct ALL operators to abide by the facility's "policy for working at height" and as is OSHA approved.
      c. The proper procedures for taking curtains down, protecting them from dirt & damage during this process, storing them properly and reinstalling them.
      d. How to properly load/offload fixtures from electric sets.
      e. Generally accepted stage practices regarding personnel on stage while sets are in use.
      f. The operation and intent of legs & rotator operation.
      g. A complete copy of manufacturer's furnished standard stage & counterweight rigging safety procedures.
      h. The minimum number of persons required for safely loading/unloading sets along with proper adult supervision requirements during major set changes (four on stage).

i. A set of blank rigging equipment inspection, maintenance and service log sheets (include as the first line item on each sheet the initial system installation, date, service performed, etc.
j. A sheet providing the name, address and phone number of the primary system installation contractor, manufacturer and supplier (if not already listed) of the system equipment, etc.
k. A simple list of any required periodic maintenance procedures that need to be performed on the rigging system (motorized hoists, counterweights or projection screen winch).

*See the training section below for the intents of training and any additional requirements.

2. A sheet showing the ratings, safety factors and load limits of each set and all individual system components (including dead hung, motorized and counterweight sets either on stage or in the main auditorium area).
3. A reduced size copy of each safety sign and the included verbiage – large enough to be read but still small enough to fit neatly into binder.
4. A complete reduced size set of the final print drawings of the installation ("as builts"), including field changes, routings, locations of sets, set numbering, installation details and other pertinent information.
5. A set of blank rigging equipment inspection, maintenance and service log sheets (include as the first line item on each sheet the initial system installation, date, service performed, etc. Each sheet shall include columns for the listing of date of service, person(s) performing service, service performed, additions or alterations to system or equipment, repairs performed, factory service tech service, etc. Log sheets shall be Microsoft Excel spreadsheet style sheets.
6. A sheet providing the name, address and phone number of the primary system installation contractor, manufacturer and supplier (if not already listed) of the system equipment, etc.
7. A sheet outlining the intents and usage of any supplementary auditorium pipe assemblies intended for the suspension of lighting instruments, including but not limited to tormentor, balcony, catwalk, gallery, cove or Shakespeare positions and the dangers involved in climbing or hanging from these assemblies (i.e. these structures should not be climbed – that is not their intent), proper access techniques, etc.
8. A sheet detailing a "show" operation overview – i.e. how an operator would set up a show, stage procedures on a dark stage, safety precautions and any required programming parameters.

   *See the training section below for the intents of training and any additional requirements.

K. The contractor must provide a letter to the owner upon completion of the installation and training work that all fabric/material utilized is flame retardant (or is FR per specifications) and that all system hardware and components have been installed per specifications and industry standard practices (note any approved digressions from

contract documents in a short, simple paragraph style format). No digression from industry standard installation practices and/or ANSI standard requirements shall be allowed.

L. The contractor must provide a copy of the "Certificate of Flame Resistance" to the owner for each type of curtain fabric used within the job. Each certificate should be complete and signed by the appropriate authority certifying its compliance with applicable fire codes – typically this is a sheet issued by the fabric manufacturer that states compliance with all appropriate NFPA regulations, etc. and is then filled out by the contractor as to the owner of the curtains, pattern and color of the fabric, the order and control numbers, date the order was processed, the contractor's invoice number and the yards processed for the fabrication of the stage curtains (some may even bear the official seal of a particular state and/or authorizing agency). Contractor sworn depositions or even duly witnessed and notarized sheets as to any particular fabric's flame-resistant characteristics is unacceptable as the contractor has no authority to make such statements.

M. A sheet detailing any maintenance procedures required for the equipment installed that is custom compiled and written by the contractor as well as a list of the specific tools required, user servicing guidelines, etc. related to serviceable devices.

N. The contractor shall provide the owner with complete instructions on maintaining the flame-resistant characteristics of any included fabrics, materials, etc. (e.g. the interval between flame retardant chemical applications) as well as the dangers involved in allowing third party vendors to apply flame retardant chemicals to IFR materials.

O. All users of the rigging system shall be instructed to read and thoroughly understand the information contained in the systems manual. Knowledge of the system-specific load capacities, operating instructions and maintenance schedules are important to establishing safe operating practices and should be understood by all users of the rigging systems and related components.

P. A DVD (or set of DVDs', depending on requirements listed below) that details the training of users on the owner's installed systems. See owner instruction section below.

Q. O&M Manual pdf requirements: The contractor shall provide a pdf copy (with appropriate titles) for each piece of documentation listed above and bound together in a pdf portfolio/binder, labeled 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 210523 - VALVES

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Provide labor, materials, equipment and services to perform operations required for the complete installation and related Work as required in Contract Document.

1.2 SUBMITTALS

A. Submit manufacturer's data in accordance with Basic Mechanical/Electrical Requirements. Obtain approval prior to ordering material.

B. Provide submittals for all items specified under Part 2 of this section.

PART 2 - PRODUCTS

2.1 VALVES

A. General: Valves shall have the following requirements:

1. Working pressure stamped or cast on bodies.

2. Stem packing serviceable without removing valve from line.

3. UL listed and FM approved and labeled for intended fire protection service. Sprinkler systems 175 WWP; standpipe/fire pumps 175 WWP; stamped/cast on body.

B. Acceptable Manufacturers:

1. Gate Valves: Kennedy, Mueller, Nibco, Stockham, Victaulic.

2. Butterfly/Ball Valves, Indicating Type: Grinnell, Kennedy, Milwaukee, Stockham, Victaulic.

3. Check Valves: Grinnell, Kennedy, Nibco, Stockham, Victaulic.

4. Wall and Post Indicator Valves: Grinnell, Kennedy, Mueller, Nibco, Stockham, Victaulic.

2.2 GATE VALVES

A. 2-1/2 in and Larger: IBBM, solid wedge disc, OS&Y, grooved ends, stems grooved for tamper switch, 250 WWP; Victaulic Series 771.

2.3 BUTTERFLY/BALL VALVE

A. 2-1/2 in. and Larger: Butterfly style, ductile iron body, ductile iron disc coated with EPDM, bubbletight shutoff, suitable for dead end service, gear operator, provision for tamper switch, grooved ends, 300 WWP; Victaulic Series 705W.

B. 2 in. and Smaller: Bronze body, threaded ends; indicating gear operator, provision for tamper switch; Milwaukee "Butterball".

2.4 CHECK VALVES

A. 2-1/2 in. and Larger: Ductile iron body, aluminum bronze or ductile iron disc coated with EPDM, stainless steel shaft and spring, grooved ends, 250 WWP; Victaulic Series 717.

B. 2 in. and Smaller: Bronze body, swing type, rubber faced, threaded ends; Grinnell #3315.

2.5 BACKFLOW PREVENTERS

A. Double Check Detector Assembly (3 in. and larger):

1. Cast iron body, stainless steel bolts and internal parts, removable bronze seats, epoxy coated.

2. Four (4) test cocks, OS&Y resilient wedge gate valves.

3. UL/FM listed and approved.

4. Same size as fire service.

5. Detector assembly consisting of an approved double check valve backflow preventer, approved water meter and shutoffs.

6. Design Equipment: Watts Series 709 DCDA.

7. Acceptable Manufacturers: Ames, Nibco, Watts, Wilkins or approved equal.

2.6 MISCELLANEOUS

A. Trim and Test Valves: Ball, plug, angle or globe type; bronze body; threaded ends; UL listed.

1. Ball Valves: Bronze two-piece body, full port, threaded ends, chrome plated ball, blowout proof stem, reinforced TFE seats, 300 psi working pressure, UL listed, FM approved; Nibco Model KT-585-70-UL.

B. Hose Thread Drain Valves:

1. Ball Valve: Bronze body, hardened chrome ball with hose thread end, cap and chain; Watts #B6001CC (sweat connection), Watts #B6000CC (threaded connection).

PART 3 - EXECUTION

3.1 INSTALLATION

A. Provide all shutoff, check, drain and other type valves as required by Code as indicated and as required for proper system maintenance, isolation and safety.

B. Locate valves for easy access and provide separate support where necessary. Install valves with stems at or above the horizontal position. Install swing check valves in horizontal position with hinge pin level.

C. Provide hose thread drain valves at all low points to enable complete drainage of all portions of the system.

D. For underground valves: Valve boxes shall be placed vertically over each valve, and the top of the box adjusted to proper grade, and the valve and box immediately backfilled with crushed stone carefully tamped into place. Valves shall be checked for proper operation before installation and, unless otherwise instructed are to be left in the open position.

E. Install valves per respective listing/approval.

F. Use 250 WWP, FM approved anti-water hammer check valves at discharge and bypass of fire pumps, otherwise use swing type.

G. Use ball valves for auxiliary drains and inspector test valves on dry pipe and pre-action systems.

3.2 BACKFLOW PREVENTERS

A. The backflow preventer(s) shall be installed in accordance with the Health Department approved drawings.

B. Prior to installation of backflow preventer(s), obtain the approved drawings from the Engineer.

C. Provide all necessary items to complete proper testing of work. Perform all testing in accordance with governing codes, local utilities and other agencies having jurisdiction and as specified. Pay all costs to perform tests. Perform all testing in a safe manner.

D. Upon completion of construction, all backflow prevention devices provided under this contract shall be tested. Tests shall be performed by a certified backflow preventer tester registered by the New York State Department of Health. Provide three (3) copies of Form DOH-1013 for each device with Part A completed by the tester. Submit forms to

Engineer. Pay all costs required for testing devices, including administrative costs associated with satisfying the requirements and regulations of Water Authority and Health Department. Repair or replace any device failing the test and repeat the test.

END OF SECTION 210523

SECTION 210553 - FIRE PROTECTION IDENTIFICATION

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Provide labor, materials, equipment and services as required for the complete installation designed in Contract Documents.

1.2 QUALIFICATIONS

A. All identification devices shall comply with ANSI A13.1 for lettering size, length of color field, colors, and viewing angles.

1.3 SUBMITTALS

A. Submit manufacturer's technical product data and installation instructions for each identification material and device. Submit valve schedule for each piping system typewritten on an 8-1/2 in. x 11 in. paper (minimum), indicating code number, location and valve function. Submit schedule of pipe, equipment and name identification for review before labeling.

1.4 ACCEPTABLE MANUFACTURERS

A. Allen Systems, Inc., Brady (W.H.) Co.; Signmark Div., Emedco, Industrial Safety Supply Co., Inc., Lab Safety Supply, Seton Name Plate Corp.

PART 2 - PRODUCTS

2.1 GENERAL

A. Provide manufacturer's standard products of categories and types required for each application. In cases where there is more than one type specified for an application, selection is installer's option, but provide single selection for each product category.

B. All adhesives used for labels in the interior of the building shall comply with the maximum Volatile Organic Compound (VOC) limits as called for in the current version of U.S. Green Building Council LEED Credits EQ 4.1 and EQ 4.2.

2.2 PIPING IDENTIFICATION

A. Identification Types:

1. Pressure sensitive type: Provide manufacturer's standard pre-printed, permanent adhesive, color coded, pressure sensitive vinyl pipe markers complying with ANSI A13.1. Provide a 360° wrap of flow arrow tape at each end of pipe label.

B. Lettering:

1. Piping labeling shall conform to the following list:

PIPE FUNCTION	IDENTIFICATION
Fire Protection Water	FIRE PROTECTION WATER
Fire Sprinkler Water	FIRE SPRINKLER WATER

2.3 VALVE IDENTIFICATION

A. Valve Tags:

1. Standard brass valve tags, 2 in. diameter with 1/2 in. high black-filled numerals. Attach to valve with brass jack chain and "S" hook. Identify between fire protection, heating and plumbing services with 1/4 in. letters above the valve number.

2. Equal to Seton Style No. M4507.

B. Provide a sign for each control, sectional and drain valve identifying the portion of the building served in accordance with NFPA 13

C. Valve Chart:

1. Provide valve chart for all valves provided as a part of this project. Frame and place under clear glass. Mount in Mechanical Room.

2.4 EQUIPMENT IDENTIFICATION

A. General:

1. Provide engraved vinyl nameplates for each major piece of mechanical equipment provided, 2-1/2 in. x 3/4 in. size.

2. Nameplates: Equal to Seton Style No. M4562.

2.5 ABOVE CEILING EQUIPMENT LOCATOR

A. 3/4 in. diameter adhesive stickers placed on ceiling grid and color-coded.

B. The color for all fire protection valves shall be RED.

PART 3 - EXECUTION

3.1 GENERAL

A. Provide valve tags for all valves provided on project.

B. Provide piping identification with directional flow arrows for all piping on project, maximum every 20'-0" or piping installed through rooms, provide at least one pipe label in each room, for each pipe function.

C. Provide equipment tags for all equipment provided.

END OF SECTION 210553

This page intentionally left blank

SECTION 211010 - PIPING SYSTEMS AND ACCESSORIES

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Provide labor, materials, equipment and services to perform operations required for the complete installation and related Work as required in Contract Documents.

1.2 SUBMITTALS

A. Provide a schedule of pipe materials, fittings and connections.

B. Provide a detailed matrix listing the specific UL approved firestop system assembly to be used for each type of piping provided and each type of construction to be penetrated along with all associated UL assembly details.

PART 2 - PRODUCTS

2.1 GENERAL

A. Pipe and fittings shall be new, marked with manufacturer's name and comply with applicable ASTM and ANSI Standards.

2.2 STEEL PIPING AND FITTINGS

A. Pipe: ASTM A53, or ASTM A106 seamless, Schedule 40 or Schedule 80 weight; black or galvanized finish as called for; ends chamfered for welding or grooved for grooved mechanical connections.

B. Fittings: Same material and pressure class as adjoining pipe.

1. Welded Fittings: Factory forged, seamless construction, butt weld type chamfered ends. Where branch connections are two or more sizes smaller than main size, use of "Weldolets", "Thredolets" or "Sockolets" acceptable. Mitered elbows, "shaped" nipples, and job fabricated reductions not acceptable unless specifically called for. Socket weld type, 2000 psi wp, where called for.

2. Threaded Fittings: Class 125, cast or malleable iron, black or galvanized, as called for; UL listed and FM approved for fire protection systems. Street type 45° and 90° elbows are not acceptable.

C. Flanges, Unions, and Couplings:

1. Threaded Connections:

a. Flanges: Cast iron companion type; for sizes 2-1/2 in. and larger.

b. Unions: Malleable iron, bronze to iron seat, 300 lb. wwp; for sizes 2 in. and smaller.

c. Couplings: Malleable iron. Steel thread protectors are not acceptable as couplings.

2. Welded Connections:

a. Flanges: Welding neck type. Slip-on type not allowed unless noted and shall not be installed in conjunction with butterfly valves.

3. Grooved Mechanical Connections:

a. Couplings: Ductile iron, ASTM A395 and ASTM A536, with painted coating, designed for rolled grooved piping, hot dipped galvanized finish complying with ASTM A153 where called for.

b. Gaskets: Grade "E" EPDM synthetic rubber, -30°F to 230°F temperature range, suitable for water service.

c. Bolts and Nuts: Heat treated, hex head carbon steel, ASTM A183, cadmium plated or zinc electroplated.

d. Fittings: Elbows, tees, laterals, reducers, adapters as required shall be ductile iron conforming to ASTM A395 and A536 Fittings shall have grooves designed to accept grooved end couplings of the same manufacturer.

e. Victaulic, rigid system, Style 005 couplings cast with offsetting angle pattern bolt pads to provide system rigidity and support in accordance with ANSI B31.1 and B 31.9. UL listed and FM approved; 300 psi wwp; follow all terms of listings/approvals.

f. Acceptable Manufacturers: Grinnell, Gruvlok by Anvil, Victaulic or approved equal.

D. Gauge and Instrument Connections: Nipples and plugs for adapting gauges and instruments to piping system shall be IPS brass.

2.3 THINWALL STEEL PIPE

A. Pipe: ASTM A53, or A135, with Schedule 10 wall thickness for 2-1/2 in. through 5 in.; 0.134 in. for 6 in. and 0.188 in. for 8 in. and 10 in.; black or galvanized finish as called for; roll grooved ends.

B. Fittings: Same construction as noted for steel pipe, ends roll grooved for grooved mechanical connections.

2.4 HANGERS, INSERTS AND SUPPORTS

A. Hangers, Inserts, Clamps: B-Line, Grinnell, Michigan Hanger, PHD Manufacturing.

B. Hangers:

1. Adjustable, wrought malleable iron or steel with electroplated zinc or cadmium finish. Copper plated or PVC coated where in contact with copper piping. Hot-dipped galvanized finish for exterior locations.

2. Adjustable ring type where piping is installed directly on hanger for piping 3 in. and smaller.

3. Adjustable steel clevis type for piping 4 in. and larger.

4. Nuts, washers and rods with electroplated zinc or cadmium finish. Hot-dipped galvanized finish for exterior locations.

C. Spacing Schedule (Maximum Distance between Hangers (ft.-in.):

NOMINAL PIPE SIZE (IN.)	**3/4**	**1**	**1-1/4**	**1-1/2**	**2**	**2-1/2**	**3**	**3-1/2**	**4**	**5**	**6**	**8**
Steel Pipe	N/A	12-0	12-0	15-0	15-0	15-0	15-0	15-0	15-0	15-0	15-0	15-0
Rod Size (in.)	3/8	3/8	3/8	3/8	3/8	3/8	3/8	3/8	3/8	1/2	1/2	1/2

D. Beam Attachments:

1. C-Clamp style, locknut, restraining strap, electroplated finish, UL listed, FM approved for pipe sizes 2 in. and smaller, complying with NFPA 13.

2. Center loaded style with clamp attachments that engage both edges of beam, electroplated finish, UL listed, FM approved, for pipe sizes larger than 2 in., refer to "Supports" for additional requirements, complying with NFPA 13

E. Inserts: Carbon steel body and square insert nut, galvanized finish, maximum loading 1300 lbs., for 3/8 in. to 3/4 in. rod sizes, reinforcing rods on both sides, MSS-SP-69 Type 19 or approved equal, complying with NFPA 13

F. Supports:

1. For all piping larger than 2 in., provide intermediate structural steel members for hanger attachment. Members shall span across the bar joists at panel points of joists. Secure member to structure. Select size of members based on a minimum factor of safety of four.

2. For weights under 1,000 lbs.: "Drill-In" inserts, "U" shaped Channel, beam clamps or other structurally reviewed support. The factor of safety shall be at least four. Follow manufacturer's recommendations.

3. For Metal Decks: Drill hole through for hanger rods and imbed a welded plate in concrete or use devices designed for this application, with a safety factor of four.

4. Acceptable Manufacturers: Hilti, ITW Ramset, Phillips "Red Head" or approved equal.

G. Hangers for fire protection piping as specified and in accordance with NFPA 13 and NFPA 14. Hangers and building attachments shall be UL listed and FM approved for fire protection service. Adjustable swivel ring type hangers are permitted for 3 in. and smaller piping.

2.5 PIPING ACCESSORIES

A. Escutcheon Plates: Steel or cast brass, split hinge type with setscrew, high plates where required for extended sleeves. Chrome plated in finished areas.

B. All bushings and nipples required for instruments and gauges shall be brass.

2.6 SLEEVES

A. Standard Type:

1. Schedule 40 black steel pipe sleeves for structural surfaces, two (2) pipe sizes larger than the pipe, and as recommended by the sealing element manufacturer. Provide full circle water stop collar for sleeves located within below grade walls, wet wells and waterproofed surfaces. The collar shall be fabricated from steel plate and welded to the sleeve around its entire circumference.

2. Schedule 40 PVC sleeves or sheet metal sleeves for nonstructural surfaces and existing construction. Sheet metal sleeves shall be 18 gauge minimum and braced to prevent collapsing.

2.7 SEALING ELEMENTS

A. Expanding neoprene link type, watertight seal consisting of interlocking links with zinc plated bolts.

1. Acceptable Manufacturers: Thunderline "Link-Seal" Series 200, 300 or 400, Pyropac, Calipco.

2.8 FIRESTOP SYSTEM FOR OPENINGS THROUGH FIRE RATED WALL AND FLOOR ASSEMBLIES

A. Materials for firestopping seals shall be listed by an approved independent testing laboratory for "Through-Penetration Firestop Systems". The system shall meet the standard fire test for Through-Penetration Firestop Systems designated ASTM E814. Firestop system seals shall be provided at locations where piping pass through fire rated wall, floor/ceiling, or ceiling/roof assembly. Minimum required fire resistant ratings of the assembly shall be maintained by the Firestop System. Installation shall conform to the manufacturer's recommendations and other requirements necessary to meet the testing laboratory's listing for the specific installation.

2.9 PIPING MATERIALS AND SCHEDULE

A. See Exhibit "A" - Piping Materials at end of this Section for Fire Protection piping.

B. See Exhibit "B" - Testing at end of this Section for Fire Protection piping.

PART 3 - EXECUTION

3.1 EQUIPMENT AND SYSTEMS

A. Install equipment and systems in accordance with provisions of each applicable section of these Specifications, and Local/State Codes/Regulations having jurisdiction. Accurately establish grade and elevation of piping before setting sleeves. Install piping without springing or forcing, except where specifically called for, making proper allowance for expansion and anchoring. Changes in size shall be made with reducing fittings. Reducing couplings are not acceptable. Arrange piping at equipment with necessary offsets, unions, flanges, and valves, to allow for easy part removal and maintenance. Offset piping and change elevation as required, to coordinate with other work. Avoid contact with other mechanical or electrical systems. Provide adequate means of draining and venting systems. Conceal piping unless otherwise called for.

B. Copper tubing shall be cut with a wheeled tubing cutter or other approved copper tubing cutter tool. The tubing must be cut square to permit proper joining with the fittings. Ream pipes after cutting and clean before installing.

C. Cap or plug equipment and pipe openings during construction. Install piping parallel with lines of building, properly spaced to provide clearance for insulation. Make changes in direction and branch connections with fittings. Do not install valves, unions and flanges in inaccessible locations. Materials within a system and between systems shall be consistent. If this is not possible, install dielectric fittings.

3.2 PIPING OVER ELECTRICAL EQUIPMENT

A. Contractor shall route piping to avoid installation directly over electric equipment, including, but not limited to panels, transformers, disconnects, starters, motor control center, adjustable speed drives and fused switches.

B. Piping shall not be installed in the dedicated electric and working space as defined by NEC 110. Dedicated electrical space is generally equal to the depth and width of electrical equipment, and extends 6 ft. above the electrical equipment, or to a structural ceiling. Dedicated working space is a minimum of 30 in. wide or the width of equipment (whichever is larger) a minimum of 6 ft.-6 in. tall, with a depth of 3ft. to 9 ft. depending on the voltage.

3.3 HANGERS, INSERTS AND SUPPORTS

A. Piping shall not be supported by wires, band iron, chains, from other piping, or by vertical expansion bolts. Support piping with individual hangers from concrete inserts, wood construction, welded supports, or beam clamps of proper configuration and loading design requirements for each location; replace if not suitable. Follow manufacturer's safe

loading recommendations. Suspend with rods of sufficient length for swing and of size called for, using four (4) nuts per rod. Provide additional structural steel members, having one coat rustproof paint, where required for proper support. Provide oversized hangers on diesel engine exhaust piping where insulation/supports must pass between pipe and hanger. Hangers, when attached to joists, shall only be placed at the top or bottom chord panel point. Only concentric type hangers are permissible on piping larger than 2-1/2 in.; "C" types are permitted for piping 2 in. and smaller on joists. Provide riser clamps for each riser at each floor.

3.4 PIPE CONNECTIONS

A. Threaded Connections: Clean out tapering threads, made up with pipe dope; screwed until tight connection. Pipe dope must be specifically selected for each application.

B. Grooved Mechanical Joints: Pipes joined with grooved fittings shall be joined by a listed combination of fittings, couplings, gaskets and grooves of a single manufacturer. Lubricate and install gasket and couplings. Follow manufacturer's recommendations. Grooved ends shall be clean and free of indentations, projections and roll marks in the area from pipe end to groove.

3.5 WELDING

A. Welding shall be performed in compliance with the welding procedure specifications prepared by the National Certified Pipe Welding Bureau. Welded piping fabricated by qualified welder. Use certified welder where specifically required by code or insurance company. If indicated and permitted for fire protection systems, all provisions for welded pipe shall additionally be in accordance with NFPA Standard 13. Use full length pipe where possible; minimum distance between welds, 18 in. on straight runs. Welds must be at least full thickness of pipe with inside smooth and remove cutting beads, slag and excess material at joints; chamfer ends. Minimum gap 1/8 in., maximum 1/4 in., for butt welds. Overlaps on position and bench welds to be not less than 3/4 in. One internal pass and one external pass minimum required on slip-on flanges. Do not apply heat to rectify distorted pipe due to concentrated welding; replace distorted pipe.

B. When welding galvanized pipe, apply cold galvanizing on joint following welding.

3.6 SLEEVES

A. Provide for pipes passing through floors, walls or ceilings. Not required for floors that are core-drilled, except where floor is waterproofed. Extend 1/8 in. above finished floor in finished areas. In above grade Mechanical Rooms and other areas with floor drains use steel pipe sleeves 2 in. above floor. Use steel pipe sleeves in bearing wall, structural slabs, beams and other structural surfaces, and where called for. Sleeves shall be as small as practical, consistent with insulation, so as to preserve fire rating. Fill abandoned sleeves with concrete. Provide rubber grommet seals for pipes passing through ducts or air chambers or built-up housings.

3.7 SLEEVE PACKING

A. Seal void space at sleeves as follows:

1. Interior locations: Firmly pack with fiberglass and caulk.

2. Exterior walls above grade: Use sealing element.

3. Exterior walls below grade and above floors: Use sealing element.

4. Cored holes: Use sealing element.

5. Fire rated, partitions and floor slabs: Use fire rated sealing elements, materials and methods. Provide per manufacturer's instructions to maintain firestop.

6. Waterproofed walls/floors: Use waterproof sealing element, device or compound.

3.8 ESCUTCHEON PLATES

A. Provide polished chrome setscrew type escutcheon plates for all exposed piping passing through floors, walls or ceilings, in all rooms except in Boiler, Fan and Mechanical Rooms.

3.9 TESTS

A. Fire suppression systems shall be hydrostatically tested at 200 psi for two (2) hours in accordance with NFPA 13 .

B. Provide all necessary items to complete proper testing of work. Perform all testing in accordance with governing Codes, local utilities and other agencies having jurisdiction and as specified. Pay all costs to perform tests. Perform all testing in a safe manner. Isolate existing systems.

3.10 PIPE LINE SIZING

A. Pipe sizes called for are to be maintained. Pipe size changes made only as reviewed by Owner's Representative and shall be justified by hydraulic calculations. Where discrepancy in size occurs, the larger size shall be provided.

EXHIBIT "A" - PIPING MATERIALS
(Note at end of Exhibit "A")

SERVICE	PIPE MATERIALS	FITTINGS	CONNECTIONS
Sprinkler (wet)	Schedule 40, black steel, 2 in. and smaller	Cast or malleable iron	Threaded
	"Thinwall" black steel, 2 in. and larger	Ductile iron	Roll grooved mechanical type couplings

NOTES FOR EXHIBIT A:

NOTE 1: Provide schedule 40 galvanized steel pipe and fittings for all aboveground exterior locations passing through exterior walls such as downstream of inspector's test and auxiliary drain valves, between fire department connection and associated check valve, and where called for.

EXHIBIT "B" - TESTING

SERVICE	TEST REQUIREMENTS
Sprinklers	Test hydrostatically at 200 psi for two (2) hours in accordance with NFPA 13.

END OF SECTION 211010

SECTION 211300 - FIRE SUPPRESSION SPRINKLER SYSTEMS

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Provide labor, materials, equipment and services to perform operations required for the complete installation and related Work as required in Contract Documents.

1.2 QUALITY ASSURANCE

A. Comply with the 2020 Fire Code of New York State referenced edition of the following National Fire Protection Association (NFPA) Standards:

1. NFPA 13: Standard for the Installation of Sprinkler Systems.
2. NFPA 24: Standard for the Installation of Private Fire Service Mains and Their Appurtenances.
3. NFPA 25: Inspection, Testing and Maintenance of Water-Based Fire Protection Systems.
4. NFPA 72: National Fire Alarm Code.
5. NFPA 241: Standard for Safeguarding Construction, Alteration and Demolition Operations.
6. NFPA 291: Recommended Practice for Fire Flow Testing and Marking of Hydrants.

B. Follow all requirements, recommendations and appendices to comply with the latest edition of the following publications, codes, standards, and listings/approvals:

1. Factory Mutual Engineering Corporation (FM) Approval Guide.
2. Underwriters Laboratories, Inc. (UL) Fire Protection Equipment Directory.
3. 2020 Fire Code of New York State.
4. OSHA Rules and Regulations.
5. Requirements of Insurance Underwriter and other Authorities Having Jurisdiction.

C. Equipment, devices, hangers and components shall be UL listed or FM approved and labeled for the intended fire protection service.

D. The fire protection work shall be performed by an experienced firm regularly engaged in the installation of fire protection sprinkler systems.

E. Preparation of working plans, calculations and site observation of systems shall be completed by a NICET Level III technician under the direction of a qualified New York State Registered Professional Engineer.

1.3 SYSTEM DESCRIPTION

A. The fire protection system shall be a wet pipe automatic sprinkler system arranged to properly protect.

B. Water is supplied from a municipal water main located in West Street, through a 6 in. underground water main to the system's main riser. Water supply data at the municipal main indicates the following:

1. 58 psi static.

2. 50 psi residual with 1060 gpm flowing.

C. The residual hydrant is located at West Street with the flow hydrant located at West Street. The flow test information above is submitted for information only. This contractor shall arrange for a new flow test on the municipal main prior to performing hydraulic calculations. The more restrictive of these two tests shall be used as the basis of design.

D. Fire department connection(s) shall be provided to allow the servicing fire department to augment the system's normal automatic water supply.

E. The system shall be hydraulically calculated in accordance with all provisions of the Contract Documents and any Authority Having Jurisdiction.

F. Use of room design method will not be permitted. Calculations shall be based upon the specific hazard for the areas being protected. The following minimum requirements shall be provided as actually installed in the protected spaces.

1. Light hazard: These areas shall include: Offices, bathrooms, cooridors, gyms, classrooms, and similar areas in accordance with NFPA 13

a. Water density: 0.10 gpm/sq. ft.

b. Maximum coverage per sprinkler = 225 sq. ft.

c. Hydraulic remote area: 1500 sq. ft.

d. Exterior hose demand: 100 gpm.

2. Ordinary Hazard Group 1: These areas shall include: Mechanical Rooms, Boiler rooms, Kitchen service areas and culinary classrooms, Storage rooms and similar spaces.

a. Water density: 0.15 gpm/sq. ft.

b. Maximum coverage per sprinkler = 130 sq. ft.

c. Hydraulic remote area: 1500 sq. ft.

d. Exterior hose demand: 250 gpm.

G. Maximum coverage for any sprinkler head shall not exceed NFPA requirements and the listing for the sprinklers provided.

H. A minimum 10**%** safety factor shall be provided between the available municipal water supply curve and the total system demand point. The total system demand point shall be at the municipal water main and include the calculated sprinkler and interior hose stream demands plus the exterior hose stream demand at the residual pressure required for proper system operation.

I. Water supply control valves shall be electrically supervised and mechanically locked for proper position. Waterflow and supervisory circuits shall be in accordance with the requirements of electrical specifications. Electric connections to sprinkler system shall be by Division 26. Furnish wiring diagrams for all equipment.

J. Provide 3/16 in. x 1 in. cadmium plated carbon steel chains and master keyed all brass case hardened padlocks to lock water supply valves in the proper position.

1.4 SUBMITTALS

A. Product Data:

1. Submit manufacturer's catalog cut, specifications and installation instructions for each item or component of fire protection system. Clearly indicate pertinent information such as, but not limited to:

a. Manufacturer's model number.

b. Materials, size, finish and type of connection.

c. Pressure ratings of components.

d. FM approval/UL listing.

B. Certification: Submit Contractor's NICET certification and number.

C. Samples:

1. If requested, submit sample of sprinklers.

D. Drawings and Calculations:

1. All drawings and calculations shall be signed and sealed by a New York State Registered Professional Engineer.

2. Submit complete NFPA 13 drawings and hydraulic calculations with cross reference to applicable drawings, water supply data, and equipment schedule with ratings for the system to the Owner's Representative, Insurance Underwriter, and other Authorities Having Jurisdiction.

3. Submit hydraulic calculations for each design density/remote area with items in NFPA 13 incorporated including sketches to indicate flow quantities, sprinklers operating and direction of flow for pipes in looped and gridded systems.

4. Drawing shall be fabrication drawings provided to indicate actual sprinkler, standpipe and equipment layouts. Drawings shall be 1/4" = 1'-0" scale on reproducible sheets of uniform size. Drawings shall show all data required by NFPA 13.

5. Submit drawings in one (1) complete package.

E. Record Drawings and Documents:

1. Submit Record Drawings, hydraulic calculations, test reports, and NFPA Above and Below Ground Material and Test Certificates to the Owner's Representative, Insurance Underwriter and other Authorities Having Jurisdiction.

PART 2 - PRODUCTS

2.1 GENERAL

A. Mixing of manufacturers or models of the same or similar component will not be acceptable.

2.2 FIRE DEPARTMENT CONNECTION

A. Cast brass; straight or angle body as required; two-way lug swivel inlets with individual drop clappers; cast brass; raised letter escutcheon labeled "AUTOSPKR"; matching brass plugs and chains.

1. 2-1/2 in. x 2-1/2 in. x 4 in.

2. 2-1/2 in. hose threads shall match those in use by the local Fire Department.

3. Polished chrome plated escutcheon, inlets, plugs, and chains.

4. Design Equipment:

a. Horizontal Flush Wall Type: Potter-Roemer 5020 Series.

2.3 PRESSURE GAUGES

A. Water Pressure Gauge:

1. Anodized aluminum case, 3-1/2 in. diameter, glass lens, brass movement, 1/4 in. NPT male bottom connection with gauge cock.

2. 0 to 300 psi range, in 5 psi increments with accuracy to meet ANSI B40.1.

2.4 SPRINKLERS AND ACCESSORIES

A. Brass or bronze, 1/2 in. orifice, 1/2 in. NPT. 165°F ordinary temperature classification for light and ordinary hazards. Use 286°F sprinklers in Mechanical, Electrical and Elevator Rooms; in vicinity of heat equipment/sources; and in accordance with NFPA 13.

1. Finished Ceiling Areas Concealed pendent sprinklers with matching cover plate, color as selected by Architect.

2. Unfinished Ceiling Areas: Natural brass/bronze finish pendent or upright sprinklers as required.

B. Sprinkler Types and Design Equipment:

1. Quick Response Pendent and Upright: Reliable Model F1FR.

2. Quick Response Concealed Pendent: Reliable Model G5A.

C. Flexible Sprinkler Drops:

1. FM Approved braided Type 304 stainless steel tube with union joints, factory tested to 400 psi and listed for up to three (3) 90° bends including bracket for mounting to ceiling or building structure.

a. Design Equipment: Victaulic "VicFlex".

D. Sprinkler Guards:

1. Steel wire cage with base plate and retaining clamps. Same manufacturer as sprinkler.

2. Design Equipment: Reliable Model C-1.

E. Sprinkler Cabinets and Spare Sprinklers:

1. Steel or aluminum construction with shelves and shell holes to accommodate the number of spare sprinklers required by NFPA 13.

2. Bright red finish with hinged front door and label.

3. Sprinkler wrenches compatible for each type used.

4. Spare sprinklers for each system of the type and proportion of those used in each system.

5. Design Equipment: Reliable Model A-4.

F. Acceptable Manufacturers: Reliable, Tyco, Victaulic, Viking or approved equal.

2.5 ALARM EQUIPMENT

A. Paddle Waterflow Detectors:

1. Adjustable retard feature, SPDT contacts, 24 volt DC, 250 psi rated.

2. Design Equipment: Potter Electric #VSR Series.

B. Tamper Switches:

1. Integral with valve or separate device installed on valve to actuate alarm upon valve movement, steel enclosure, SPDT contacts, 24 volt DC, mounting brackets and hardware.

2. Design Equipment: Potter Electric #OSYSU (for OS&Y valves) and #PIVSU-A (for post indicator and butterfly valves).

C. Acceptable Manufacturers: Autocall, Potter Electric, System Sensor or approved equal.

2.6 INSPECTOR'S TEST EQUIPMENT

A. Test and Drain Valve:

1. Combined test and drain valves, sight glass and interchangeable restricting orifice, sized for smallest orifice in sprinkler zone.

2. Design Equipment: AGF Manufacturing "Test and Drain".

3. Acceptable Manufacturers: AGF Manufacturing, Viking, Victaulic or approved equal.

2.7 SYSTEM COMPONENT IDENTIFICATION

A. At control, test and drain valves, provide permanently marked identification signs constructed of 18 gauge steel with baked enameled finish. The signs shall be permanently mounted on the piping or wall at the valve, or on the valve, but shall not be hung on the valve with wires or chains which permits easy removal of the sign. The sign shall clearly indicate the valve's purpose and what portion of the structure it serves. Additional signs, shall be provided at each alarm check and dry pipe valve to clearly indicate hydraulic calculation data.

2.8 ADDITIONAL SPRINKLERS AND SPRINKLER GUARDS

A. Include allowance for providing 10 additional sprinklers with related piping, fittings, hangers and 10 sprinkler guards installed at locations where job conditions or equipment selections may be required. Provide a credit for sprinklers and guards not installed.

PART 3 - EXECUTION

3.1 INSTALLATION

A. The nature of the work requires coordination with other trades. Shop fabrication shall be done at the Contractor's risk. Relocation of piping and components to avoid obstructions may be necessary. Relocation, if required, shall be done at the Contractor's expense. The installation shall be performed in a workmanlike manner as determined by the Owner's Representative and in accordance with the Contract Documents, manufacturer's printed installation instructions, and submitted and Owner's Representative reviewed drawings.

B. Piping shall not pass directly over electric panelboards, switchboards, motor control centers, and similar electric and telephone equipment. However, protection for these spaces shall be provided.

C. Piping shall be installed concealed above finish ceiling area with sprinklers located in the center of ceiling tiles where ceiling tiles are used.

D. Provide a readily removable flushing connection consisting of a cap at each end of cross mains.

E. Provide sprinkler guards for sprinklers in mechanical and storage spaces, less than 8 ft. above finished floor subject to mechanical damage.

F. Pipe ball drip valves at a floor drain or to the exterior. Pipe 2 in. main drains and water motor gong drains to discharge to the exterior at approximately 2 ft. above finished grade.

G. Securely install the spare sprinkler cabinets to the building wall at the main riser.

H. Inspector's test valves auxiliary drains shall be installed 7 ft. or less above the finished floor.

I. Fire department connections shall be installed 3 ft. above finished grade and water motor gongs approximately 10 ft. above finished grade.

J. Upright sprinklers directly on branch lines shall be installed with their frame parallel to the piping.

K. Provide sprinkler protection under ductwork, groups of ductwork and other obstructions to water spray and distribution. Use intermediate level sprinklers if subject to waterspray from above.

L. Exposed pipe shall be left clean for painting.

M. Coordinate and activate the systems or portions of the system to operational status as soon as possible.

3.2 PIPING, VALVES AND HANGERS

A. Refer to other applicable sections.

B. All piping shall be installed to permit drainage of the system through a main drain valve. Where a change in piping direction prevents drainage of the system, auxiliary drains shall be provided. The auxiliary drain assembly shall consist of a lockable ball valve, nipple and cap or plug and shall be located 7 ft. or less above the finished floor. Pipe drain to an accessible location.

3.3 TESTS

A. General:

1. Pipe installation shall be inspected by Owner's Representative prior to being covered by building construction or backfill.

2. Give the Owner's Representative advance notice of final tests. Perform tests in a safe manner. Provide written certification that tests have been successfully completed. Use NFPA Above and Below Ground Material and Test Certificate Forms.

3. Correct system leaks prior to final test. Do not utilize water additives, caulking, etc. to correct leaks. Provide appliances, equipment, instruments, devices and personnel.

4. Flushing: Follow Contract Documents and utilize open end pipe sections if possible.

B. Pressure Tests:

1. Hydrostatic Tests: Minimum 200 psi and in accordance with NFPA 13 for two (2) hours.

a. Air test not accepted as final test.

2. Do not subject existing systems to excess pressures.

C. Alarm Tests:

1. Demonstrate activation of alarms

3.4 SYSTEM TURNOVER

A. Prior to final acceptance, instruct the Owner's Representative in the proper operation, maintenance, testing, inspection and emergency procedures for all systems furnished, for a period of time as needed. Provide one (1) new original pamphlet of NFPA 25. Indicate in writing to the Owner's Representative the provisions for proper maintenance, testing, and inspection of the systems as required by local fire codes.

END OF SECTION 211300

SECTION 220523 - VALVES

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Provide labor, materials, equipment and services to perform operations required for the complete installation and related Work as required in Contract Document.

1.2 SUBMITTALS

A. Submit manufacturer's data in accordance with Basic Mechanical and Electrical Requirements. Obtain approval prior to ordering material.

B. Provide submittals for all items specified under Part 2 of this section.

PART 2 - PRODUCTS

2.1 VALVES - GENERAL

A. Valves shall have following requirements:

1. Working pressure stamped or cast on bodies.

2. Stem packing serviceable without removing valve from line.

3. All items here-in used to convey water for potable use shall be lead free in accordance with NSF Standard, Standard 61, Section 9 - Standard for Drinking Water and Lavatory Faucets and NSF Standard 372 - Maximum Lead Requirements. Compliance shall be via third party testing and certification.

B. Acceptable Manufacturers:

1. Thermostatic Balance Valves: Caleffi, Bell & Gossett, ThermOmegaTech

2. Ball Valves: Apollo, Hammond, Milwaukee, Nibco, Red White, Watts.

3. Butterfly Valves: Bray, Jamesbury, Keystone, Milwaukee, Red White, Watts.

4. Gate and Check Valves: Hammond, Milwaukee, Nibco, Red White, Stockham, Watts.

5. To establish a standard of quality and identify features, certain manufacturer's numbers are given in the following paragraphs.

2.2 DOMESTIC WATER VALVES

A. Gate Valves:

1. 4 in. and Larger, Cold Water Service: Epoxy coated, resilient wedge, OS&Y, flanged ends, 175 wwp, UL/FM; Watts 408 RW.

B. Check Valves:

1. 3 in. and Larger: IBBM, renewable seat and disc, bolted flange cap, flanged ends, 125 SWP; Milwaukee F-2974.

2. 2 in. and Smaller: Lead-free swing check with silicone bronze body, bonnet and trim, PTFE disc seat and stainless steel seat disc washer, 200 psi working pressure, Nibco T-413-Y-LF (threaded) or Nibco's S-413-Y-LF (solder).

3. Silent Type: Lead-free spring check with silicone bronze body, stainless steel trim and PTFE disc: 250 psi working pressure; Nibco T-480-4-LF (threaded) or Nibco S-480-Y-LF (solder).

C. Ball Valves:

1. 2-1/2 in. and Larger: Lead-free, forged copper silicon 2-piece body, chrome plated brass ball, full port, teflon seats and stem packing, separate packing and handle nut, blowout proof stem extended for insulation, vinyl insulator for handle, 600 WOG, 125 WSP; Watts LF-FBV-3C Series (threaded ends) or Watts LF-FBVS-3C series (sweat ends).

2. 3in.and Smaller: Lead-free, forged copper silicon alloy 2-piece body, chrome-plated lead-free brass ball, full port, teflon seats and stem packing, separate packing and handle nut, blowout proof stem extended for insulation, vinyl insulator for handle, 400 WOG, 125 WSP; Watts LFFBV-3C-M1 Series (threaded ends) or Watts LFFBVS-3C-M1 series (sweat ends).

D. Thermostatic Balance Valves:

1. 2 in. and Smaller: stainless steel, rated for 200 PSIG working pressure and 250°F max. temperature, have a fixed, non-adjustable (tamper proof) temperature setpoint; temperature setpoints range from 80°F to 170°F in 5°F increments. The valve shall have a temperature accuracy of ±3.0°F, and shall have a wax thermostatic element. ThermOmegaTech CircutSolver Series.

2.2 GAS VALVES

A. Ball Valves:

1. 2 in. and Smaller: Ball type, two-piece, full port, brass body with chrome plated brass ball, teflon seats, threaded ends, 600 psi WOG, UL listed for natural gas, Watts FBV-3C-UL.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Provide all shutoff, check, balancing and other type valves as indicated, as required by Code and as required for proper system maintenance, isolation and safety. Provide at major building and systems sections. Provide shutoff valves on all branch lines serving

two fixtures or more, at all equipment, fixtures, before and after automatic control valves, and at future connections.

B. Locate valves for easy access and provide separate support where necessary. Install valves with stems at or above the horizontal position. Install swing check valves in horizontal position with hinge pin level.

C. Provide drain valves with hose thread connections on all equipment. Provide hose thread drain valves at all low points to enable complete drainage of all piping systems including, water mains, branches, at base of vertical risers and at strainers.

D. Provide shutoff valve and wye-strainer before all automatic control valves and pressure reducing valves.

E. Inspect valves for proper operation before installation. Install underground valve boxes vertically over each valve. Adjust top of box to proper grade. Immediately backfill with crushed stone and carefully tamp into place. Unless otherwise noted, leave in the open position.

3.2 DOMESTIC WATER SYSTEM

A. The main water service shutoff valve inside the building and valves for a 3 in. and larger water meter assembly shall be OS&Y gate valves in accordance with the local water authority requirements.

B. Install balance valves in each hot water circulation branch and where noted.

3.3 NATURAL GAS SYSTEM

A. Ball valves shall be UL listed for use in natural gas systems, or certified by another acceptable third-party testing agency.

END OF SECTION 220523

This page intentionally left blank

SECTION 220553 - PLUMBING IDENTIFICATION

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Provide labor, materials, equipment and services as required for the complete installation designed in Contract Documents.

1.2 QUALIFICATIONS

A. All identification devices shall comply with ANSI A13.1 for lettering size, length of color field, colors, and viewing angles.

1.3 SUBMITTALS

A. Submit manufacturer's technical product data and installation instructions for each identification material and device. Submit valve schedule for each piping system typewritten on an 8-1/2 in. x 11 in. paper (minimum), indicating valve number, location and valve function. Submit schedule of pipe, equipment and name identification for review before stenciling or labeling.

1.4 MAKES

A. Allen Systems, Inc., Brady (W.H.) Co.; Signmark Div., Industrial Safety Supply Co., Inc., Seton Name Plate Corp.

PART 2 - PRODUCTS

2.1 GENERAL

A. Provide manufacturer's standard products of categories and types required for each application. In cases where there is more than one type specified for an application, selection is installer's option, but provide single selection for each product category.

B. All adhesives used for labels in the interior of the building shall comply with the maximum Volatile Organic Compound (VOC) limits as called for in the current version of U.S. Green Building Council LEED Credits EQ 4.1 and EQ 4.2.

2.2 PIPING IDENTIFICATION

A. Identification Types:

1. Pressure Sensitive Type: Provide manufacturer's standard pre-printed, permanent adhesive, color coded, pressure sensitive vinyl pipe markers complying with ANSI A13.1. Provide a 360° wrap of flow arrow tape at each end of pipe label.

B. Lettering:

1. Piping labeling shall conform to the following list:

PIPE FUNCTION	IDENTIFICATION
Cold Water	DOMESTIC COLD WATER
Hot Water	DOMESTIC HOT WATER
Hot Water Recirculating	DOMESTIC HOT WATER RECIRCULATING
140 Degree Hot Water	DOMESTIC HOT WATER - 140°F
140 Degree Hot Water Recirculating	DOMESTIC HOT WATER RECIRCULATING - 140°F
Sanitary Waste	SANITARY WASTE
Indirect Waste	INDIRECT WASTE
Storm	STORM
Vent	VENT
Pump Discharge	PUMP DISCHARGE
Natural Gas	NATURAL GAS
Compressed Air	COMPRESSED AIR

2.3 VALVE IDENTIFICATION

A. Valve Tags:

1. Standard brass valve tags, 2 in. diameter with 1/2 in. high black-filled numerals. Attach to valve with brass jack chain and "S" hook. Identify between heating and plumbing services with 1/4 in. letters above the valve number.

2. Acceptable Manufacturers: Seton Style No. M4507, or approved equal.

B. Valve Chart:

1. Provide valve chart for all valves provided as a part of this project. Frame and place under clear glass. Mount in Mechanical Room.

2.4 EQUIPMENT IDENTIFICATION

A. General:

1. Provide engraved vinyl nameplates for each major piece of mechanical equipment provided, 2-1/2 in. x 3/4 in. size.

2. Acceptable Manufacturers: Seton Style No. M4562, or approved equal.

2.5 ABOVE CEILING EQUIPMENT LOCATOR

A. 3/4 in. diameter adhesive stickers placed on ceiling grid and color-coded.

B. The color for all plumbing valves shall be BLUE.

PART 3 - EXECUTION

3.1 GENERAL

A. Provide valve tags for all valves provided on project.

B. Provide equipment tags for all equipment provided on project.

C. Provide piping identification with directional flow arrows for all piping on project, maximum intervals of 20'-0". For piping installed through rooms, provide at least one (1) pipe label in each room, for each pipe function.

END OF SECTION 220553

This page intentionally left blank

SECTION 220593 - ADJUSTING AND BALANCING

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Provide labor, materials, equipment and services to perform operations required for complete adjusting and balancing Work as required in Contract Documents.

1.2 SUBMITTALS

A. Provide information in report form listing items required by specifications. Report shall be typed and three copies submitted for review. Results shall be guaranteed. Contractor shall be subject to recall to site to verify report information before acceptance of the report by the Owner's Representative.

B. Report format shall consist of the following:

1. Title sheet with job name, contractor, engineer, date, balance contractor's name, address, telephone number and contact person's name and the balancing technician's name.

1.3 QUALIFICATIONS

A. Follow procedures and methods published by one or more of the following:

1. Individual manufacturer requirements and recommendations.

B. Maintain qualified person at project for system operation, trouble shooting and perform mechanical adjustments in conjunction with balancing procedure.

C. Balancing contractor shall be current member of AABC or NEBB.

1.4 GENERAL REQUIREMENTS

A. Before concealment of systems visit the job site to verify and advise on type and location of balancing devices and test points. Make changes as required to balancing facilities.

B. Place systems in satisfactory operating condition.

1. Adjusting and balancing shall be accomplished as soon as the systems are complete and before Owner takes possession.

2. Prior to balancing adjust balancing devices for full flow; fill, vent and clean hydronic systems, replace temporary strainers.

3. Initial adjustment and balancing to quantities as called for or as directed by the engineer, to satisfy job conditions.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS

A. Provide tools, ladders, recording meters, gauges, thermometers, velometers, anemometers, inclined gauge manometers, magnehelic gauges, amprobes, voltmeters, psychrometers and tachometers required. Instruments used shall be accurately calibrated as per AABC or NEBB requirements.

PART 3 - EXECUTION

3.1 PREPARATION

A. Examine Bid Documents and notify Owner's Representative of any questions regarding balancing, within thirty (30) days after receipt of bid and prior to starting work.

3.2 WATER SIDE

A. Test, adjust and record the following:

1. Hot Water Recirculating Pump:

a. Check rotation
b. GPM
c. Running suction pressure
d. Running discharge pressure
e. Running load amps
f. RPM - motor
g. Complete nameplate motor and pump

2. Thermostatic Balancing Valves:

a. Ensure every valve set to 5°F below supply temperature, unless otherwise noted.

END OF SECTION 220593

SECTION 220700 - INSULATION

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Provide labor, materials, equipment and services to perform operations required for the complete installation and related Work as required in Contract Documents.

1.2 SUBMITTAL

A. Shall include product description, manufacturer's installation instructions, types and recommended thicknesses for each application, and location of materials.

PART 2 - PRODUCTS

2.1 GENERAL

A. Insulation, jackets, adhesive, and coatings shall comply with the following:

1. Treatment of jackets or facing for flame and smoke safety must be permanent. Water-soluble treatments not permitted.

2. Insulation, including jackets, finishes and adhesives on the exterior surfaces of pipes and equipment, shall have a flame spread rating of 25 or less and a smoke developed rating of 50 or less.

3. Asbestos or asbestos bearing materials are prohibited.

4. 2020 Energy Conservation Code of New York State**.**

5. All adhesives and sealants used for insulation in the interior of the building shall comply with the maximum Volatile Organic Compound (VOC) limits as called for in the current version of U.S. Green Building Council LEED Credits EQ E4.1 and EQ E4.2.

6. Provide materials which are the standard products of manufacturers regularly engaged in the manufacture of such products and that essentially duplicate items that have been in satisfactory use for at least two (2) years prior to bid opening. Provide insulation systems in accordance with the approved MICA or NAIMA Insulation Standards.

7. Insulation shall be clearly marked with manufacturer's name, identification of installed thermal resistance (R) value, out-of-package R value, flame spread and smoke developed indexes in accordance with Energy Code requirements.

2.2 ACCEPTABLE MANUFACTURERS

A. Fiberglass: Knauf, Johns Manville, Owen-Corning, Certainteed.

B. Polyisocyanurate: Dow Trymer 2000XP, HyTherm.

C. Calcium Silicate: Industrial Insulation Group (ILG).

D. Flexible Elastomeric: Armacell, K-Flex.

E. Adhesives: Childers Products, Foster.

F. Heat Tracing: Raychem, Thermon.

2.3 PIPE INSULATION (RIGID FIBERGLASS TYPE)

A. Product meeting ASTM C 547, ASTM C 585, and ASTM C 795; rigid, molded, noncombustible.

B. 'K' Value: ASTM C 335, 0.23 at 75°F mean temperature. Maximum Service Temperature: 1000°F.

C. Vapor Retarder Jacket: ASJ/SSL conforming to ASTM C 1136 Type I, secured with self-sealing longitudinal laps and butt strips.

D. Field-Applied PVC Fitting Covers with Flexible Fiberglass Insulation: Proto Corporation 25/50 or Indoor/Outdoor, UV-resistant fittings, jacketing and accessories, white or colored. Fitting cover system shall consist of pre-molded, high-impact PVC materials with blanket type fiberglass wrap inserts. Blanket fiberglass wrap inserts shall have a thermal conductivity ('K') of 0.26 at 75°F mean temperature. Closures shall be stainless steel tacks, matching PVC tape, or PVC adhesive per manufacturer's recommendations.

E. Prefabricated Thermal Insulating Fitting Covers: Comply with ASTM C 450 for dimensions used in pre-forming insulation to cover valves, elbows, tees, and flanges.

2.4 PIPE INSULATION (RIGID POLYISOCYANURATE TYPE)

A. Preformed Rigid Polyisocyanurate Insulation: Cellular foam complying with ASTM C591, rigid molded, non-combustible. 2-lb./ft^3 nominal density. Maximum thermal conductivity (k) shall be 0.19 BTU-in/ft^2 hr. °F at 75°F mean temperature.

2.5 CALCIUM SILICATE

A. Flat-, curved- and grooved-block sections of noncombustible, inorganic, hydrous calcium silicate with a non-asbestos fibrous reinforcement. Comply with ASTM C 533, Type II, rated for a maximum temperature of 1700 degree F.

2.6 FIELD-APPLIED JACKETS

A. Piping:

1. PVC Pipe Jacket: High-impact, ultraviolet-resistant PVC; 30 mils thick; 25 or less flame spread rating/50 or less smoke developed rating, roll stock ready for

shop or field cutting and forming. Adhesive: As recommended by insulation material manufacturer. PVC Jacket Color: White.

2.7 COATINGS, MASTICS, ADHESIVES AND SEALANTS

A. Vapor Barrier Coatings: Used in conjunction with reinforcing mesh to coat insulation on below ambient services temperatures. FOSTER 30-80 AF. COATING SHALL MEET ASTM D 5590 WITH 0 GROWTH RATING. MAXIMUM PERM RATING OF 0.08 PERMS OR LESS AT 37 MILS DRY TESTED AT 100°F (38°C) AND 90% RH PER ASTM F1249 Lagging Adhesives: Used in conjunction with canvas or glass lagging cloth to protect equipment/piping indoors. Foster 30-36 Sealfas; Childers CP-50AMV1 Chil Seal, or approved equal.

B. Weather Barrier Mastic: Used outdoors to protect above ambient insulation from weather. Foster 46-50 Weatherite; Childers CP-10 Vi Cryl, or approved equal.

C. Fiberglass Adhesive: Used bond low density fibrous insulation to metal surfaces. Shall meet ASTM C916 Type II. Foster 85-60; Childers CP-127, or approved equal.

D. Elastomeric Insulation Adhesive: Used to bond elastomeric insulation. Foster 85-75; Childers CP-82, or approved equal.

E. Elastomeric Insulation Coating: Water based coating used to protect outside of elastomeric insulation. Foster 30-65, Childers CP-34 or approved equal.

F. Insulation Joint Sealant: Used as a vapor sealant on below ambient piping with polyisocyanurate and cellular glass insulation. Foster 95-50; Childers CP-76, or approved equal.

G. Metal Jacketing Sealant: Used as a sealant on metal jacketing seams to prevent water entry. Foster 95-44; Childers CP-76, or approved equal.

H. Reinforcing Mesh: Used in conjunction with coatings/mastics to reinforce. Foster Mast A Fab; Childers Chil Glass #10, or approved equal.

2.8 PIPE SUPPORT INSULATION INSERTS

A. 20 lbs./cu. ft. molded fiberglass, for -120°F to +450°F service temperature, non-combustible, 0.30 thermal conductivity (k), same thickness as pipe insulation.

B. Acceptable Manufacturers: Hamfab "H" Block, or approved equal.

2.9 MATERIALS AND SCHEDULES

A. See Exhibits at the end of this section.

PART 3 - EXECUTION

3.1 GENERAL REQUIREMENTS

A. All materials shall be installed by skilled labor regularly engaged in this type of work. All materials shall be installed in strict accordance with manufacturer's recommendations, building codes, and industry standards.

B. Locate insulation and cover seams in the least visible location. All surface finishes shall be extended in such a manner as to protect all raw edges, ends and surfaces of insulation. No glass fibers shall be exposed to the air.

C. All pipe insulation shall be continuous through hangers, sleeves, walls, ceiling, floor, or roof openings, unless not allowed by fire stop system. Refer to Sections 220500, "Basic Plumbing Requirements" and 221010, "Piping Systems and Accessories" for firestop systems.

D. Provide thermal insulation on clean, dry surfaces and after piping and equipment (as applicable) have been tested. Do not cover pipe joints with insulation until required tests are completed.

E. All cold surfaces that may "sweat" must be insulated. Vapor barrier must be maintained; insulation shall be applied with a continuous, unbroken moisture and vapor seal. All hangers, supports, anchors, or other projections that are secured to cold surfaces shall be insulated and vapor sealed to prevent condensation. Cover valves, fittings and similar items in each piping system with insulation as applied to adjoining pipe run. Extra care must be taken on piping appurtenances to insure a tight fit to the piping system. For piping systems with fluid temperatures below ambient, all vapor retarder jacket (ASJ) seams must be coated with vapor barrier coating. All associated elbows, fittings, valves, etc. must be coated with vapor barrier coating and reinforcing mesh to prevent moisture ingress. Valve extension stems require Elastomeric insulation that is tight fitting to the adjoining fiberglass system insulation. Pumps, strainers, drain valves, etc. must be totally encapsulated with Elastomeric insulation.

F. Items such as manholes, handholds, clean-outs, plugged connections, pet cocks, air vents, ASME stamp, and manufacturers' nameplates, may be left un-insulated unless omitting insulation would cause a condensation problem. When such is the case, appropriate tagging shall be provided to identify the presence of these items. Provide neatly beveled edges at interruptions of insulation.

G. Provide protective insulation as required to prevent personal injury.

H. All pipes shall be individually insulated.

I. If any insulation material becomes wet because of transit or job site exposure to moisture or water, the contractor shall not install such material, and shall remove it from the job site.

J. All exposed surfaces shall be white, unless noted otherwise.

3.2 PIPE INSULATION

A. Insulate piping systems including fittings, valves, flanges, unions, strainers, and other attachments installed in piping system, whether exposed or concealed

B. Insulation installed on piping operating below ambient temperatures must have a continuous vapor retarder. All joints, seams and fittings must be sealed. Insulation shall be continuous through hangers on all water piping and storm water piping.

C. Hanger Shields: Refer to Section 221010 "Piping Systems and Accessories".

D. Hanger shields shall be installed between hangers or supports and the piping insulation. Rigid insulation inserts shall be installed as required between the pipe and the insulation shields. Inserts shall be of equal thickness to the adjacent insulation and shall be vapor sealed as required.

1. Pre-Insulated Type: Butt insulation to hanger shields and apply a wet coat of vapor barrier cement to the joints and seal with 3 in. wide vapor barrier tape.

2. Field Insulated Type: Provide Hamfab Co. "H" blocks per manufacturers recommended spacing between pipe and shield.

3. Tape shields to insulation.

E. Joints in section pipe covering made as follows:

1. All ends must be firmly butted and secured with appropriate butt-strip material. On high-temperature piping, double layering with staggered joints may be appropriate. When double layering, the inner layer should not be jacketed.

2. Standard: Longitudinal laps and butt joint sealing strips cemented with white vapor barrier coating, or factory supplied pressure sensitive adhesive lap seal.

3. Vapor Barrier: For cold services, Longitudinal laps and 4 in. vapor barrier strip at butt joints shall be sealed with white vapor barrier coating. Seal ends of pipe insulation at valves, flanges, and fittings with white vapor barrier coating.

F. Fittings, Valves and Flanges:

1. Domestic Hot and Cold Water: Premolded fitting insulation of the same material and thickness as the adjacent pipe insulation.

2. White PVC jacketing, with continuous solvent weld of all seams. Tape all fittings.

G. Flexible Pipe Insulation:

1. Split longitudinal joint and seal with adhesive.

2. Fittings made from miter-cut pieces properly sealed with adhesive, or elbows may be continuous.

H. Apply PVC jacket where indicated, with 1 in. overlap at longitudinal seams and end joints. Seal with manufacturers recommended adhesive.

I. Apply either aluminum or PVC jacketing to exposed insulated pipe, valves, fittings, and specialties, at an elevation of 8 feet or less above finished floor in mechanical/electrical rooms, penthouses, and services aisles/pipe chases. Fittings of aluminum-jacketed piping may be either aluminum or standard PVC fitting covers.

J. Piping in exterior walls, spaces, overhangs, attics, or where subject to freezing: Insulate pipe with double the thickness called for. Piping in wall chases: In addition to the above, pack chase with loose glass fiber insulation.

K. Provide insulation on exposed hot and cold plumbing piping to within 18 in. of fixture or equipment connection.

L. Insulate exposed domestic water and waste piping for plumbing fixtures designated for use by the handicapped.

3.3 EQUIPMENT INSULATION

A. Apply insulation with joints firmly butted as close as possible to the equipment surface. Insulation shall be secured as required with adhesive, mechanical fasteners or banding material. Fasteners shall be located a maximum of 3 in. from each edge and spaced no greater than 12 in. on center.

B. Vapor retarders shall overlap a minimum of 2 in. at all seams and be sealed with appropriate pressure-sensitive tape or mastic. All penetrations, facing damage, and mechanical fasteners shall be covered with a minimum 2 in. overlap of tape and vapor barrier coating.

C. Calcium Silicate Equipment Insulation: Secure blocks with galvanized steel bands, 12 in. O.C., then point with insulating cement. Field apply 8 oz. knit fiberglass cloth, cemented and applied over standard jacket. Properly cut at fittings to avoid wrinkles and coat with white mastic coating. Leave ready for painting.

D. Fiberglass Equipment Insulation: Secure fiberglass with pins, studs, or clips. Field apply 8 oz. knit fiberglass cloth, cemented and applied over standard jacket. Properly cut at fittings to avoid wrinkles and coat with white mastic coating. Leave ready for painting.

E. Recovering: Field apply 8 oz. knit fiberglass cloth, cemented and applied over standard jacket. Properly cut at fittings to avoid wrinkles and coat with white mastic coating. Leave ready for painting.

F. For Equipment insulation exposed in mechanical rooms or subject to mechanical abuse, finish with minimum 0.020 in. thick PVC Jacketing or metal. All other insulation shall be finished as appropriate for the location and service or as specified on the drawings.

EXHIBIT "I" - PIPE INSULATION MATERIALS
(Notes at end of Exhibit "I")

SERVICE	INSULATION MATERIAL	THICKNESS	REMARKS
Domestic cold water	Glass fiber	1-1/2 in. and larger: 1 in. 1-1/4 in. and smaller: 1/2 in.	SEE NOTES 1, 2
Domestic cold water (buried)	Flexible	1-1/2 in. and larger: 1 in. 1-1/4 in. and smaller: 1/2 in.	
Non potable cold water	Glass fiber	1-1/2 in. and larger: 1 in. 1-1/4 in. and smaller: 1/2 in.	SEE NOTE 2
Domestic hot, tempered and circulation water (105°F - 140°F)	Glass fiber	1-1/2 in. and larger: 1-1/2 in. 1-1/4 in. and smaller: 1 in.	SEE NOTES 1, 2
Domestic hot, tempered and circulation water (105°F - 140°F) (buried)	Flexible	1-1/2 in. and larger: 1-1/2 in. 1-1/4 in. and smaller: 1 in.	
AC unit drains, overflows and indirect waste piping associated with any HVAC equipment	Glass fiber Flexible	All sizes: 1/2 in.	Not required for exposed PVC drains SEE NOTE 2
Storm and secondary storm water	Glass fiber	All sizes: 1 in.	Insulate body of drain and storm water piping, horizontal and vertical, down to connection below ground floor slab or in crawl space SEE NOTE 4
Sanitary and waste	Glass fiber	All sizes: 1/2 in.	SEE NOTE 3, 4

NOTES FOR EXHIBIT I:

NOTE 1: Exposed insulation in the kitchen, laundry, and sterilizer equipment shall be covered with PVC jacket.

NOTE 2: Flexible allowed in 1/2 in. thickness only.

NOTE 3: Insulation on sanitary and waste piping located within plumbing chases and crawl spaces are not required.

NOTE 4: When PVC piping is installed for storm, sanitary and vent piping within return air plenums, the piping shall be insulated and enclosed in materials listed and labeled for installation within a plenum.

END OF SECTION 220700

SECTION 221010 - PIPING SYSTEMS AND ACCESSORIES

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Provide labor, materials, equipment and services to perform operations required for the complete installation and related Work as required in Contract Documents.

1.2 SUBMITTALS

A. Provide a schedule of pipe materials, fittings and connections.

B. Provide a detailed matrix listing the specific UL approved firestop system assembly to be used for each type of piping provided and each type of construction to be penetrated along with all associated UL assembly details.

PART 2 - PRODUCTS

2.1 GENERAL

A. Pipe and fittings shall be new, marked with manufacturer's name and comply with applicable ASTM and ANSI Standards.

B. All items here-in used to convey water for potable use shall be lead free in accordance with NSF, Standard 61, Section 9 - Standard for Drinking Water and Lavatory Faucets and NSF Standard 372 - Maximum Lead Requirements. Compliance shall be via third party testing and certification.

2.2 STEEL PIPING AND FITTINGS

A. Pipe: ASTM A53, or ASTM A106 seamless, Schedule 40 or Schedule 80 weight; black or galvanized finish as called for; ends chamfered for welding or grooved for grooved mechanical connections.

B. Fittings: Same material and pressure class as adjoining pipe.

1. Welded fittings: Factory forged, seamless construction, butt weld type chamfered ends. Where branch connections are two or more sizes smaller than main size, use of "Weldolets", "Thredolets" or "Sockolets" acceptable. Mitered elbows, "shaped" nipples, and job fabricated reductions not acceptable unless specifically called for. Socket weld type, 2000 psi wp, where called for.

2. Threaded fittings: Cast or malleable iron, black or galvanized, as called for; drainage type where called for; UL listed and FM approved for fire protection systems. Street type 45° and 90° elbows are not acceptable.

C. Flanges, Unions, and Couplings:

1. Threaded Connections:

a. Flanges: Cast iron companion type; for sizes 2-1/2 in. and larger.

b. Unions: Malleable iron, bronze to iron seat, 300 lb. wwp; for sizes 2 in. and smaller.

c. Couplings: Malleable iron. Steel thread protectors are not acceptable as couplings.

2. Welded Connections:

a. Flanges: Welding neck type. Slip-on type not allowed unless noted and shall not be installed in conjunction with butterfly valves.

3. Grooved Mechanical Connections:

a. Couplings: Ductile iron, ASTM A536, with painted coating, designed for rolled grooved piping, hot dipped galvanized finish were called for.

b. Gaskets: Grade "E" EPDM synthetic rubber, -30°F to 230°F temperature range, suitable for water service.

c. Bolts and Nuts: Heat treated, hex head carbon steel, ASTM A183, cadmium plated or zinc electroplated.

d. Fittings: Elbows, tees, laterals, reducers, adapters as required. Same construction as couplings.

e. Design Equipment: Victaulic, rigid system, Style 07 couplings.

f. Acceptable Manufacturers: Grinnell, Gruvlok, Victaulic.

D. Gauge and Instrument Connections: Nipples and plugs for adapting gauges and instruments to piping system shall be IPS brass.

2.3 STEEL PIPING AND FITTINGS - PRESS CONNECT FITTINGS

A. Piping Standard: Black steel piping shall conform to ASTM A53 or ASTM A106 seamless, Schedule 40 weight pipe.

B. Fittings: Listed in accordance with ANSI LC4/CSA 6.32.

1. For natural gas service, -40 deg. F to 180 deg F at 125 PSI.

2. Sizes 1/2 inch through 4 inch, Schedule 40.

3. Schedule 40 steel fittings with zinc/nickel coating for use with IPS schedule 40 carbon steel, pipe conforming to ASTM A53 or ASTM A106. Fittings shall have an HNBR sealing element, 420 stainless steel grip ring, separator ring and "Smart Connect" (SC) feature.

C. Design Make: Viega Mega Press G System.

D. Acceptable Manufacturer: Viega.

2.4 COPPER TUBE AND FITTINGS

A. Pipe: ASTM B88; Type K or L, hard temper. Soft temper only as called for. Plans show copper tube sizes.

B. Fittings: Wrought copper and copper alloy, ASME B16.22 or cast copper alloy, ASME B16.18; solder end connections.

C. Joints: Comply with the requirements of ASTM B828.

D. Unions and Flanges: 2 in. and smaller use unions, solder type, cast bronze, ground joint, 150 lb. swp: 2-1/2 in. and over use flanges, cast bronze, companion type, ASME drilled, solder connection, 150 lb. swp.

E. Flux Materials: Flux shall comply with ASTM B813 and the provisions of the New York State Plumbing Code.

F. Solder Materials: No-lead solder, using alloys made from tin, copper, silver and nickel. Harris, Inc., "Stay-Safe 50" and "Bright", Engelhard "Silvabright 100", Canfield "Watersafe" or approved equal.

G. Brazing Materials: Class BcuP-5 for brazing copper to brass, bronze to copper. Harris, Inc. "Stay-Silv 15" or approved equal.

2.5 COPPER TUBE AND FITTINGS - PRESS FITTINGS

A. Tubing Standard: Copper tubing shall conform to ASTM B75 or ASTM B88.

B. Fitting Standard: Copper fittings shall conform to ASME B16.18, ASME B16.22, or ASME B16.26.

C. Press Fittings: Copper press fittings shall conform to the material and sizing requirements of ASME B16.18 or ASME B16.22. O-rings for copper press fittings shall be EPDM.

D. Acceptable Manufacturers: Apollo, Mueller, Nibco, Viega.

2.6 COPPER TUBE AND FITTINGS - GROOVED MECHANICAL CONNECTIONS

A. Pipe: ASTM B88, Type K or L, hard temper.

B. Fittings: Wrought copper, roll grooved mechanical connections, ASTM B-75, ANSI B16.22 for 4 in. size. Cast bronze, rolled grooved mechanical connections, ASTM B-584, ANSI B16.18 for sizes 5 in. - 8 in.

C. Couplings: Ductile iron, ASTM A-536, with copper colored alkyd enamel finish, designed for rolled grooved piping.

D. Gaskets: Grade "E" EPDM synthetic rubber, copper color coded, -30°F to 230°F temperature range, suitable for water service.

E. Bolts and Nuts: Heat treated, hex head carbon steel, ASTM A183, cadmium plated or zinc electroplated finish.

F. Design Equipment: Victaulic Style 606 couplings.

G. Acceptable Manufacturers: Grinnell, Gruvlok, Victaulic.

2.7 COPPER DRAINAGE TUBE AND FITTINGS

A. Pipe: ASTM B306, Type DWV, hard temper.

1. Copper not allowed for urinal waste.

B. Fittings: Wrought copper, ANSI B16.29 or cast bronze, ANSI B16.23; solder end connections.

C. Flux Materials: Flux shall comply with ASTM B813 and the provisions of the New York State Plumbing Code.

D. Solder Materials: No lead solder, using alloys made from tin, copper, silver and nickel.

E. Acceptable Manufacturers: Harris, Inc., "Stay-Safe 50" and "Bright", Engelhard "Silvabright 100", Canfield "Watersafe", or approved equal.

2.8 HUB AND SPIGOT CAST IRON SOIL PIPE AND FITTINGS

A. Pipe: ASTM A74 service weight cast iron, bitumen coated.

B. Fittings: Cast iron, service weight, hub and spigot, drainage pattern, bitumen coated.

C. Connections: ASTM C564 neoprene gaskets and lubricant.

D. All cast iron soil pipe and fittings shall be marked with the collective trademark of the Cast Iron Soil Pipe Institute (CISPI) and be listed by NSF International.

2.9 NO-HUB CAST IRON SOIL PIPE AND FITTINGS

A. Pipe: ASTM A888, CISPI Standard 301, no-hub cast iron, bitumen coated.

1. For above grade only.

B. Fittings: Cast iron, no-hub drainage pattern, bitumen coated.

C. Couplings:

1. 1-1/2 in. to 2 in.: CISPI standard 310 with 300 series stainless steel corrugated shield and clamp assembly with ASTM C564 neoprene sealing sleeve (or) same as specified for 3 in. and larger.

2. 3 in. and Larger: 24 gauge, Type 304 stainless steel housing clamp assembly with ASTM C564 neoprene sealing sleeve, 60 in. lbs. minimum torque rating, shall meet requirements of pipe manufacturer and shall be compatible with specified pipe. Acceptable Manufacturers: Clamp-All Coupling System, Tyler "Wide Body", Husky "Series 2000", Mission "Heavy Weight" or approved equal.

D. All cast iron soil pipe and fittings shall be marked with the collective trademark of the Cast Iron Soil Pipe Institute (CISPI) and be listed by NSF International.

2.10 PVC SOLID WALL PIPE AND FITTINGS - DWV SYSTEM

A. Pipe: PVC Schedule 40 solid wall pipe, iron pipe size conforming to ASTM D1785 and ASTM D2665. Pipe shall be manufactured from PVC compounds as identified in ASTM D1784. Both pipe and fittings shall conform to National Sanitation Foundation Standard 14.

B. Fittings: Type DWV, socket type conforming to ASTM D2665. Fittings shall be manufactured from PVC compounds as identified in ASTM D1784. Solvent cement joints shall be made utilizing a two-step process with primer manufactured for thermoplastic piping and solvent cement conforming to ASTM D2564.

2.11 SPECIAL FITTINGS

A. Cast Iron to Lead Pipe: Red brass ferrules and wiped joints. Caulk ferrule into cast iron hub.

B. Copper to Cast Iron: Cast bronze, cast iron to sweat adapter.

C. Copper to Steel Piping:

1. Cast bronze copper to iron male or female adapter with shoulder for drainage piping only.

2. Dielectric pipefittings.

D. Steel to Cast Iron: Cast iron soil pipe connector with spigot and IPS male thread end (Manhoff fittings).

E. No-Hub, Cast Iron, Glass, Polypropylene or High Silicon Cast Iron: Proper adapter to piping being connected.

F. Cast Iron and PVC Solvent: Aerators and deaerators as manufactured by Conine Manufacturing Co., Inc.

2.12 HANGERS, INSERTS AND SUPPORTS

A. Hangers, Inserts, Clamps: B-Line, Grinnell, Michigan Hanger, PHD Manufacturing.

B. Hangers:

1. Adjustable, wrought malleable iron or steel with electroplated zinc or cadmium finish. PVC coated where in contact with copper piping.

2. Adjustable ring type where piping is installed directly on hanger for piping 3 in. and smaller.

3. Adjustable steel clevis type for piping 4 in. and larger.

4. Nuts, washers and rods with electroplated zinc or cadmium finish.

5. Provide hot dipped galvanized finish for hangers and accessories installed in exterior locations and interior areas with moist environment conditions such as pools, pool filter rooms, areaways, garages and similar areas.

C. Spacing Schedule:

Pipe Size	Steel	Copper	Plastic	Cast Iron	Rod Size
3/4 in. to 1 in.	8 ft.	6 ft.	3 ft.	Each	3/8 in.
1-1/4 in. to 2 in.	10 ft.	6 ft.	3 ft.	Horizontal	3/8 in.
2-1/2 in. to 4 in.	12 ft.	10 ft.	4 ft.	Joint 5 ft.	1/2 in.
5 in. and over	12 ft.	10 ft.	4 ft.	Maximum	5/8 in.
8 in.	12 ft.	10 ft.	4 ft.	O.C.	3/4 in.
Over 8 in.	To suit loading conditions.				

D. Cast Iron No-Hub Supports:

1. In accordance with manufacturer's recommendations.

2. Vertical piping supported at each stack base, at each floor and 15 ft. on center, maximum. Freestanding vertical pipe should be adequately staked or braced during construction to maintain alignment. Bases of stacks shall be supported on concrete, brick laid in cement mortar, metal brackets attached to the building construction or by other methods approved by the Owner's Representative.

3. Horizontal piping supported within 24 in. each side of the coupling joint at 10 ft. intervals for 10 ft. pipe lengths and at 5 ft. intervals for 5 ft. pipe lengths. Supports or hangers placed to maintain alignment and grade with provision made to prevent shear. Greater than 3 in. diameter pipe braced at changes of direction to prevent horizontal movement.

E. Beam Attachments:

1. C-Clamp style, locknut, restraining strap, electroplated finish, UL listed, FM approved for pipe sizes 2 in. and smaller.

2. Center loaded style with clamp attachments that engage both edges of beam, electroplated finish, UL listed, FM approved, for pipe sizes larger than 2 in., refer to "Supports" for additional requirements.

F. Inserts: Carbon steel body and square insert nut, galvanized finish, maximum loading 1300 lbs., for 3/8 in. to 3/4 in. rod sizes, reinforcing rods on both sides, MSS-SP-69 Type 19 or approved equal.

G. Supports:

1. Provide intermediate structural steel members where required for hanger attachment. Members shall span across the bar joists at panel points of joists. Secure member to structure. Select size of members based on a minimum factor of safety of four.

2. For Weights Under 1000 lbs.: "Drill-In" inserts, "U" shaped Channel, beam clamps or other structurally reviewed support. The factor of safety shall be at least four. Follow manufacturer's recommendations.

3. For Weights Above 1000 lbs.: Drill through floor slabs and provide flat flush plate welded to top of rod or provide additional "Drill-In" inserts and hangers to reduce load per hanger below 1000 lbs.

4. For Metal Decks: Drill hole through for hanger rods and imbed a welded plate in concrete or use devices designed for this application, with a safety factor of four.

5. For Wood Construction: Provide hangers and supports designed for attachment to wood construction.

6. Acceptable Manufacturers: Hilti, ITW Ramset, Phillips "Red Head" or approved equal.

H. Trapeze Hangers:

1. For plumbing systems only.

2. Hangers shall be supported with rod sized with a safety factor of four.

3. May be manufactured type "U" shaped channel, or suitable angle iron or channel. Round off all sharp edges.

4. Securely fasten piping to trapeze with "U" bolt or pipe clamps, dissimilar metals shall not touch, use isolation gaskets, similar to HoldRite strut-mounted cushion clamps. Fasten piping to trapeze at every third support, except uninsulated

piping which shall be fastened at every support using strut-mounted cushion clamps.

5. Acceptable Manufacturers: B-Line, HoldRite, Kindorf, Unistrut or approved equal.

I. Roof Pipe Supports - Deck Mounted Rail:

1. Raised cant for insulated roof, heavy-gauge galvanized steel with integral base, 2 x 4 pressure treated wood nailer, removable galvanized steel counter flashing.

2. Steel channel track, roller assembly and accessories, adjustable, locking devices in roller assembly, all parts galvanized except painted cast iron roller.

3. Length as required for quantity of pipes to be supported. Anchor to roof deck per manufacturer.

4. Acceptable Manufacturers: Pate #PRS-5A or approved equal.

J. Roof Pipe Supports - Fixed and Adjustable Pillow Block Style:

1. Pipe support for placement on roof surface with base perforated for drainage. Provide pipe anchor strap option and manufacturer's support pad or roofing manufacturer's recommended slip sheet below support. Support models shall be selected based on total pipe O.D. and pipe weight operating full. All polycarbonate materials shall be UV stabilized.

2. Fixed Height Pipe Stand: For bare piping up to 5 in. nominal or insulated piping up to 6 in. outside diameter. Polycarbonate resin base plate with fixed height self-lubricating polycarbonate roller supported by glass-filled nylon or stainless steel rod. Miro Industries Model R Series.

3. Adjustable Height Pipe Stand with Polycarbonate Base: For bare piping up to 5 in. nominal or insulated piping up to 6 in. outside diameter. Polycarbonate base plate with adjustable stainless steel all thread rod vertical supports, polycarbonate roller on stainless steel rod. Miro Industries Model RAH Series.

4. Adjustable Height Pipe Stand with Metal Base: For bare piping 4 in. to 6 in. nominal or insulated piping up to 7 in. outside diameter. 12 in. by 16 in. wide stainless steel base plate with adjustable stainless steel all thread rod vertical supports, polycarbonate roller on stainless steel rod. Miro Industries Model RAH SS Series.

5. Pipe Hanger Stand with Polycarbonate Base: For bare piping up to 2-1/2 in. nominal or insulated piping up to 3-1/2 in. outside diameter. 9 in. by 15 in. wide polycarbonate resin base plate with adjustable stainless steel all thread rod vertical supports, galvanized top strut with clevis hanger suspended on stainless steel all thread rod. Miro Industries Model 2.5-SB-H Series.

6. Adjustable Height Pipe Stand with Metal Base: For bare piping up to 6 in. nominal or insulated piping up to 7-1/2 in. outside diameter. Two (2) 8 in. by 14 in. wide stainless steel base plates, with adjustable height galvanized braced strut assembly with clevis hanger suspended on a stainless steel all thread rod. Miro Industries Model 6-H Series.

K. Piping systems with material not listed above shall be supported and protected in accordance with manufacturer's recommendations.

2.13 PIPING ACCESSORIES

A. Escutcheon Plates: Steel or cast brass, split hinge type with setscrew, high plates where required for extended sleeves. Chrome plated in finished areas and at plumbing fixtures.

B. All cleanout plugs, bushings and nipples, required for instruments and gauges shall be brass.

C. Hubless cast iron fitting restraints shall be Holdrite Series #117 or approved equal.

2.14 SLEEVES

A. Standard Type:

1. Schedule 40 black steel pipe sleeves for structural surfaces, two pipe sizes larger than the pipe, and as recommended by the sealing element manufacturer. Provide full circle water stop collar for sleeves located within below grade walls, wet wells and waterproofed surfaces. The collar shall be fabricated from steel plate and welded to the sleeve around its entire circumference.

2. Schedule 40 PVC sleeves or sheet metal sleeves for nonstructural surfaces and existing construction. Sheet metal sleeves shall be 18 gauge minimum and braced to prevent collapsing.

2.15 SEALING ELEMENTS

A. Expanding neoprene link type, watertight seal consisting of interlocking links with zinc plated bolts.

1. Acceptable Manufacturers: Thunderline "Link-Seal" Series 200, 300 or 400, Pyropac, Calipco.

2.16 FIRESTOP SYSTEM FOR OPENINGS THROUGH FIRE RATED WALL AND FLOOR ASSEMBLIES

A. Materials for firestopping seals shall be listed by an approved independent testing laboratory for "Through-Penetration Firestop Systems". The system shall meet the standard fire test for Through-Penetration Firestop Systems designated ASTM E814. Firestop system seals shall be provided at locations where piping pass through fire rated wall, floor/ceiling, or ceiling/roof assembly. Minimum required fire resistant ratings of the assembly shall be maintained by the Firestop System. Installation shall conform with

the manufacturer's recommendations and other requirements necessary to meet the testing laboratory's listing for the specific installation.

2.17 STACK SLEEVE

A. Cast iron body with caulking recess, flashing clamp and under deck clamp.

B. Acceptable Manufacturers: Jay R. Smith Series 1720, Zurn, Wade.

2.18 STRAINERS

A. Description: Y-Pattern, self-cleaning, except where otherwise indicated, full size of connecting piping, Type 304 stainless steel screens, 125 lb. SWP, unless otherwise indicated.

B. Copper Piping 2-1/2 in. and Smaller: Lead free, cast bronze body, threaded ends, tapped retainer cap with closure plug, 20 mesh screen, Watts #LF777S.

C. Steel Piping 2-1/2 in. and Smaller: Iron body, threaded ends, tapped retainer cap with closure plug, 20 mesh screen, Watts #77S

D. Piping 3 in. and Larger, Cold Water Applications: Lead free, cast iron body, flanged ends, standard screen openings, FDA approved epoxy coating, tapped retainer cap and gasket with closure plug; Watts #77F-DI-FDA-125.

E. Fuel Oil Strainers 2 in. and Smaller: Line strainer, top cleanout, cast iron body and cap, malleable iron yoke, 50 psi operating pressure, 24 mesh stainless steel cage and basket for #2 fuel oil, female threaded ends, UL listed; Morrison Figure #286-U.

2.19 STAINLESS STEEL FLUE PIPE

A. Double wall stainless steel flue pipe shall consist of 430 stainless steel outer jacket, 1/2 in. air space, AL-29-4C inner jacket. Flue piping shall be tested and listed to UL1738, for Categories III and IV. All joints shall be equipped with a factory-applied seal.

B. Acceptable Manufacturers: Heatfab, Precision Vent, Selkirk.

2.20 PIPING MATERIALS AND SCHEDULE

A. See Exhibit "A", "Schedule of Piping Materials" at end of this Section for (Plumbing) piping.

B. See Exhibit "B", "Testing" at end of this Section.

PART 3 - EXECUTION

3.1 EQUIPMENT AND SYSTEMS

A. Install equipment and systems in accordance with provisions of each applicable Section of these Specifications, and Local/State Codes/Regulations having jurisdiction.

Accurately establish grade and elevation of piping before setting sleeves. Install piping without springing or forcing, except where specifically called for, making proper allowance for expansion and anchoring. Changes in sizes shall be made with reducing fittings. Reducing couplings are not acceptable. Arrange piping at equipment with necessary offsets, unions, flanges, and valves, to allow for easy part removal and maintenance. Offset piping and change elevation as required to coordinate with other work. Avoid contact with other mechanical or electrical systems. Provide adequate means of draining and venting units, risers, circuits and systems. Conceal piping unless otherwise called for. Copper tubing shall be cut with a wheeled tubing cutter or other approved copper tubing cutter tool. The tubing must be cut square to permit proper joining with the fittings. Ream pipes after cutting and clean before installing. Cap or plug equipment and pipe openings during construction. Install piping parallel with lines of building, properly spaced to provide clearance for insulation. Make changes in direction and branch connections with fittings. Do not install valves, unions and flanges in inaccessible locations. Materials within a system and between systems shall be consistent. If this is not possible, install dielectric fittings.

3.2 PIPING OVER ELECTRICAL EQUIPMENT

A. Contractor shall route piping to avoid installation directly over electric equipment, including, but not limited to panels, transformers, disconnects, starters, motor control center, adjustable speed drives and fused switches.

B. Piping shall not be installed in the dedicated electric and working space as defined by NEC 110. Dedicated electrical space is generally equal to the depth and width of electrical equipment, and extends 6 ft. above the electrical equipment, or to a structural ceiling. Dedicated working space is a minimum of 30 in. wide or the width of equipment (whichever is larger) a minimum of 6 ft.-6 in. tall, with a depth of 3ft. to 9 ft. depending on the voltage.

3.3 HANGERS, INSERTS AND SUPPORTS

A. Piping shall not be supported by wires, band iron, chains, from other piping, or by vertical expansion bolts. Support piping with individual hangers from concrete inserts, wood construction, welded supports, or beams clamps of proper configuration and loading design requirements for each location; replace if not suitable. Follow manufacturer's safe loading recommendations. Suspend with rods of sufficient length for swing and of size called for, using four (4) nuts per rod. Provide additional structural steel members, having one coat rustproof paint, where required for proper support. Provide oversized hangers where insulation/supports must pass between pipe and hanger. Provide continuous support or extra supports for plastic piping per manufacturer's requirements. Hangers, when attached to joists, shall only be placed at the top or bottom chord panel point. Only concentric type hangers are permissible on piping larger that 2-1/2 in.; "C" types are permitted for piping 2 in. and smaller on joists. Provide riser clamps for each riser at each floor. Use trapeze hangers where a group of piping can be installed.

B. Provide a pipe hanger within 12 inches of pipe unions and piping connections to equipment, in order to facilitate disconnections of piping without pipe sagging.

3.4 PIPE CONNECTIONS

A. No-Lead Solder Connections: Nonacid flux and clean off excess flux and solder.

B. Copper Press Connections: Copper press fittings shall be made in accordance with the manufacturer's installation instructions. The tubing shall be fully inserted into the fitting and the tubing marked at the shoulder of the fitting. The fitting alignment shall be checked against the mark on the tubing to assure the tubing is fully engaged (inserted) in the fitting. The joints shall be pressed using the tool approved by the manufacturer.

C. Steel Press Connections:

1. Natural Gas Systems: Sealing elements shall be verified for the intended use. Pipe ends shall be cut on a right angle (square) to the pipe. Pipe ends shall be reamed and all paint, lacquer, grease, oil, and dirt shall be removed from the pipe end with an abrasive cloth, or with a Ridgid MegaPress pipe end prep tool. Visually examine each fitting sealing element to ensure there is no damage. Insert the pipe fully into the fitting and mark the pipe wall at the face of the fitting. Always examine the pipe to ensure it is fully inserted into the fitting prior to pressing the joint. Steel Press fittings shall be installed using Ridgid, MegaPress Tools. Steel Press fittings shall be installed according to the most current edition of the manufacturer's installation guidelines. Installers shall be trained by a manufacturer representative on proper installation procedures.

2. Testing: After Steel Press fittings have been installed a “two step test” shall be followed. Utilizing air or, dry nitrogen, pressurize the system between 5 psi and 45 psi. Check the pressure gauge for pressure loss. If the system does not hold pressure, inspect entire system and check for un-pressed fittings. Should un-pressed fittings be identified, ensure the pipe is fully inserted into the fitting and properly marked prior to pressing the joint. After appropriate repairs have been made, test the system per local code, or specification requirements, not to exceed 200 psig.

D. Brazed Connections: Make joints with silver brazing alloy in accordance with manufacturer's instructions. Remove working parts of valves before applying heat.

E. Threaded Connections: Clean out tapering threads, made up with pipe dope; screwed until tight connection. Pipe dope must be specifically selected for each application.

F. Flanged Joints: Select appropriate gasket material, size, type and thickness for service applications. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

G. Dielectric Pipe Fittings: Provide dielectric unions at ALL equipment connections where dissimilar metals meet. In addition, provide dielectric unions in all open type piping systems (condensing water, domestic water, etc.) where dissimilar metals are to be joined.

H. FRP Pipe Joints: Bonded with resin catalyst adhesive.

I. Grooved Mechanical Joints: Pipe to be prepared in accordance with the latest manufacturer's grooving specification. Use manufacturer's recommended grooving tools. Pipe shall be checked to be sure it is free of indentations, projections; weld seams or roll marks on the exterior of the pipe over the entire gasket seating area. Pipe ends are to be square cut. Lubricant shall be applied to gasket and/or pipe ends and housing interiors to eliminate pinching the gasket.

J. Solvent-Cement Plastic Piping Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:

1. Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements. Apply primer.

2. PVC Piping: Join according to ASTM D 2855.

3.5 WELDING

A. Welding shall be performed in compliance with the welding procedure specifications prepared by the National Certified Pipe Welding Bureau. Welded pipe fabricated by certified welder. Contractor shall submit proof of current certification of each welder if requested by Owner. Use full-length pipe where possible; minimum distance between welds, 18 in. on straight runs. Welds must be at least full thickness of pipe inside smooth and remove cutting beads, slag and excess material at joints; chamfer ends. Minimum gap 1/8 in., maximum 1/4 in., for butt welds. Overlaps on position and bench welds to be not less than 3/4 in. One internal pass and one external pass minimum required on slip-on flanges. Do not apply heat to rectify distorted pipe due to concentrated welding; replace distorted pipe.

B. When welding galvanized pipe, apply cold galvanizing on joint following welding.

3.6 SLEEVES

A. Provide for pipes passing through floors, walls or ceilings. Not required for floors that are core-drilled, except where floor is waterproofed.

B. Extend 1/8 in. above finished floor in finished areas. In above grade Mechanical Rooms and other areas with floor drains, use steel pipe sleeves 2 in. above floor.

C. Use steel pipe sleeves in bearing wall, structural slabs, beams and other structural surfaces, and where called for.

D. Sleeves shall be as small as practical, consistent with insulation, so as to preserve fire rating.

E. Fill abandoned sleeves with concrete.

F. Provide rubber grommet seals for pipes passing through ducts or air chambers or built-up housings.

3.7 SLEEVE PACKING

A. Seal void space at sleeves as follows:

1. Interior Locations: Firmly pack with fiberglass and caulk.

2. Exterior Walls and Below Grade Cored Holes: Use sealing element.

3. Cored Holes: Use sealing element.

4. Fire Rated, Partitions and Floor Slabs: Use fire rated sealing elements, materials and methods. Provide per manufacturer's instructions to maintain firestop.

5. Waterproofed Walls/Floors: Use waterproof sealing element, device or compound.

3.8 ESCUTCHEON PLATES

A. Provide polished chrome setscrew type escutcheon plates for all exposed piping passing through floors, walls or ceilings, in all rooms except in Boiler, Fan and Mechanical Rooms.

3.9 TESTS

A. Refer to Exhibit "B" at the end of this section for testing of Plumbing Systems.

B. Provide all necessary items to complete proper testing of work. Perform all testing in accordance with governing Codes, local utilities and other agencies having jurisdiction and as specified. Pay all costs to perform tests. Perform all testing in a safe manner. Isolate existing systems.

C. Domestic Water:

1. Do not cover joints with insulation until required tests are completed and the Owner's Representative accepts the system.

2. Make leaks tight; no caulking permitted. Replace defective fittings, pipe or connections. Piping shall be tight and show no loss of pressure.

3. Air test not acceptable as final test.

4. Confirm in writing that tests and flushing have been conducted and successfully completed. Submit copy of the test report to Owner's Representative.

D. Sanitary and Storm:

1. There shall be no loss of water when testing interior piping.

2. Air test not acceptable as final test.

3. Should any leaks, defective joints or defective construction be detected in sewers and/or floors or walls of appurtenant structures, they shall be permanently stopped. Should any defective pipes, fittings or accessories be discovered they shall be removed and replaced at the Contractor's expense.

4. Confirm in writing that tests have been conducted and successfully completed. Submit copy of the test report to Owner's Representative.

3.10 DOMESTIC WATER PIPING CLEANING AND DISINFECTION

A. Cleaning and disinfecting shall be in accordance with requirements of New York State Department of Health and authority having jurisdiction. Prior to disinfecting, flush piping to remove any sediment and debris.

B. Clean and disinfect water distribution piping systems and parts of existing potable water systems that have been altered, extended or repaired.

C. After disinfection procedures, submit water samples in sterile bottles to an approved Department of Health Laboratory. Samples shall be proven equal to the water quality served to the public from the existing water supply system and acceptable to the Department of Health. Flush and disinfect all sections of pipe that fail the laboratory tests. Submit test results indicating water is potable.

3.11 CONNECTIONS TO SPECIAL EQUIPMENT

A. Kitchen Equipment:

1. Kitchen Equipment shall be furnished by others and set in place by others.

2. Provide all piping, stops, valves, traps and fittings.

3. Where exposed, provide chrome plated brass piping, valves, hangers, brackets and accessories.

4. Pipe relief valves to floor. Size and arrangement of pipe, traps, valves and fittings, as recommended by manufacturer of equipment.

3.12 PIPE LINE SIZING

A. Pipe sizes called for are to be maintained. Pipe size changes made only as reviewed by Owner's Representative. Where discrepancy in size occurs, the larger size shall be provided.

EXHIBIT "A" - PIPING MATERIALS (PLUMBING)
(Notes at end of Exhibit "A")

SERVICE	PIPE MATERIALS	FITTINGS	CONNECTIONS
Water service	SEE "UNDERGROUND PIPING AND ACCESSORIES" SECTION 221020		
Domestic water interior/hot, cold and circulating 3 in. and smaller	Type L copper	Wrought or cast copper	No-lead solder
	Type L copper	Wrought or cast copper	Press fit
Domestic water interior/hot, cold and circulating 4 in. and larger	Schedule 40 galvanized steel	Galvanized ductile iron	Roll grooved mechanical type couplings (SEE NOTE 1)
	Schedule 40 galvanized steel	Galvanized cast or malleable iron	Flanged
	Type L copper	Wrought copper	Brazed
	Type L copper	Wrought or cast copper	Roll grooved mechanical type couplings
Non-potable water	Type L copper	Wrought or cast copper	No-lead solder
	Type L copper	Wrought or cast copper	Press fit
Sanitary, sanitary vent, grease waste and storm (buried)	SEE "UNDERGROUND PIPING AND ACCESSORIES" SECTION 221020		
Sanitary, sanitary vent and grease waste	Service weight cast iron soil pipe	Cast iron hub and spigot	Neoprene compression type gasket
	Service weight cast iron soil pipe	No hub	No hub neoprene gasket and stainless steel clamp assembly
	Type DWV copper	Wrought copper	No-lead solder (SEE NOTE 5)
	Schedule 40 PVC, solid wall	PVC, socket type	Solvent cement (SEE NOTE 4)

SERVICE	PIPE MATERIALS	FITTINGS	CONNECTIONS
Storm	Service weight cast iron soil pipe	Cast iron hub and spigot	Neoprene compression type gasket
	Service weight cast iron soil pipe	No hub	No hub neoprene gasket and stainless steel clamp assembly
	Schedule 40 PVC, solid wall	PVC, socket type	Solvent cement (SEE NOTE 4)
Water heater intake piping	Schedule 40 PVC, solid wall	PVC, socket type	Solvent cement (SEE NOTE 4)
Water heater exhaust piping	AL-29-4C stainless steel (exhaust)	Stainless steel	Sealed closure system
Indirect waste	Type DWV copper	Wrought copper	No-lead solder
	Schedule 40 PVC, solid wall	PVC, socket type	Solvent cement (SEE NOTE 4)
Pump discharge	Schedule 40 galvanized steel	Galvanized cast iron drainage	Threaded
	Type L Copper	Wrought copper	No-lead solder
Natural gas (exterior above grade)	Schedule 40, black steel	Butt welded steel	Welded (SEE NOTE 2)
	Schedule 40, black steel	Malleable iron, 2 in. and smaller	Threaded (SEE NOTE 2)
	Schedule 40, black steel	Steel with zinc/nickel coating	Press fit
Natural gas (interior)	Schedule 40, black steel	Malleable iron, 2 in. and smaller	Threaded (SEE NOTE 2)
	Schedule 40, black steel	Butt welded steel, 2-1/2 in. and larger	Welded (SEE NOTE 2)
Compressed air (shop and industrial)	Schedule 40, black steel	Malleable iron, 3 in. and smaller	Threaded

NOTES FOR EXHIBIT A:

NOTE 1: Provide ductile iron, double thickness cement - lined pipe and fittings up to the water meter inlet valve in accordance with the New York State Plumbing Code and Water Bureau Requirements. Pipe and fittings shall be flanged.

NOTE 2: Provide one coat of alkyd primer and two coats of exterior acrylic latex gloss enamel on exposed exterior and interior piping. Color as selected.

NOTE 3: For gas piping systems having operating pressure other than the standard 50 to 55 psig (or 160 psig for nitrogen), provide Type K copper for medical gas.

NOTE 4: PVC piping shall not be installed within return air plenums.

NOTE 5: Copper piping shall not be used for urinal waste piping.

EXHIBIT "B" - TESTING

SERVICE	TEST REQUIREMENTS
Domestic water	Test hydrostatically at 150 PSI for two (2) hours or at 1.5 times the working pressure when working pressure exceeds 100 PSI
Sanitary, sanitary vent, storm	Maintain 10 ft. head of water for two (2) hours.
Indirect waste	Maintain 10 ft. head of water for two (2) hours.
Pump discharge	Hydrostatically test at 5 PSI greater than the pump rating for two (2) hours.
Natural gas	Refer to Section 227010 - "Natural Gas Systems".
Compressed air (house, shop and industrial)	Test with clean air or nitrogen at a pressure of 175 PSI for 24 hours.

END OF SECTION 221010

This page intentionally left blank

SECTION 221020 - UNDERGROUND PIPING AND ACCESSORIES

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Provide labor, materials, equipment and services to perform operations required for the complete installation and related Work as required in Contract Documents

1.2 SUBMITTALS

A. Provide a schedule of pipe materials, fittings and connections.

PART 2 - PRODUCTS

2.1 GENERAL

A. Pipe and fittings new and marked with manufacturer's name, complying with applicable ASTM and ANSI Standards.

2.2 CAST IRON SOIL PIPE AND FITTINGS

A. Pipe: ASTM A74 service weight cast iron, bitumen coated, hub and spigot.

B. Fittings: Service weight cast iron, bitumen coated, hub and spigot, ASTM C564 service weight neoprene gasket of same manufacturer as piping.

C. All cast iron pipe and fittings shall be marked with the collective trademark of the Cast Iron Soil Pipe Institute (CISPI) and be listed by NSF International.

2.3 COPPER PIPE AND FITTINGS

A. Pipe: ASTM B88, Type K, Soft Temper

B. Fittings: ANSI B16.22 wrought copper; ANSI B16.26 and ASTM B62 cast bronze; flared end connections.

2.4 DUCTILE IRON PIPE AND FITTINGS

A. Pipe: AWWA C151/ANSI A21.51, Class 52, ductile iron, mechanical type joints for short runs, otherwise use push-on type joints.

B. Fittings: AWWA C110/ANSI A21.51, ductile iron, 250-psi pressure rating (or) AWWA C153/ANSI A21.53 ductile iron compact fitting, 350 psi pressure rating. Joints shall be restrained, mechanical type for short runs, otherwise use push-on type.

C. Lining: Pipe and fittings shall have double thickness cement mortar lining with seal per AWWA C104/ANSI A21.4 on interior and asphaltic coating on outside.

D. Glands and Gaskets: AWWA C111/ANSI A21.11, ductile iron gland, rubber gasket joints, provide two bronze wedges for each joint of pipe.

2.5 PVC SOLID WALL PIPE AND FITTINGS - DWV SYSTEM

A. Pipe: PVC Schedule 40 solid wall pipe, iron pipe size conforming to ASTM D1785 and ASTM D2665. Pipe shall be manufactured from PVC compounds as identified in ASTM D1784. Both pipe and fittings shall conform to National Sanitation Foundation Standard 14.

B. Fittings: Type DWV, socket type conforming to ASTM D2665. Fittings shall be manufactured from PVC compounds as identified in ASTM D1784. Solvent cement joints shall be made utilizing a two-step process with primer manufactured for thermoplastic piping and solvent cement conforming to ASTM D2564.

2.6 STEEL PIPING AND FITTINGS

A. Pipe: ASTM A53 or ASTM A106 seamless, Schedule 40 or 80 weight; black or galvanized finish, factory coated.

B. Fittings: Same material and pressure class as adjoining pipe, black or galvanized finish, field coated and wrapped.

1. Welded Fittings: Factory forged, seamless construction, butt weld type, chamfered ends.

2. Threaded Fittings: Malleable iron.

2.7 SCHEDULE OF PIPING MATERIALS

A. See Exhibit "A", Schedule of Piping Materials at end of this section for piping.

PART 3 - EXECUTION

3.1 TESTING

A. Sanitary and Storm:

1. Do not backfill over piping until required tests are completed and the Owner's Representative accepts the system.

2. There shall be no loss of water when testing interior piping inside the building foundation.

3. Air test not acceptable as final test.

4. Should any leaks, defective joints or defective construction be detected in sewers, floors or walls of appurtenant structures, they shall be permanently stopped. Should any defective pipes, fittings or accessories be discovered they shall be removed and replaced at the Contractor's expense.

5. Test exterior piping outside the building foundation in 100 ft. sections. The allowable rate of leakage per 24 hours per in. of diameter per 1,000 ft. of sewer tested shall not exceed 25 gallons. Piping shall be inspected and tested prior to backfill.

6. Confirm in writing that tests have been conducted and successfully completed. Submit copy of the test reports to Owner's Representative.

B. Domestic Water:

1. Do not backfill over piping until required tests are completed and the Owner's Representative accepts the system.

2. Make leaks tight; no caulking permitted. Replace defective fittings, pipe or connections. Piping shall be tight and show no loss of pressure.

3. Air test not acceptable as final test.

4. Confirm in writing that tests and flushing have been conducted and successfully completed. Submit copy of the test report to Owner's Representative.

C. Test exterior water and fire service piping outside the building foundation hydrostatically at 200 psi for two (2) hours. The amount of leakage shall not exceed two (2) quarts per hour per 100 gaskets or joints. Conform to NFPA 24.

3.2 GAS PIPING

A. Refer to Section 227010, "Natural Gas Systems"

EXHIBIT "A" - PIPING MATERIALS (PLUMBING)
(Notes are at end of Exhibit "A")

SERVICE	PIPE MATERIALS	FITTINGS	CONNECTIONS
Water service	Ductile iron water main with cement lining	Ductile iron	Mechanical or push-on type
Sanitary and grease waste	Service weight cast iron soil pipe	Cast iron, hub and spigot	Neoprene gasket compression type
	Schedule 40 PVC, solid wall	PVC, socket type	Solvent cement (SEE NOTE 6)
Sanitary and grease waste vent	Service weight cast iron soil pipe	Cast iron, hub and spigot	Neoprene gasket compression type
Storm	Service weight cast iron soil pipe	Cast iron, hub and spigot	Neoprene gasket compression type
	Schedule 40 PVC, solid wall	PVC, socket type	Solvent cement

NOTES FOR EXHIBIT A:

NOTE 1: On buried coated steel pipe, tape all joints with Scotchwrap #50, 2 in. wide, 50% overlap. Provide cathodic protection system.

NOTE 2: Above ground vent piping shall be galvanized steel, Schedule 40; galvanized malleable iron fittings with threaded connections.

NOTE 3: Provide secondary containment for oil, diesel fuel, and unleaded gas piping.

NOTE 4: Piping between the tank and building or dispensers shall be continuous. Fittings and adapters used shall be specifically made for the piping system installed. All underground piping shall be installed within ducting pipe.

NOTE 5: Provide ductile iron, double thickness cement - lined pipe and fittings up to the water meter inlet valve in accordance with the New York State Plumbing Code and Water Bureau Requirements. Pipe and fittings shall be flanged.

NOTE 6: Schedule 40 PVC pipe may not be used when the temperature of the waste can exceed 140°F.

EXHIBIT "B" - TESTING

SERVICE	TEST REQUIREMENTS
Water service	Test hydrostatically at 150 PSI for two (2) hours
Sanitary, sanitary vent, storm	Maintain 10 ft. head of water for two (2) hours.
Fire service	Test hydrostatically at 200 PSI or 50 PSI in excess of the system working pressure, whichever is greater for two (2) hours.

END OF SECTION 221020

This page intentionally left blank

SECTION 221030 - PUMPS

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Provide labor, materials, equipment and services to perform operations required for the complete installation and related Work as required in Contract Documents.

1.2 QUALITY ASSURANCE

A. Follow all requirements, recommendations and appendices to comply with the following publications, codes, standards and listings/approvals:

1. All items here-in used to convey water for potable use shall be lead free in accordance with NSF 61, Standard 61, Section 9 - Standard for Drinking Water and Lavatory Faucets and NSF Standard 372 - Maximum Lead Requirements. Compliance shall be via third party testing and certification.

1.3 SUBMITTALS

A. Submit manufacturer's data in accordance with the Basic Mechanical and Electrical Requirements. Obtain approval prior to ordering material.

B. Provide submittals for all items specified under Part 2 of this Section.

PART 2 - PRODUCTS

2.1 HOT WATER CIRCULATING PUMP

A. Pump: Inline centrifugal, all bronze, horizontal oil lubricated type, 125 psi working pressure, 225°F water temperature, ground polished steel shaft with hardened integral thrust collar, mechanical seal, flange mount, flexible spring loaded coupler.

B. Motor: Refer to Specification Section 220513, "Motors"; non-overloading throughout the pump curve.

C. Electric Control: Time clock and aquastat for each pump and wiring to motor starter. Starter and time clock by Electrical Contractor.

D. Acceptable Manufacturers: Armstrong, Bell and Gossett, Taco.

2.2 SUMP PUMP - SUBMERSIBLE

A. Pump: Simplex, submersible type, 2 in. discharge, bronze construction, non clog impeller, stainless steel shaft, capable of handling 5/8 in. solids, mechanical seal, minimum 50 gpm capacity.

B. Motor: Oil filled, permanent lubrication, automatic reset thermal overload, oil and water resistant power cord with plug, non-overloading throughout the pump curve.

C. Electric Control: Built-in automatic diaphragm-type pressure switch, completely prewired, requiring only receptacle for plug in power connection.

D. Basin: Basin and cover shall be provided by the General Contractor.

E. Refer to schedule on drawings for capacity and electrical characteristics.

F. Acceptable Manufacturers: Hydromatic, Goulds, Weil, Zoeller.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Pumps shall be installed, aligned and started in accordance with manufacturers written installation instruction.

B. Install pumps in locations to provide access for maintenance and replacement of parts.

C. Support pumps and piping separately so that piping does not support pumps.

D. Provide the services of a factory trained mechanic to start up the system based on factory recommendations. Provide Owner instruction at time of start up. Submit three (3) copies of start up report to the Owner's Representative.

E. All wiring for sewage ejector, sump pump(s) between control panel and junction box shall be continuous. No junction boxes allowed within pump basin.

3.2 HOT WATER CIRCULATING PUMP

A. Install shutoff valve and strainer on pump suction; check valve, balancing valve and shutoff valve in pump discharge. Install pressure gauge on suction and discharge piping. Adjust gpm of each circulating pump to capacity as noted.

3.3 SUMP PUMP

A. Install gate valve and check valve in discharge piping for each pump.

B. Simplex pump operation shall be completely automatic. Pressure style switch shall start and stop the pump at the factory set levels. Float style switches shall be adjusted to start and stop the pump at the specified levels.

C. Install liquid level control devices at proper elevation to produce specified sump drawdown. Secure control devices to discharge piping with corrosion resistant brackets and fasteners.

D. Install high water alarm and make electrical connections. Install liquid level control device at proper liquid depth. Secure control device to discharge piping with corrosion resistant brackets and fasteners.

3.4 TESTING

A. Test hot water recirculating pumps for operation.

B. Certify in writing that tests have been performed and the systems are properly operating. Submit three (3) copies of all test reports to the Owner's Representative.

END OF SECTION 221030

This page intentionally left blank

SECTION 221100 - WATER SUPPLY

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Provide labor, materials, equipment and services to perform operations required for the complete installation and related Work as required in Contract Documents.

1.2 QUALITY ASSURANCE

A. Follow all requirements, recommendations and appendices to comply with the following publications, codes, standards, and listings/approvals:

1. ANSI/AWWA C600: AWWA Standard for Installation of Ductile Iron Water Mains and Their Appurtenances.

2. NFPA 24: Standard for the Installation of Private Fire Service Mains and Their Appurtenances.

3. New York State Health Department.

4. Local municipality and fire department requirements and standards.

5. All items here-in used to convey water for potable use shall be lead free in accordance with NSF 61, Standard 61, Section 9 - Standard for Drinking Water and Lavatory Faucets and NSF Standard 372 - Maximum Lead Requirements. Compliance shall be via third party testing and certification.

1.3 SUBMITTALS

A. Provide submittals for all items specified under Part 2 of this Section.

PART 2 - PRODUCTS

2.1 WATER PIPING

A. Piping Materials: Refer to Specification Section 221010, "Piping Systems and Accessories" and Section 221020, "Underground Piping and Accessories".

2.2 WATER METER

A. Water Service: AWWA Standard. Obtain meter from local Water Authority. Pay all costs. Shall meet local Water Authority Standards.

1. Acceptable Manufacturers: Hersey, Rockwell, Trident, or approved equal.

2.3 BACKFLOW PREVENTERS AND ACCESSORIES

A. Reduced Pressure Type (Domestic Water - 2 in. and Smaller):

1. All bronze body construction, stainless steel bolts and internal parts, stainless steel check seats.

2. Four (4) test cocks, bronze strainer and full port ball valve shutoffs.

3. Design Equipment: Watts Series 909.

4. Acceptable Manufacturers: Ames, Febco, Wilkins, Watts.

B. Double Check Detector Assembly Type (Fire Service - 3 in. and Larger):

1. Cast iron body, stainless steel bolts and internal parts, removable bronze seats, epoxy coated.

2. Four (4) test cocks, OS&Y resilient wedge gate valves.

3. UL/FM listed and approved.

4. Same size as fire service.

5. Detector assembly consisting of an approved double check valve backflow preventer, approved water meter and shutoffs.

6. Design Equipment: Watts Series 709 DCDA.

7. Acceptable Manufacturers: Ames, Febco, Wilkins, Watts.

2.4 VACUUM BREAKERS

A. Atmospheric Type:

1. Lead free brass body, silicone disc, ASSE 1001, threaded inlet and outlet connections, polished chrome for finished areas.

2. Design Equipment: Watts Series #LF288-A

3. Acceptable Manufacturers: Watts, Conbraco, Zurn or approved equal.

B. Hose Connection Type:

1. Brass body, stainless steel working parts, rubber diaphragm and disc, drainable, non removable feature, polished chrome for finished areas.

2. Design Equipment: Watts #8A.

3. Acceptable Manufacturers: Watts, Conbraco, Zurn or approved equal.

PART 3 - EXECUTION

3.1 GENERAL

A. Coordinate work with all other trades and utility company.

B. Inspect pipe, fittings and equipment prior to installation. Remove all defective materials from the site.

C. Do not backfill until inspection by Owner's Representative.

D. Install pipe and equipment in accordance with manufacturer's recommendations and in a workmanlike manner as determined by the Owner's Representative.

3.2 WATER SERVICE

A. Install all piping on firm bed, using caution where piping passes over excavation. Provide concrete thrust blocks to support hydrant and prevent movement at all changes in direction of piping. Thrust blocks not required for Type K copper piping installation. Provide rods, clamps and retainer glands on all elbows and fittings in accordance with manufacturer's recommendations to prevent fitting from blowing off under line pressure. Coat all clamps, rods, nuts with two coats of bitumastic.

B. Minimum earth cover shall be 5 ft. - 0 in. unless otherwise noted.

C. Water mains crossing sanitary or storm sewers shall be installed to provide a minimum vertical distance of 1 ft. - 6 inches between the outside of the pipes where the water main is above or below the sewer. Locate the water pipe so that the crossing of the sewer occurs at the mid-section of a full length of pipe. The minimum horizontal separation between water mains and sewer mains shall be 10 ft. - 0 in. measured from the outside of the pipes. If separation or distance of joints from pipe crossing cannot be established, encase water piping in 6 in. concrete for a distance 10 ft. - 0 in. each side of crossing.

3.3 WATER METER

A. Provide pressure gauge on outlet side of meter. Provide line size strainer on inlet side of meter. Provide concrete base or pipe stands to support meter assembly. Provide bypass piping with sealed valve around meter.

B. The water meter assembly and piping arrangement shall be installed in accordance with the local Water Authority Standards.

3.4 BACKFLOW PREVENTERS

A. The backflow preventer installation shall be installed in accordance to the Health Department approved drawings.

B. Prior to installation of backflow preventers, obtain the approved drawings from the Engineer.

C. Provide hub style drain for emergency relief drain with a pipe separation of at least two (2) pipe diameters from backflow preventer relief outlet.

3.5 PIPING

A. Run slightly off level to low points; provide drain valves at low points. Provide shock absorbers where shown, or specified. Branch headers serving flush valves shall be full size as shown. Exposed water piping in Kitchen shall be chrome plated brass (from insulation to fixture or equipment connection.). Provide dielectric pipe fittings when connecting to piping systems of dissimilar metals. All supply piping to fixtures, faucets, hydrants and flush valves shall be anchored to prevent movement.

B. Provide shock absorbers where flush valves and quick closing valves are used as specified in Section 223010.

3.6 ARRANGEMENTS

A. Provide for application to and obtain approval from the local Water Authority for connection to municipal systems.

B. Contact the Water Authority for the extent of their work, the costs, fees, required permits and their installation requirements. Make all arrangements, pay all costs, fees and obtain all permits. Include all costs within the base bid.

3.7 CLEANING AND DISINFECTING

A. Refer to Specification Section 221010, "Piping Systems and Accessories" for domestic water piping cleaning and disinfecting requirements.

3.8 TESTS

A. Provide all necessary items to complete proper testing of work. Perform all testing in accordance with governing codes, local utilities and other agencies having jurisdiction and as specified. Pay all costs to perform tests. Perform all testing in a safe manner.

B. Upon completion of construction, all backflow prevention devices provided under this contract shall be tested. Tests shall be performed by a certified backflow preventer tester registered by the New York State Department of Health. Provide three (3) copies of Form DOH-1013 for each device with Part A completed by the tester. Submit forms to Engineer. Pay all costs required for testing devices, including administrative costs associated with satisfying the requirements and regulations of Water Authority and Health Department. Repair or replace any device failing the test and repeat the test.

C. Test each vacuum breaker according to authorities having jurisdiction and the device's reference standard.

D. Refer to Specification Section 221010, "Piping Systems and Accessories" for pipe testing requirements.

END OF SECTION 221100

SECTION 223010 - EQUIPMENT

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Provide labor, materials, equipment and services to perform operations required for the complete installation and related Work as required in Contract Document.

1.2 SUBMITTALS

A. Provide submittals for all items specified under Part 2 of this section.

PART 2 - PRODUCTS

2.1 FLOOR DRAINS

A. Drain Description: All Floor Drains Type A unless otherwise noted.

1. Type A: Cast iron body, flashing collar with weepholes, chrome plated, 7 in. diameter adjustable strainer; Jay R. Smith Figure #2010-A.

2. Type B: Cast iron body, flashing collar with weepholes, nickel bronze, 7 in. diameter adjustable strainer; Jay R. Smith Figure #2010-A.

B. Type C: Cast iron body, flashing collar with weepholes, nickel bronze 7 in. diameter adjustable strainer with separate oval funnel; Jay R. Smith Figure #2010-A with #3590 funnel Where floor drains are not installed in slabs on grade, provide flashing collar and flash with 24 in. square four (4) pound lead flashing or equal.

C. Make: Josam, Jay R. Smith, Mifab, Watts or Zurn.

2.2 FLOOR SINKS

A. Sink Description:

1. Type A: Acid resistant coated body with 12-1/2 in. square nickel bronze top, 8 in. deep with sediment bucket; Jay R. Smith Figure #3150.

B. Make: Josam, Jay R. Smith, Mifab, Watts or Zurn.

2.3 ROOF DRAINS

A. Drain Description: All Roof Drains Type A unless otherwise noted.

1. Type A: Coated cast iron body with round sump and flange, bottom threaded outlet, cast iron removable locking type dome, deck clamp, receiver, cast iron bolted flashing clamp ring integral with V-notched gravel stop with adjustable extension; Jay R. Smith Figure #1015.

2. Type B: Coated cast iron body with round sump and flange, bottom outlet, removable cast iron locking type dome, deck clamp, sump receiver, cast iron bolted flashing clam ring integral with V-notched gravel stop, adjustable extension, standpipe type water dam, no hub outlet; Jay R. Smith Figure #1074.

B. Expansion Joints:

1. Coated cast iron, bronze sleeve, packing gland, bolted pressure ring; Jay R. Smith Figure #1710.

C. Downspout Nozzles

1. Stainless steel type 304 downspout cover with hinged perforated cover. J.R. Smith Figure 1775

D. Make: Josam, Jay R. Smith, Mifab, Watts or Zurn.

2.4 CLEANOUTS

A. Floors: Cast iron body, nickel-bronze top with adjustable feature, bronze plug and flashing clamp where required, carpet marker and tile cover where applicable; Jay R. Smith Series #4028.

B. Walls: Cast iron ferrule, with bronze plug and stainless steel smooth access cover.

1. Horizontal: Jay R. Smith Figure #4402.

2. Vertical: Jay R. Smith Figure #4531.

C. Yard Cleanout:

1. Cast iron body, adjustable round heavy duty top, with tractor cover, vandal proof screws and bronze plug; Jay R. Smith Figure #4246.

D. Make: Josam, Jay R. Smith, Mifab, Watts or Zurn.

2.5 WALL HYDRANTS

A. Exposed type hose connection, lead-free, solder connection, nickel bronze face, quarter turn valve, nonfreeze type, 3/4 in. hose connection, self draining, integral vacuum breaker with vandal resistant cap, loose key control and wall clamp; Jay R. Smith Figure #5609QT.

B. #5509QT.

C. Make: Jay R. Smith, Prier, Watts, Woodford or Zurn.

2.6 ROOF HYDRANT

A. Non-freeze, post-type roof hydrant with ASSE 1052 dual check backflow preventer, underdeck clamp support, 1 in. water inlet, 3/4 in. hose connection and 1/8 inch drain port: Wood #RYH2-MS.

B. Make: Jay R. Smith, Watts, Woodford or Zurn.

2.7 HOSE BIBBS (INTERIOR)

A. Inside sill faucet, vacuum breaker, lead-free, solder connection, 3/4 in. hose thread outlet, lock shield cap, loose key control, flanged female inlet, polished chrome plate finish for finished rooms, rough chromium for unfinished rooms.

B. Make: Woodford Model 84, Prier, Chicago Faucets or Acorn in finished room; Chicago Faucets #998 in Mechanical Rooms, Boiler Room, Penthouse, or other unfinished rooms.

2.8 SHOCK ABSORBERS

A. Hydropneumatically controlled with permanently sealed expansion chamber pre-charged with non-combustible gas; lead-free, threaded connection, meets or exceeds Plumbing and Drainage Institute Standard PDI WH-201 and ASSE Standard 1010.

1. Bellows Type: Stainless steel construction with stainless steel bellows.

2. Piston Type: Hard drawn copper body with brass piston, cap and adapter, and elastomer seals.

B. Elastomer or rubber compound type bellows not allowed.

C. Make: Watts #LF15M2, Precision Plumbing Products, Jay R. Smith, or Zurn.

2.9 TRAP GUARDS

A. Elastomeric, normally closed seal to prevent evaporation of P-traps. Inserts into throat of floor drain. Provide for each new floor drain.

B. Make: ProVent Systems, Inc. "ProSet Trap Guard".

2.10 WATER PRESSURE GAUGES

A. Construction to be Bourdon tube type; 4-1/2 in. diameter, minimum dial face, stamped stainless steel, replaceable glass lens, with snap-on rings. Phosphor bronze tube, bronze bushed rotary movement, silver brazed or soldered to brass socket and brass tip, 1/4 in. bottom connection. Accuracy, on (1.0) percent of included scale range. White dial face with black numerals, graduated in pounds; equipped with bronze pulsation dampener or snubber and needle valve.

B. Make: Trerice, Weiss, Weksler, Winters.

2.11 PIPING SYSTEM THERMOMETERS

A. Industrial type, plastic, aluminum or steel case, glass or plastic front, non-toxic organic liquid filled, red reading column, white or silver V-shaped scale, black numerals. Union flange mounted, separable socket with thermowell, extension necks were required; range as called for service. Universal adjustable type, 9 in. scale. For installation in water systems where the maximum temperature is less than 120°F, graduations of 1°F, accurate to within 1/2°F. For installation greater than 120°F, graduations of 2°F, accurate to within 1°F.

B. Make: Trerice, Weiss, Weksler, Winters.

2.12 TEMPERATURE MIXING VALVE - HIGH/LOW TYPE

A. Valve shall mix 140°F hot water with 40°F cold water to obtain a water outlet temperature of 130°F. The valve shall consist of the following:

1. High/low style, single thermostatic mixing valve with an inlet and outlet size and floa capacity as per schedules on plumbing drawings.

2. Combination strainer check stops with union at each inlet, union on outlet, tamper resistant temperature adjustment control.

3. Provide valves on hot, cold and tempered water piping with fittings, nipples, trim piping and escutcheon plates. Horizontal stem dial thermometers on hot, cold and tempered water piping.

4. Rough bronze lead free mixing valve and trim exposed on wall.

B. Make: Powers Series LFSH 1430, Leonard, or Symmons.

2.13 LAUNDRY UTILITY BOX

A. Guy Gray, washing machine supply and drain fitting with hot and cold water 1/2 in. sweat shutoff valves, 2 in. drain connection and 20 amp/120 volt GFCI duplex receptacle in 20 gauge galvanized steel cabinet with faceplate.

B. Provide vacuum breakers on each hose connection.

PART 3 - EXECUTION

3.1 EQUIPMENT CONNECTIONS

A. Plumbing Contractor shall:

1. Provide all roughing and final water, waste, vent, gas, air, vacuum, diesel and/or oxygen connections to all equipment requiring same as called for on Contract Documents.

2. Refer to Contract Documents for roughing schedules, and equipment and lists indicating scope of connections required.

3. Provide loose key stops, "P" traps, tailpieces, adapters, gas or air cocks and all necessary piping and fittings from roughing point to equipment.

4. Provide for installation of sinks, faucets, traps, tailpieces provided by an Equipment Contractor. These items to be delivered, in easily identified cartons, to the proper room for Contractor's installation.

5. Install controls and devices furnished by others.

6. Provide cold water line with gate valve and backflow prevention device at locations called for. Continuation and connection to equipment by others.

7. Install relief valve discharge piping from equipment relief valves.

8. Provide for Owner furnished equipment:

   a. Connect complete and ready for use, including all valves, piping, piping accessories, traps, pressure reducing valves, gauges, relief valves, vents, drains, insulation, sheet metal work, controls, dampers, etc., as required by Owner.

   b. Refer to manufacturer Drawings and Specifications for requirements of Kitchen Equipment. Verify connection requirements before bidding.

3.2 ROOF DRAINS

A. Install according to manufacturer's written installation instructions.

B. Clean drains and strainers just prior to final inspection.

C. Provide expansion joints for roof drains located more than 25 ft. - 0 in. above finished floor.

3.3 CLEANOUTS

A. Install cleanouts out of traffic patterns and flush to floor. Provide offset from sanitary line served. Do not locate under doors or under lockers. Maintain distance between cleanouts on piping 4 in. and smaller, 50 ft.; over 4 in., 100 ft. At changes in direction greater than 45°. Install at base of soil, waste, vent, stacks and roof conductors and where called for.

B. Cleanouts: Same nominal size as pipe, but not larger than 4 in.

3.4 WALL HYDRANTS

A. Install minimum 24 in. above grade.

3.5 HOSE BIBBS

A. Install at low points of piping system.

3.6 SHOCK ABSORBERS

A. Install in vertical position.

3.7 THERMOMETERS

A. Provide on piping system where called for and shown, with thermometer well at each location, mounted in oversize tee or elbow to provide as little restriction as possible to fluid flow, stems or proper length to allow accurate reading. Arrange to be easily read from floor.

B. Select range such that the maximum system working temperature is in the middle one-third of the scale.

3.8 PRESSURE GAUGES

A. Provide in piping system where called for and shown, with needle valve and pulsation damper or snubber at each location. Arrange to be easily read from the floor.

B. Select range such that the maximum system working temperature is in the middle one-third of the scale.

3.9 TEMPERATURE MIXING VALVE

A. Provide where called for. Provide 2 ft. - 0 in. deep heat trap on hot water supply line ahead of connection to mixing valve.

B. Provide factory-trained technician to start up, adjust and inspect the mixing valve and piping for correct installation and temperature adjustment.

END OF SECTION 223010

SECTION 223200 - COMPRESSED AIR AND VACUUM EQUIPMENT

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Provide labor, materials, equipment and other services to perform operations required for the complete installation and related work as required in the Contract Documents.

B. Equipment listed in this section shall be used for laboratory and general use only.

1.2 SUBMITTALS

A. Submit shop drawings for all items specified in this section under Part 2 - Products.

1.3 EQUIPMENT MANUFACTURER

A. All system equipment specified under this section shall be provided by the same supplier.

B. Make arrangements for supplier's representative to supervise, inspect and test installation to assure system operates as specified.

PART 2 - PRODUCTS

2.1 DISTRIBUTION PIPING

A. Refer to Specification Section 221010, "Piping Systems and Accessories".

B. Connections: All brazed connections except valves or equipment requiring threaded connections.

C. Fittings:

1. Vacuum: Long-turn drainage pattern, brazing type fittings.

2. Compressed Air: Brazing type fittings.

2.2 VALVES

A. Refer to Specification Section 220523, "Valves".

2.3 COMPRESSED AIR SYSTEM

A. Provide Ingersoll-Rand Model 7100E15, or equivalent Quincy or Champion, simplex rotary screw compressor rated to produce 51.0 ACFM at 90 psig, and a maximum pressure of 175 psi. The compressor shall be mounted on a horizontal tank. Motor shall be 15 HP, 60 Hz.

1. Receiver shall be ASME rated for 150 psig working pressure with liquid level gauge glass, safety relief valve, manual drain valve and a timed automatic solenoid drain valve. Tank shall be horizontal with a capacity of 120 gallons.

2. Automatic start and stop operation with NEMA 1 pressure switch and all standard controls, starting unloader, factory mounted starter/disconnect and Hand-Off-Automatic selector switch. Provide two (2) year warranty.

B. Refrigerated Dryer:

1. General: Provide Ingersoll-Rand Model D85EC refrigerated air dryer or approved equal capable of reducing the temperature of 50 SCFM air at 100 psig to a pressure dew point (33°F to 39°F). Include with automatic drain valve.

2. Dryer shall incorporate a hermetically sealed air cooled refrigeration compressor/condenser and liquid refrigerant filter dryer.

3. Dryer shall be equipped with a panel mounted evaporator light, power-on light and pre-wired power cord.

4. Electrical Requirements: 115 volts, 60 Hz, single phase.

C. Air Filters:

1. Provide Ingersoll-Rand Model FA110I high efficiency oil removal filtration filter to remove water, solids and oils from 65 SCFM of air at 100 psig and capable of removing particles as small as 0.01 micron.

D. Pressure Regulating Valves:

1. 2 in. and Smaller: Bronze body with threaded ends, bronze trim, brass strainer screen, neoprene diaphragm and steel pressure spring.

2. Design Equipment: Cash Acme No. E-55, arranged for compressed air.

PART 3 - EXECUTION

3.1 PIPING INSTALLATION

A. Installations:

1. All work in this section shall be done in accordance with the equipment manufacturer's installation instructions and the latest applicable Codes and NFPA requirements.

2. Provide rigid supports for all valves and equipment to avoid strain on piping.

B. Cleanouts:

1. Install cleanouts in vacuum piping at the top of each riser, at all 90° turns, etc. Use only "Y" type fittings; tees are not acceptable.

3.2 TESTING

A. After installation of tubing but before connecting to system components, test piping sections with a minimum 150 psig of oil free dry nitrogen.

1. Test each joint for leaks by means of soap suds.

2. All leaks shall be located, repaired and piping retested.

3.3 EQUIPMENT START-UP

A. Provide equipment start-up services by a factory-authorized technician based on factory recommendations. Technician shall inspect the work for proper installation, operation and to confirm specified operating parameters. Submit three (3) copies of startup reports with all factory checkout data in writing to the Owner's Representative.

END OF SECTION 223200

This page intentionally left blank

SECTION 223400 - WATER HEATERS

PART 1 - GENERAL

1.1 SCOPE OF WORK

A. Work of this section shall be performed in accordance with the requirements of the Contract Documents, including but not limited to Instructions to Bidders, Agreement and General Conditions, General Requirements and Basic Mechanical/Electrical Requirements.

B. Provide labor, materials, equipment and services to perform work and related work required by Contract Documents for a complete operating system.

1.2 SUBMITTALS

A. Submit manufacturer's data for approval in accordance with Basic Mechanical/Electrical Requirements. Obtain approval prior to ordering material.

B. Provide submittals for all products to be installed including, but not limited to:

1. Water Heater.

2. Tank Protective Valves.

3. Expansion Tank.

4. All Heater and Tank Accessories.

5. All System Wiring Diagrams.

6. Tank Lining.

7. Condensate Neutralizer Kit.

1.3 SPECIAL COORDINATION

A. Coordinate all work of other trades in Plumbing Room.

B. Furnish Division 26 "Electric" with dimensional drawings showing location of electrical connections, location of equipment mounted on walls, and of other equipment requiring electrical connections, removals or replacements.

PART 2 - PRODUCTS

2.1 WATER HEATER COMMERCIAL GAS-FIRED, CONDENSING TANK TYPE

A. Refer to drawing schedules for capacities and recovery rates.

B. Provide units with 94% minimum thermal efficiency and sealed, submerged combustion chamber. Provide units with zero clearance capabilities from combustibles. Provide units with power burner and diagnostic electronic controls. Modulating burner with 5:1 turndown.

C. Provide AGA rated, ASME stamped temperature and pressure relief valve. Pipe to drain.

D. Provide venting as per detail conventional vertical using 4 in. AL-294C stainless steel construction. Terminations per code.

E. Provide condensate drain for exhaust elbow.

F. Provide condensate neutralizer for drain.

G. Provide a three (3) year warranty against tank leakage.

H. Provide start up report from factory authorized service agent to include combustion efficiency, safety and operating control check and verification of proper venting.

I. Design Equipment: AO Smith Cyclone

J. Acceptable Manufacturers: State, Heat Transfer Products "Phoenix" or approved equal.

2.2 THERMAL EXPANSION TANK

A. Vertical steel expansion tank constructed and designed per ASME Code Section VIII, 125 PSI working pressure, steel outer shell, rigid polypropylene liner, heavy duty butyl rubber diaphragm and non-ferrous system connection tapping, suitable for potable hot water. Refer to drawing schedules for sizes and capacities.

B. Design Equipment: Watts.

C. Acceptable Manufacturers: Amtrol, Watts, Wessel or approved equal.

2.3 TANK PROTECTIVE VALVES

A. Pressure Relief Valves:

1. ASME stamped and rated.

2. Open at 125 lbs. pressure sized for full heating capacity.

3. Make: Bell & Gossett, Kunkle, Watts or approved equal.

B. Temperature and Pressure Relief Valve:

1. ASME stamped and rated (for steam or hot water).

2. Size for full heat input.

3. Complying with Federal Spec. MIL-V-13612C.

4. Valve shall be sized and selected by manufacturer for tank and heater installed.

5. Make: Camco, Cash-Acme, Watts, or approved equal.

PART 3 - EXECUTION

3.1 WATER HEATERS

A. Install each heater on a 6 in. high concrete pad.

B. Pipe pressure and temperature relief valve drain to discharge to nearest floor drain.

C. Provide all electric wiring and equipment in accordance with manufacturer's wiring diagrams and instructions. Make all final connections.

D. Provide all piping, valves and fittings in accordance with manufacturer's piping instructions. Make all final connections.

E. Provide equipment in accordance with contract drawings and all local codes.

F. Provide gas pressure regulator when inlet gas pressure exceeds 14 in. w.c.

G. Provide start-up services of a factory trained technician to inspect the installation based on factory recommendations. Items include but are not limited to:

1. Verification of proper piping arrangement.

2. Fuel supply piping and connection(s).

3. Combustion efficiency.

4. Verification of proper temperature rise across heater(s).

5. Verification of proper venting with draft reading.

6. Operating and safety controls.

7. Proper operation of equipment.

8. Verification of piping arrangement and aquastat location.

9. Verification of proper gas pressure to unit and to burners.

10. Relief valve settings and AGA BTU capacities.

11. All control settings.

H. Submit three (3) copies of startup reports in writing with all factory checkout data signed by the factory authorized service agent to the Owner's Representative.

I. Place equipment in operation.

J. The installation of water heaters shall be based on the details shown on the drawings and specified in this Section. Approved water heaters provided other than type shown or specified shall be installed in accordance with manufacturer's recommended installation instructions and piping diagrams.

3.2 CONDENSATE NEUTRALIZERS

A. Verify if condensate neutralizer is available from factory to be provided with water heater to site.

B. Install unit with 1/2 in. polyethylene tubing or piping in accordance with the water heater manufacturer's recommendations.

END OF SECTION 223400

SECTION 224000 - PLUMBING FIXTURES AND TRIM

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Provide labor, materials, equipment and services to perform operations required for the complete installation and related Work as required in Contract Documents.

1.2 SUBMITTALS

A. Submit manufacturer's data in accordance with Basic Mechanical/Electrical Requirements. Obtain approval prior to ordering material.

B. Provide submittals for all items specified under Part 2 - Products of this section.

1.3 DESCRIPTION OF FIXTURES

A. Fixtures and trim shall be of those manufacturers listed, unless otherwise indicated. Fixtures for this project shall be of same manufacturer.

1. Fixtures: American Standard, Kohler, Mansfield, Sloan, Toto, Watts or Zurn.

2. Faucets: Chicago Faucets, Delta, Moen, Symmons, T&S Brass or Zurn. All faucets shall be lead-free in accordance with NSF 61 and NSF 372.

3. Flushometers: Sloan "Regal XL" or Zurn.

4. Closet Seats: Bemis, Beneke, Church or Olsonite.

5. Fixture Carriers: Jay R. Smith, Watts, Wade, Josam or Zurn.

6. Sinks: Elkay, Just or Kohler.

7. Water Coolers: Elkay, Halsey Taylor or Haws.

8. Supplies, Stops and Traps: Brasscraft, EBC, McGuire or Sanitary Dash.

B. Exposed parts of trim shall have polished chrome plated finish.

C. Tubular drainage products ("P" traps, nipples, etc.) shall be 17 gauge brass.

1.4 QUALITY ASSURANCE

A. Comply with requirements of the Plumbing Fixture Law of the New York State Department of Environmental Conservation.

B. Comply with the American Disabilities Act Guidelines and ANSI A117.1 "Accessible and Usable Buildings and Facilities".

C. All items here-in used to convey water for potable use shall be lead free in accordance with NSF Standard 61, Section 9 Standard for Drinking Water and Lavatory Faucets and NSF Standard 372 - Maximum Lead Requirements. Compliance shall be via third-party testing and certification.

D. All fixture trim used to convey water for potable use shall be lead free.

PART 2 - PRODUCTS

2.1 WATER CLOSETS

A. WC-A:

1. American Standard #2257.101 Afwall, wall hung, vitreous china, siphon jet, elongated bowl, 1.28 GPF, fully glazed 2 in. ball pass trapway, with 1-1/2 in. top spud, fitted with following:

a. FV-A flush valve as specified herein.

b. Church #9500SSC, extra heavy weight, white elongated solid plastic, open front closet seat with combination self-sustaining check hinges, less cover.

c. Jay R. Smith Series 200 closet fittings and carrier.

B. WC-B (HDCP):

1. American Standard #2257.101 Afwall, wall hung, vitreous china, siphon jet, elongated bowl, 1.28 GPF, fully glazed 2 in. ball pass trapway, with 1-1/2 in. top spud, fitted with following:

a. FV-A flush valve as specified herein.

b. Church #9500SSC, extra heavy weight, white elongated solid plastic, open front closet seat with combination self-sustaining check hinges, less cover.

c. Jay R. Smith Series 200 closet fittings and carrier.

d. Mount at ADA required height and location or as shown on Architectural drawings.

C. WC-C:

1. American Standard #2257.101 Afwall, wall hung, vitreous china, siphon jet, elongated bowl, 1.28 GPF, fully glazed 2 in. ball pass trapway, with 1-1/2 in. top spud, fitted with following:

a. FV-B flush valve as specified herein.

b. Church #9500SSC, extra heavy weight, white elongated solid plastic, open front closet seat with combination self-sustaining check hinges, less cover.

c. Jay R. Smith Series 200 closet fittings and carrier.

d. Mount at ADA required height and location or as shown on Architectural drawings.

2.2 FLUSH VALVES

A. FV-A: Sloan Royal #1111.6-HW, , sensor operated, hard wired powered, closet flushometer, for left or right hand supplies, exposed diaphragm type, 1 in. screwdriver angle stop with vandal resistant metal cap and replaceable sensor window, bumper on stop, vacuum breaker, adjustable tailpiece, sweat solder adaptor kit and cast wall flange with set screw, override button, with adjustable sensor on centerline of fixture and two (2) chrome plated double gang box covers with vandal resistant screws.

1. Solenoid extension nipple option to protect low voltage wiring from wall plate to solenoid.

2. Sloan #EL-485-A flushometer electrical box positioning and support kit.

3. Sloan #EL-154 120 volt transformer. Refer to plans for locations and quantity required.

4. Plumbing Contractor shall furnish transformer(s) and provide low voltage wiring. Electrical Contractor shall install transformer(s) and provide power to transformer.

B. FV-B: Sloan #BPW-8150 , bedpan washer closet flushometer, 1.6 GPF, exposed diaphragm type, 1 in. screwdriver angle stop with vandal resistant cap, two wall bumpers, vacuum breaker, adjustable tailpiece, sweat solder adaptor kit, cast wall flange with set screw, ADA compliant handle and bedpan washer diverter assembly.

1. Solenoid extension nipple option to protect low voltage wiring from wall plate to solenoid.

2. Sloan #EL-518-A flushometer electrical box positioning and support kit.

3. Sloan EL-154 transformer. Refer to plans for quantity required.

4. P.C. shall furnish transformer(s) and provide low voltage wiring. E.C. shall install transformer(s) and provide power to transformer.

2.3 LAVATORIES

A. LV-A (HDCP):

1. Sloan BASYS AER-DEC one station wall mounted sink, Corian finish, deck mounted hand dryer, soap dispenser , concealed arm carrier, fitted with following:

a. F-A faucet as specified herein.

b. McGuire #155WC offset chrome plated P.O. plug with open grid strainer and 1-1/4 in., 17 gauge offset tailpiece.

c. McGuire #8902 chrome plated, 17 gauge, 1-1/4 in. x 1-1/2 in. "P" trap with cleanout plug and cast brass escutcheon with set screw.

d. McGuire # LF165LKF, lead-free, 3/8 in. chrome plated wall supplies with loose key angle stops, 12 in. long flexible risers, cast brass escutcheon with set screws.

e. Jay R. Smith Series 700 concealed arm floor mounted carrier with rectangular uprights.

f. Cover exposed waste, stops and supply piping with ADA conforming pipe covers, Truebro, Inc. "Lav-Guard".

g. Mount at ADA required height and location or as shown on Architectural drawings.

B. LV-B (HDCP):

1. Sloan BASYS AER-DEC two station wall mounted sink, Corian finish, deck mounted hand dryer, soap dispenser , concealed arm carrier, fitted with following:

a. F-A faucet as specified herein.

b. McGuire #155WC offset chrome plated P.O. plug with open grid strainer and 1-1/4 in., 17 gauge offset tailpiece.

c. McGuire #8902 chrome plated, 17 gauge, 1-1/4 in. x 1-1/2 in. "P" trap with cleanout plug and cast brass escutcheon with set screw.

d. McGuire # LF165LKF, lead-free, 3/8 in. chrome plated wall supplies with loose key angle stops, 12 in. long flexible risers, cast brass escutcheon with set screws.

e. Jay R. Smith Series 700 concealed arm floor mounted carrier with rectangular uprights.

f. Cover exposed waste, stops and supply piping with ADA conforming pipe covers, Truebro, Inc. "Lav-Guard".

g. Mount at ADA required height and location or as shown on Architectural drawings.

C. LV-A (HDCP):

1. Sloan BASYS AER-DEC three station wall mounted sink, Corian finish, deck mounted hand dryer, soap dispenser, concealed arm carrier, fitted with following:

a. F-A faucet as specified herein.

b. McGuire #155WC offset chrome plated P.O. plug with open grid strainer and 1-1/4 in., 17 gauge offset tailpiece.

c. McGuire #8902 chrome plated, 17 gauge, 1-1/4 in. x 1-1/2 in. "P" trap with cleanout plug and cast brass escutcheon with set screw.

d. McGuire # LF165LKF, lead-free, 3/8 in. chrome plated wall supplies with loose key angle stops, 12 in. long flexible risers, cast brass escutcheon with set screws.

e. Jay R. Smith Series 700 concealed arm floor mounted carrier with rectangular uprights.

f. Cover exposed waste, stops and supply piping with ADA conforming pipe covers, Truebro, Inc. "Lav-Guard".

g. Mount at ADA required height and location or as shown on Architectural drawings.

2.4 SINKS

A. SK-A:

1. Elkay Lustertone LR2219, 22 in. x 19 in., 7-5/8 in. deep, nickel type 304 stainless steel single bowl sink, three (3) faucet holes, 18 gauge, self rimming, fitted with the following:

a. F-B faucet as specified herein.

b. Elkay #LK-18 stamped brass drain outlet with 3 in. perforated grid strainer and 1-1/2 in. O.D. tailpiece.

c. McGuire #8912 semi-cast brass adjustable "P" trap, 1-1/2 in. x 1-1/2 in., with cleanout plug and cast brass escutcheon with set screw.

d. McGuire #LF2167LKF, lead-free, 1/2 in. supplies with 1/2 in. O.D. flexible risers, loose key stops and cast brass escutcheons with set screws.

B. SK-B (HDCP):

1. Elkay Lustertone LRAD2219, 22 in. x 19 in. x 6 in. deep, nickel type 302 stainless steel single bowl sink, ADA compliant, three (3) faucet holes, 18 gauge, self rimming for countertop installation, fitted with the following:

a. F-B faucet as specified herein.

b. Elkay #LKAD18 stamped brass drain outlet with 3 in. perforated grid strainer and LKADOS 1-1/2 in. O.D. offset tailpiece.

c. McGuire #8912 semi-cast brass adjustable "P" trap, 1-1/2 in. x 1-1/2 in., with cleanout plug and cast brass escutcheon with set screw.

d. McGuire #LF2167LKF, lead-free, 1/2 in. copper sweat supplies with 1/2 in. OD flexible risers, loose key stops and cast brass escutcheons with set screws.

C. SK-C (HDCP):

1. Elkay Lustertone LRAD2219, 22 in. x 19 in. x 6 in. deep, nickel type 302 stainless steel single bowl sink, ADA compliant, three (3) faucet holes, 18 gauge, self rimming for countertop installation, fitted with the following:

a. F-B faucet as specified herein.

b. Elkay #LKAD18 stamped brass drain outlet with 3 in. perforated grid strainer and LKADOS 1-1/2 in. O.D. offset tailpiece.

c. McGuire #8912 semi-cast brass adjustable "P" trap, 1-1/2 in. x 1-1/2 in., with cleanout plug and cast brass escutcheon with set screw.

d. McGuire #LF2167LKF, lead-free, 1/2 in. copper sweat supplies with 1/2 in. OD flexible risers, loose key stops and cast brass escutcheons with set screws.

e. EEW-B: Bradley S19274C Swing-Activated Halo Eyewash with S19-20000 EFX8 Emergency Thermostatic mixing valve and thermometer below counter.

D. SK-D:

1. Elkay Dependabilt Stainless Steel, 39” x 25-13/16” x 43-3/4”, two compartment, 18 gauge, center drain location, fitted with the following:

   a. F-C faucet as specified herein.

   b. Elkay #LK35 strainer with removable cup, tailpiece.

   c. McGuire #8912 semi-cast brass adjustable "P" trap, 1-1/2 in. x 1-1/2 in., with cleanout plug and cast brass escutcheon with set screw.

   d. McGuire #LF2167LKF, lead-free, 1/2 in. copper sweat supplies with 1/2 in. OD flexible risers, loose key stops and cast brass escutcheons with set screws.

E. SK-E:

1. Elkay Sturdibilt Stainless Steel, 27” x 27-1/2” x 14”, one compartment, 18 gauge, center drain location, fitted with the following:

   a. F-C faucet as specified herein.

   b. Elkay #LK35 strainer with removable cup, tailpiece.

   c. McGuire #8912 semi-cast brass adjustable "P" trap, 1-1/2 in. x 1-1/2 in., with cleanout plug and cast brass escutcheon with set screw.

   d. McGuire #LF2167LKF, lead-free, 1/2 in. copper sweat supplies with 1/2 in. OD flexible risers, loose key stops and cast brass escutcheons with set screws.

F. SK-F (HDCP):

1. Durcon Epoxy Resin drop-in sink, 25” x 15” x 4.75”, ADA compliant, fitted with the following:

   a. F-B faucet as specified herein.

   b. Durcon S03 Epoxy Resin sink outlet

   c. LKADOS 1-1/2 in. O.D. offset tailpiece.

   d. McGuire #8912 semi-cast brass adjustable "P" trap, 1-1/2 in. x 1-1/2 in., with cleanout plug and cast brass escutcheon with set screw.

   e. McGuire #LF2167LKF, lead-free, 1/2 in. copper sweat supplies with 1/2 in. OD flexible risers, loose key stops and cast brass escutcheons with set screws.

G. SK-C (HDCP):

1. Durcon Epoxy Resin drop-in sink, 25” x 15” x 4.75”, ADA compliant, fitted with the following:

a. F-B faucet as specified herein.

b. Durcon S03 Epoxy Resin sink outlet

c. LKADOS 1-1/2 in. O.D. offset tailpiece.

d. McGuire #8912 semi-cast brass adjustable "P" trap, 1-1/2 in. x 1-1/2 in., with cleanout plug and cast brass escutcheon with set screw.

e. McGuire #LF2167LKF, lead-free, 1/2 in. copper sweat supplies with 1/2 in. OD flexible risers, loose key stops and cast brass escutcheons with set screws.

f. EEW-B: Bradley S19274C Swing-Activated Halo Eyewash with S19-20000 EFX8 Emergency Thermostatic mixing valve and thermometer below counter.

2.5 FAUCETS

A. F-A:

1. Sloan BASYS EFX-200 solid cast brass electronic sensor faucet, hardwired, deck mounted, lead-free, cover plate, vandalproof non-aerating spray outlet, stainless steel braided hose supply, ADA compliant and fitted with the following:

a. 0.50 GPM aerator.

b. Chicago #131-ABNF, lead-free, thermostatic mixing valve, 3/8 in. connections.

c. 12 volt AC transformer.

d. ADA compliant.

B. F-B: Chicago Faucets #895-317FCABCP, lead-free manual close faucet, quarter-turn cartridges, deck mounted, 4 in. centers, 4 in. wrist blade handles with color coded indexes, rigid/swing plain end gooseneck spout with 1.5 GPM laminar flow control device in spout base, ADA compliant.

1. Chicago #131-ABNF, lead-free, thermostatic mixing valve, 3/8 in. connections.

C. F-C: American Standard 8351.076 Exposed yoke wall mounted utility faucet, 3” cast brass spout with vacuum breaker, ceramic disk valves, integral supply stops, with bucket hook, 8” centers

2.6 MOP BASINS

A. MB-A:

1. Fiat Model TSB, terrazzo, 36 in. x 36 in. x 12 in. deep, stainless steel flat strainer, 3 in. outlet, stainless steel cap on all sides, color as selected by the Architect, with the following:

a. T&S Brass #B-0665-BSTP, lead-free, exposed wall mounted faucet with integral stops, rough chrome finish, lever handles, top-brace spout with bucket hook, hose end and vacuum breaker.

b. Fiat # 832AA Hose and Hose Bracket.

c. Fiat #889CC Mop Hanger.

d. Fiat # E77AA Vinyl Bumper guard on exposed sides.

e. Fiat #MSG Stainless Steel Wall Guard.

f. Provide silicone sealant between wall, floor and mop basin.

2.7 SHOWERS

A. Type "A": Shower areas will be constructed and tiled by others. This Contractor shall provide the following trim and base for each shower.

1. Powers #413 "Hydroguard" mixing valve, pressure balanced type, chrome plated, metal lever and escutcheon plate, maximum temperature stop, one piece dial and lever assembly, checkstops on inlets.

2. Powers #141-376 showerhead, ball joint, self-cleaning showerhead with sturdy all brass construction and chrome plated finish: full range spray pattern adjustment, 2.5 gpm flow control with #141-198 chrome plated brass shower arm and wall flange.

3. Fiat receptor, Model MFT, 36 in. x 36 in. integral threshold, tilting flange, precast Terrazzo. Drain body, cast integral, caulked lead connection, 2 in. drain, stainless steel strainer.

B. Type "B": Shower areas will be constructed and tiled by others. This Contractor shall provide the following trim for each shower.

1. Powers "Hydroguard" Type #413 mixing valve, pressure balanced type, chrome plated, metal lever and escutcheon plate, maximum temperature stop, one piece dial and lever assembly, checkstops on inlets.

2. Powers "Institutional Ball Joint Showerhead" #141-337, chrome plated, spray adjustment, 2.5 gpm flow control, vandal resistant, rigid wall mounted head bracket with anchor plate and mounting screws.

2.8 EMERGENCY EYE WASH

1. EEW-A: Bradley S19224 Series Wall-mount Halo Eye/face wash station. Provide with Navigator S19-2000 EFX8 Emergency Thermostatic Mixing Valve with thermometer. Include with 316 stainless steel bowl and cover.

2.9 ELECTRIC WATER COOLER

A. EWC-A:

1. Elkay #LZSTL8WSSK two level wheelchair access model, wall mounted, ADA compliant, lead-free construction, type 304 stainless steel cabinet, one piece stainless steel basin, flexible bubbler, self-closing front and side push bar control on each side with in-line stream regulator, adjustable temperature control, permanently sealed and lubricated fan motor, hermetically sealed compressor and motor, 1/5 hp, 120V, capacity of 8.0 GPH at 80°F inlet water, 50°F outlet water with room temperature of 90°F, with optional #LKAPREZL apron, included with LZWSR Bottle Filler, fitted with the following:

a. McGuire #LF165LKE, lead-free, 3/8 in. lavatory wall supply with loose key angle stop, 3/8 in. flexible tube riser, cast brass escutcheon with set screw.

b. McGuire #8902, 1-1/4 in. x 1-1/2 in. semi-cast brass "P" trap with cleanout and cast brass escutcheon with set screw.

c. Jay R. Smith floor mounted carrier with rectangular uprights.

d. Acceptable Manufacturers: Elkay, Halsey Taylor.

B. EWC-B:

1. Elkay #LZS-8S, wall mounted, ADA compliant, lead-free construction, type 304 stainless steel cabinet, one piece stainless steel basin, flexible bubbler, self-closing front and side push bar control with in-line stream regulator, adjustable temperature control, permanently sealed and lubricated fan motor, hermetically sealed compressor and control, 1/5 HP, 120V, capacity of 8.0 gph at 80°F inlet water, 50°F outlet water with room temperature of 90°F, fitted with the following:

a. McGuire #LF165LKE, lead-free, 3/8 in. lavatory wall supply with loose key angle stop, 3/8 in. flexible tube riser, and cast brass escutcheons with set screws.

b. McGuire #8902, 1-1/4 in. x 1-1/2 in. semi-cast brass "P" trap with cleanout and cast brass escutcheon with set screw.

c. Jay R. Smith floor mounted carrier with rectangular uprights.

d. Acceptable Manufacturers: Elkay, Halsey Taylor.

C. BF-A:

1. Elkay #LZ8WSSSMC Bottle Filling Station, wall mounted, ADA compliant, lead-free construction, type 304 stainless steel cabinet, one piece stainless steel basin, adjustable temperature control, permanently sealed and lubricated fan motor, hermetically sealed compressor and motor, 1/5 hp, 120V, capacity of 8.0 GPH at 80°F inlet water, 50°F outlet water with room temperature of 90°F, , fitted with the following:

a. McGuire #LF165LKE, lead-free, 3/8 in. lavatory wall supply with loose key angle stop, 3/8 in. flexible tube riser, cast brass escutcheon with set screw.

b. McGuire #8902, 1-1/4 in. x 1-1/2 in. semi-cast brass "P" trap with cleanout and cast brass escutcheon with set screw.

c. Jay R. Smith floor mounted carrier with rectangular uprights.

d. Acceptable Manufacturers: Elkay, Halsey Taylor.

PART 3 - EXECUTION

3.1 FIXTURES, EQUIPMENT AND SYSTEMS

A. Install fixtures, equipment and systems as shown on Drawings or specified herein in accordance with provisions of each applicable Specification Section and all local and state codes having jurisdiction.

3.2 INSTALLATION OF PLUMBING FIXTURES

A. Install plumbing fixtures level and plumb, in accordance with fixture manufacturers written installation instructions.

B. Carefully drill holes for through bolts to avoid chipping blocks or plaster.

C. Except where carriers are specified, attach hangers or brackets to walls as follows:

1. Masonry Construction: Secure fixture hangers to partition by thru-bolts extending through a steel plate on opposite side of partition. Obtain Owner's Representative's approval prior to work.

2. Metal Stud Construction: Anchor backing for fixtures or equipment to 1/8 in. x 12 in. steel plate bolted or riveted to at least three studs. Obtain Owner's Representative's approval prior to work.

D. Anchor carriers to concrete floor with 1/2 in. x 3 in. anchor or thru-bolts and washers. Provide for drilling of floor and installation of expansion shields. Quantity of anchors:

1. Water Closets - Four (4).

2. Lavatories - Eight (8).

3. Urinals - Eight (8).

E. Seal fixtures in contact with walls, floors and counters using a sanitary-type, one-part, mildew-resistant, silicone caulk. Match color to fixture color.

F. Set self-rimming lavatories and sinks in a bed of silicone caulk.

G. Install floor-mounted, floor-outlet water closets with closet flanges and gasket seals.

H. Install wall-hanging, back-outlet water closets with support manufacturer's tiling frame or setting gage.

I. Install wall-hanging, back-outlet urinals with gasket seals.

J. Fasten wall-hanging plumbing fixtures securely to supports attached to building substrate when supports are specified and to building wall construction where no support is indicated.

K. Fasten counter-mounting-type plumbing fixtures to casework.

L. Metering faucets shall be adjusted for minimum ten (10) second run time, but not more than 0.25 gallons per cycle.

M. Immediately after installation, provide protective covering over fixtures and trim.

3.3 MOUNTING HEIGHT AND LOCATION

A. Mount fixtures at height and location as indicated on Architectural plans and elevations.

B. Mount accessible fixtures in conformance with the requirements of ANSI A117.1.

3.4 CONNECTIONS

A. Install piping connections between plumbing fixtures and piping systems and plumbing equipment specified in other sections of Division 22.

3.5 ADJUSTING AND CLEANING

A. Operate and adjust faucets and controls. Replace damaged and malfunctioning fixtures, fittings and controls.

B. Adjust water pressure at electric water coolers, faucets and flush valves to provide proper flow and stream.

C. Replace washers of leaking and dripping faucets and stops.

D. Clean fixtures, fittings, spout and drain strainers with manufacturers' recommended cleaning methods and materials.

E. Test fixtures to demonstrate proper operation upon completion of installation and after units are water pressurized. Replace malfunctioning fixtures and components and retest. Repeat procedure until all units operate properly.

F. Adjust all flush valves, faucets, etc. for proper operation following commissioning of booster pump system.

END OF SECTION 224000

APPENDIX A

TAG	MOUNT TYPE	FLUSH TYPE	ADA	HEALTH CARE	K-12	HIGHER ED	COMMERCIAL	RES.	LEED	REMARKS
WATER CLOSETS										
WC-A	WALL	FV 1.6		X	X	X	X			MANUAL/BATTERY/WIRED
WC-B	WALL	FV 1.6	X	X	X	X	X			MANUAL/BATTERY/WIRED
WC-C	FLOOR	FV 1.6		X	X	X	X			MANUAL
WC-D	FLOOR	FV 1.6	X	X	X	X	X			MANUAL
WC-E	FLOOR	TANK					X	X		
WC-F	FLOOR	TANK	X				X	X		
WC-G	FLOOR	FV 1.6			X					CHILD HEIGHT
WC-H	WALL	FV 3.5	X	X						BEDPAN WASHER
WC-I	FLOOR	FV 3.5	X	X						BEDPAN WASHER
WC-J	FLOOR	TANK				X	X			PRESSURE ASSIST
WC-K	FLOOR	TANK				X	X			PRESSURE ASSIST
WC-L	WALL	FV 1.6	X	X						BARIATRIC
WC-M	FLOOR	FV 1.6	X	X						BARIATRIC
WC-N	WALL	FV 1.28			X	X	X		X	HETS MANUAL
WC-O	WALL	FV 1.28	X		X	X	X		X	HETS MANUAL

WC-P	WALL	FV 1.28			X	X	X		X	HETS BATTERY
WC-Q	WALL	FV 1.28	X		X	X	X		X	HETS BATTERY
WC-R	FLOOR	FV 1.28			X	X	X		X	HETS MANUAL
WC-S	FLOOR	FV 1.28	X		X	X	X		X	HETS MANUAL

TAG	MOUNT TYPE	FLUSH TYPE	ADA	HEALTH CARE	K-12	HIGHER ED	COMMERCIAL	RES.	LEED	REMARKS
URINALS										
UR-A	WALL	FV 1.0		X	X	X	X			MANUAL/BATTERY/ WIRED
UR-B	WALL	FV 1.0	X	X	X	X	X			MANUAL/BATTERY/ WIRED
UR-C	WALL	WATERLESS							X	
UR-D	WALL	WATERLESS	X						X	
UR-E	FLOOR	FV 1.0	X							REPLACEMENT ONLY

FLUSH VALVES										
FV-A										
FV-B										

FV-C										
FV-D										
FV-E										
FV-F										
FV-G										
FV-H										

TAG	MOUNT TYPE	DRAIN STYLE	ADA	HEALTH CARE	K-12	HIGHER ED	COMMERCIAL	RES.	LEED	FAUCET STYLE & TYPE
LAVATORIES										
LAV-A	WALL	GRID		X	X	X	X			MANUAL/METERING/ BATTERY/HARDWIRED
LAV-B	WALL	GRID	X	X						GOOSENECK W/WRIST BLADES
LAV-C	WALL	POP-UP						X		SINGLE HANDLE LEVER
LAV-D	WALL	GRID	X					X		SINGLE HANDLE LEVER
LAV-E	SELF-RIMMING	GRID			X	X	X	X		MANUAL/METERING/ BATTERY/HARDWIRED
LAV-F	SELF-RIMMING	GRID	X	X						GOOSENECK W/WRIST BLADES

LAV-G	UNDER-MOUNT	GRID								MANUAL/METERING/ BATTERY/HARDWIRED
LAV-H	UNDER-MOUNT	GRID	X							MANUAL/METERING/ BATTERY/HARDWIRED

TAG	MANUF.	MODEL #	FLOW RATE (GPM)	TYPE	ADA	LEED	REMARKS
LAVATORY FAUCETS							
F-A	CHICAGO						
F-B	CHICAGO						
F-C	CHICAGO						
F-D	CHICAGO						
F-E	CHICAGO						
F-F	CHICAGO						
F-G	CHICAGO						
F-H	CHICAGO						
F-I	CHICAGO						
F-J	CHICAGO						
F-K	CHICAGO						
F-L	CHICAGO						

TAG	MANUF.	MODEL #	FLOW RATE (GPM)	TYPE	ADA	LEED	REMARKS
LAVATORY FAUCETS							
F-M	CHICAGO						
F-N	CHICAGO						
F-O	CHICAGO						

TAG	MOUNT TYPE	DRAIN STYLE	ADA	HEALTH CARE	K-12	HIGHER ED	COMMERCIAL	RES.	LEED	FAUCET STYLE & TYPE
SINKS										
SK-A	SELF-RIMMING SINGLE BOWL	GRID/BASKET		X	X	X	X	X		MANUAL, SINGLE & DUAL HANDLE
SK-B	SELF-RIMMING SINGLE BOWL	GRID/BASKET	X	X	X	X	X	X		MANUAL, SINGLE & DUAL HANDLE
SK-C	SELF-RIMMING DOUBLE BOWL	GRID/BASKET		X	X	X	X	X		MANUAL, SINGLE HANDLE

SK-D	SELF-RIMMING SINGLE BOWL	BASKET	X	X	X	X	X	X		MANUAL, SINGLE HANDLE

TAG	MOUNT TYPE	ADA	HEALTH CARE	K-12	HIGHER ED	COMMERCIAL	RES.	LEED	REMARKS
SERVICE SINKS									
SS-A	WALL/TRAP STANDARD	X	X	X	X	X			ENAMELED CAST IRON

TAG	MOUNT TYPE	ADA	HEALTH CARE	K-12	HIGHER ED	COMMERCIAL	RES.	LEED	REMARKS
MOP BASINS									
MB-A	FLOOR	X	X	X	X	X			TERAZZO
MB-B	FLOOR	X	X	X	X	X			MOLDED STONE

TAG	MOUNT TYPE	ADA	HEALTH CARE	K-12	HIGHER ED	COMMERCIAL	RES.	LEED	REMARKS
ELECTRIC WATER COOLERS									
EWC-A	WALL, SURFACE	X	X	X	X	X			SINGLE LEVEL
EWC-B	WALL, SURFACE	X	X	X	X	X			BI-LEVEL
EWC-C	WALL, RECESSED	X	X	X	X	X			BI-LEVEL
EWC-C	WALL, RECESSED	X	X	X	X	X			SINGLE LEVEL

SECTION 227010 - NATURAL GAS SYSTEMS

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Provide labor, materials, equipment and services to perform operations required for the complete installation and related Work as required in Contract Documents.

1.2 SUBMITTALS

A. Provide manufacturer's data sheets and installation instructions for all equipment and accessories in this section in accordance with Basic Mechanical/Electrical Requirements and Division 01.

1.3 QUALITY ASSURANCE

A. Follow all requirements, recommendations, and appendices to comply with the following publications, codes, standards, and listings:

1. 2020 Fuel Gas Code of New York State.

2. American Gas Association.

3. Local Utility Company.

B. Provide equipment and accessories that are listed and labeled by a nationally recognized testing laboratory.

1.4 GAS SERVICE

A. All new underground gas service piping from the street main to, and including, the gas meter will be installed by National Grid.

B. The cost of this work shall be included in this Contractor's bid.

C. This Contractor shall provide the meter pad, pipe bollards and meter enclosure.

1.5 GAS PRESSURE

A. The maximum allowable gas pressure inside the building is 1/2 psi.

1.6 UNDERGROUND GAS PIPING

A. All underground gas piping located downstream of the gas meter shall be installed by a National Grid approved utility contractor in accordance with the gas company's requirements.

B. The cost of this work shall be included in this Contractor's bid.

PART 2 - PRODUCTS

2.1 GAS PIPING

A. Piping Materials: Refer to Specification Section 221010, "Piping Systems and Accessories" and Section 221020, "Underground Piping And Accessories".

B. All exposed exterior and interior piping shall be primed and painted with one coat of alkyd primer and two coats of exterior acrylic latex gloss enamel. Color shall be as selected.

2.2 VALVES

A. Refer to Specification Section 220523, "Valves".

2.3 FLEXIBLE CONNECTORS

A. Stainless steel construction and in accordance with ANSI Z21.24.

PART 3 - EXECUTION

3.1 ARRANGEMENTS

A. Make arrangements with National Grid to provide the gas service and meter at the indicated location.

B. Contact the utility company for the cost of the service, its fees and required permits. Pay all costs and include within the base bid.

C. The service load is 3,000,00 Btuh. The pressure at the meter outlet shall be set at 14 in. wc.

D. Coordinate all service requirements with the utility company.

E. The contractor shall arrange for the plumbing inspector to inspect the gas piping and vent installations upon completion including underground and rough-ins, as well as installation of gas-fired appliances.

3.2 GAS DISTRIBUTION SYSTEM

A. Provide distribution system from gas meter outlet, including meter pad, fence enclosure, mains, risers, branches, drips, shut-offs and other required parts. Connect to equipment or appliances indicated or specified as requiring gas for their operation.

B. Provide shutoff valve at the meter outlet. Provide all parts and accessories needed to connect to meter.

C. Furnish sleeve and sealing element for above ground gas piping entry through outside wall. Make entry gas and watertight.

3.3 PIPING INSTALLATION

A. Install gas piping at a uniform slope of 1/4 in. in 15 ft. to prevent traps. Horizontal lines shall slope upward to risers to the equipment.

B. Drips and Sediment Traps: Install drips at points where condensate may collect. Locate where readily accessible to permit cleaning and emptying. Do not install where condensate would be subject to freezing. The sediment trap shall be installed in the gas supply line to gas fired equipment. The trap shall be a tee fitting having a threaded capped nipple installed vertically in the bottom most opening of the tee.

C. Make reductions in pipe sizes using eccentric reducer fittings installed with the level side down. Connect branch piping from top or side of horizontal piping.

D. Install unions in pipes 2 in. and smaller, adjacent to each valve, regulator and at final connection to each piece of equipment. Unions are not required on flanged devices.

E. Provide pressure regulator in supply to each gas fired appliance as required.

F. Install valve and strainer on the supply side of each gas pressure regulator.

G. Install vent piping for gas pressure regulators and gas trains, extend outside building and vent to atmosphere. Terminate vents with turned-down reducing elbow fittings with corrosion-resistant insect screens in large end.

H. Install containment conduits for buried gas piping within building in gas-tight conduits extending 12 in. minimum outside building and vented to atmosphere. Terminate vents with turned-down, reducing elbow fittings with corrosion-resistant insect screens in large end. Prepare and paint outside of conduits with coal tar epoxy.

I. Install pressure-relief or pressure-limiting devices so they can be readily operated to determine if valve is free; test to determine pressure at which they will operate; and examine for leakage when in closed position.

J. Install gas piping across exit corridors within an airtight conduit constructed of Schedule 40 seamless black steel pipe with welded joints. Vent conduit to outside of exit corridor.

3.4 WELDING

A. Welding shall be performed in compliance with the welding procedure specifications prepared by the National Certified Pipe Welding Bureau. Welded pipe fabricated by certified welder. Contractor shall submit proof of current certification of each welder if requested by the Owner. Use full-length pipe where possible; minimum distance between welds, 18 in. on straight runs. Welds must be at least full thickness of pipe with inside smooth; remove cutting beads, slag and excess material at joints; chamfer ends. Minimum gap 1/8 in., maximum 1/4 in. for butt welds. Overlaps on position and bench welds to be not less than 3/4 in. One internal pass and one external pass minimum required on slip-on flanges. Do not apply heat to rectify distorted pipe due to concentrated welding; replace distorted pipe. Exercise caution to prevent heat related damage to plastic parts within the gas meter or regulators.

B. Welder qualifications: Welded piping fabricated by certified welder. Welder shall be certified under ASME or API Code III.

3.5 CONNECTIONS

A. Install gas piping next to gas-utilizing equipment and appliances for servicing and maintenance. Connect gas piping to gas-utilizing equipment and appliances with shutoff valves and unions. Make connections to equipment downstream of valves and unions with flexible connectors. Valves, unions and flexible connectors shall be same size as the gas supply piping to the equipment.

B. Install a gas valve upstream within 6 ft. of each gas-utilizing appliance. Install a union connection downstream from the valve to permit removal of controls.

C. Sediment Traps: Install full size threaded tee fittings forming drips, as close as practical to gas appliance inlets. Cap or plug bottom outlet.

3.6 GAS PIPING TESTS

A. Test natural gas systems according to 2020 Fuel Gas Code of New York State and the local utility requirements unless otherwise noted:

1. Test pressure shall be 15 psi for one (1) hour for steel piping.

2. Pressure testing of plastic piping shall be per utility's requirements.

B. Tests shall be witnessed by utility company. Make arrangements, provide all necessary items to complete testing and pay all costs.

C. All tests shall be performed prior to the connection of equipment. Regulator shall be isolated from test pressures. Soap test shall be conducted on all joints. Repair leaks and defects with new materials. Retest system until satisfactory results are obtained.

D. Verify correct pressure settings for pressure regulators.

E. Provide written certification that tests have been conducted and satisfactorily completed. Submit to Owner's Representative.

3.7 GAS LINE PURGING

A. At completion of pressure test, purge all natural gas systems according to 2020 Fuel Gas Code of New York State and the utility company requirements.

B. Provide three (3) days notice to utility company to have the meter unlocked for service and equipment start up. Make all arrangements and pay all fees as required by the Utility Company.

END OF SECTION 227010

SECTION 230500 - COMMON HVAC REQUIREMENTS

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 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.

1.3 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.

1.4 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.

1.5 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.

1.6 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.

1.7 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.

1.8 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.

1.9 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.

1.10 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.

1.11 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 230513 - COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes 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.

1.3 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 box, suited to control method.

B. 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.

C. 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.

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.

PART 3 - EXECUTION (Not Applicable)

END OF SECTION 230513

SECTION 230516 - EXPANSION FITTINGS FOR HVAC PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Flexible hose expansion loop joints
   2. Grooved-joint expansion joints.
   3. Alignment guides and anchors.
   4. Pipe loops and swing connections.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Delegated-Design Submittal: For each anchor and alignment guide, including analysis data, signed and sealed by the qualified professional engineer responsible for their preparation.

   1. Design Calculations: Calculate requirements for thermal expansion of piping systems and for selecting and designing expansion joints, loops, and swing connections.
   2. Anchor Details: Detail fabrication of each anchor indicated. Show dimensions and methods of assembly and attachment to building structure.
   3. Alignment Guide Details: Detail field assembly and attachment to building structure.
   4. Schedule: Indicate type, manufacturer's number, size, material, pressure rating, end connections, and location for each expansion joint.

1.3 INFORMATIONAL SUBMITTALS

A. Welding certificates.

1.4 CLOSEOUT SUBMITTALS

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

1.5 QUALITY ASSURANCE

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

B. Pipe and Pressure-Vessel Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Compatibility: Products shall be suitable for piping service fluids, materials, working pressures, and temperatures.

B. Capability: Products to absorb 200 percent of maximum axial movement between anchors.

2.2 FLEXIBLE HOSE EXPANSION LOOP JOINTS

A. Basis-of-Design Product: Subject to compliance with requirements, provide product by Metraflex or approved equal.

B. Description: Manufactured assembly with inlet and outlet elbow fittings and two flexible-metal-hose legs joined by long-radius, 180-degree return bend or center section of flexible hose.

C. Flexible Hoses: Corrugated-metal inner hoses and braided outer sheaths.

D. Fittings Materials of construction and end fitting type shall be consistent with pipe material and equipment/ pipe connection fittings. Copper fittings shall not be attached to stainless steel hose.

E. Flexible hose expansion loops shall be rated for the same of higher working pressure than the system they are provided for.

F. Flexible hose expansion loops shall have a factory supplied, hanger / support lug located at the bottom of the 180deg return.

G. Flexible hose expansion loop(s) shall be furnished with a plugged FPT to be used for a drain or air release vent.

2.3 GROOVED-JOINT EXPANSION JOINTS

A. Description: Factory-assembled expansion joint made of several grooved-end pipe nipples, couplings, and grooved joints.

B. Standard: AWWA C606, for grooved joints.

C. Nipples: ASTM A 53/A 53M, Schedule 40, Type E or S, steel pipe with grooved ends.

D. Couplings: Five, flexible type for steel-pipe dimensions. Include ferrous housing sections, Buna-N gasket suitable for diluted acid, alkaline fluids, and cold and hot water, and bolts and nuts.

2.4 ALIGNMENT GUIDES AND ANCHORS

A. Alignment Guides
1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
a. Mason Industries, Inc
b. Senior Flexonics Pathway
c. U.S. Bellows, Inc.

2. Description: Steel, factory-fabricated alignment guide, with bolted two-section outer cylinder and base for attaching to structure; with two-section guiding slider for bolting to pipe.

B. Anchor Materials:
1. Steel Shapes and Plates: ASTM A 36/A 36M.
2. Bolts and Nuts: ASME B18.10 or ASTM A 183, steel hex head.
3. Washers: ASTM F 844, steel, plain, flat washers.
4. Mechanical Fasteners: Insert-wedge-type stud with expansion plug anchor for use in hardened portland cement concrete, with tension and shear capacities appropriate for application.

a. Stud: Threaded, zinc-coated carbon steel.
b. Expansion Plug: Zinc-coated steel.
c. Washer and Nut: Zinc-coated steel.

5. Chemical Fasteners: Insert-type stud, bonding-system anchor for use with hardened portland cement concrete, with tension and shear capacities appropriate for application.

a. Bonding Material: ASTM C 881/C 881M, Type IV, Grade 3, two-component epoxy resin suitable for surface temperature of hardened concrete where fastener is to be installed.

b. Stud: ASTM A 307, zinc-coated carbon steel with continuous thread on stud, unless otherwise indicated.
c. Washer and Nut: Zinc-coated steel.

PART 3 - EXECUTION

3.1 EXPANSION JOINT INSTALLATION

A. Install expansion joints of sizes matching sizes of piping in which they are installed.

B. Install grooved-joint expansion joints to grooved-end steel piping.

3.2 PIPE LOOP AND SWING CONNECTION INSTALLATION

A. Install pipe expansion loops per manufacturer's requirements to absorb tension or compression produced during anticipated change in temperature and movements at building joints and isolation breaks.

B. Connect risers and branch connections to mains with at least three pipe fittings, including tee in main.

C. Connect risers, mains, and branch connections to terminal units with at least four pipe fittings, including tee in riser.

3.3 ALIGNMENT-GUIDE AND ANCHOR INSTALLATION

A. Install alignment guides to guide expansion and to avoid end-loading and torsional stress.

Indicate locations and number of guides on Drawings.

B. Install guide(s) on each side of pipe expansion fittings per manufacturer's instructions.

Coordinate first paragraph below with structural Drawings if welding is included in structural work.

C. Attach guides to pipe, and secure guides to building structure.

D. Install anchors at locations to prevent stresses from exceeding those permitted by ASME B31.9 and to prevent transfer of loading and stresses to connected equipment.

E. Anchor Attachments:

Coordinate first subparagraph below with structural Drawings if welding is included in structural work.

1. Anchor Attachment to Steel Pipe: Attach by welding. Comply with ASME B31.9 and ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
2. Anchor Attachment to Copper Tubing: Attach with pipe hangers. Use MSS SP-69, Type 24; U bolts bolted to anchor.

Coordinate first paragraph below with structural Drawings if welding is included in structural work.

F. Fabricate and install steel anchors by welding steel shapes, plates, and bars. Comply with ASME B31.9 and AWS D1.1/D1.1M.

1. Anchor Attachment to Steel Structural Members: Attach by welding.
2. Anchor Attachment to Concrete Structural Members: Attach by fasteners. Follow fastener manufacturer's written instructions.

G. Use grout to form flat bearing surfaces for guides and anchors attached to concrete.

END OF SECTION 230516

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 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. 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.

3. Concrete Slabs Above Grade:

a. Piping Smaller Than NPS 6: Steel pipe sleeves.
b. Piping NPS 6 and Larger: Steel pipe sleeves.

4. 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

This page intentionally left blank

SECTION 230518 - ESCUTCHEONS FOR HVAC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Escutcheons.
2. Floor plates.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

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.

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

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.
9. Flowmeters.
10. Thermal-energy meters.

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.
9. Flowmeters.
10. Thermal-energy meters.

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.

2.9 FLOWMETERS

A. Performance Requirements: Manufacturer is to certify that each flowmeter complies with specified performance requirements and characteristics.

B. Flowmeters - Venturi:

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

a. Armstrong International, Inc.
b. Gerand Engineering Co.
c. Hyspan Precision Products, Inc.
d. Nexus Valve, Inc.; Aalberts Hydronic Flow Control.
e. Preso Meters; Badger Meter Inc.

f. Rosemount; Emerson Electric Co., Automation Solutions.

2. Source Limitations: Provide venturi flowmeters from single manufacturer.
3. Description: Flowmeter with calibrated flow-measuring element, hoses or tubing, fittings, valves, indicator, and conversion chart.
4. Flow Range: Sensor and indicator is to cover operating range of equipment or system served.
5. Flow-Measuring Element:

   a. Design: Differential-pressure-type measurement for water.
   b. Venturi type with in-line or insertion element.
   c. Construction: Bronze, brass, or factory-primed steel, with brass fittings and attached tag with flow conversion data.
   d. Minimum Pressure Rating: 250 psig.
   e. Minimum Temperature Rating: 250 deg F.
   f. End Connections for NPS 2 (DN 50) and Smaller: Threaded.
   g. End Connections for NPS 2-1/2 (DN 65) and Larger: Flanged or welded.
   h. Flow Range: Flow-measuring element and flowmeter are to cover operating range of equipment or system served.

6. Permanent Indicators: Meter suitable for wall or bracket mounting, calibrated for connected flowmeter element, and has 6-inch diameter, or equivalent, dial with fittings and copper tubing for connecting to flowmeter element.

   a. Scale: Gallons per minute.
   b. Accuracy: Plus or minus 1 percent between 20 and 80 percent of scale range.

7. Display: Shows rate of flow, with register to indicate total volume in gallons.
8. Conversion Chart: Flow rate data compatible with sensor.
9. Operating Instructions: Include complete instructions with each flowmeter.

2.10 THERMAL-ENERGY METERS

A. Performance Requirements: Manufacturer is to certify that each flowmeter complies with specified performance requirements and characteristics.

B. Thermal-Energy Meters - Ultrasonic:

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

   a. ARCHON Industries, Inc.
   b. Dwyer Instruments, Inc.

c. KOBOLD Instruments, Inc. - USA.
d. OPW Engineered Systems; OPW Fluid Transfer Group; a Dover company.
e. Onicon Inc.
f. Belimo Inc.

2. Source Limitations: Provide ultrasonic thermal-energy meters from single manufacturer.
3. Description: Meter with flow sensor, two temperature sensors, transmitter, indicator, and connecting wiring.
4. Flow Sensor: Transit-time ultrasonic type with transmitter.
5. Temperature Sensors: Insertion-type or strap-on transducer.
6. Indicator: Solid-state, integrating-type meter with integral battery pack.

    a. Data Output: Six-digit electromechanical counter with readout in kilowatts per hour or British thermal units .
    b. Battery Pack: Five-year lithium battery.

7. Accuracy: Plus or minus 1 percent.
8. Display: Visually indicates total fluid volume in gallons and thermal-energy flow in kilowatts per hour or British thermal units.
9. Operating Instructions: Include complete instructions with each thermal-energy meter system.

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. Assemble and install connections, tubing, and accessories between flow-measuring elements and flowmeters according to manufacturer's written instructions.

P. Install flowmeter elements in accessible positions in piping systems.

Q. Install wafer-orifice flowmeter elements between orifice-type pipe flanges.

R. Install all flowmeter elements, with at least minimum straight lengths of pipe, upstream and downstream from element according to manufacturer's written instructions.

S. Install permanent indicators on walls or brackets in accessible and readable positions.

T. Install connection fittings in accessible locations for attachment to portable indicators.

U. Mount thermal-energy meters on wall if accessible; if not, provide brackets to support meters.

V. 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.

W. 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.

B. Connect flowmeter-system elements to meters.

C. Connect flowmeter transmitters to meters.

D. Connect thermal-energy meter transmitters to meters.

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 Heating, Hot-Water Piping:

1. 0 to 250 deg F.

B. 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 Heating, Hot-Water Piping:

1. 0 to 160 psi.

3.8 FLOWMETER SCHEDULE

A. Flowmeters are to be: Venturi type.

3.9 THERMAL-ENERGY METER SCHEDULE

A. Thermal-Energy Meters are to be: Ultrasonic type.

END OF SECTION 230519

This page intentionally left blank

SECTION 230523.12 - BALL VALVES FOR HVAC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
   1. Bronze ball valves.

1.3 DEFINITIONS

A. CWP: Cold working pressure.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of valve.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Prepare valves for shipping as follows:

   1. Protect internal parts against rust and corrosion.
   2. Protect threads, flange faces, and weld ends.
   3. Set ball valves open to minimize exposure of functional surfaces.

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 operating handles or stems as lifting or rigging points.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR VALVES

A. Source Limitations for Valves: Obtain each type of valve from single source from single manufacturer.

B. 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 steel valves.
4. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
5. ASME B16.18 for solder-joint connections.
6. ASME B31.1 for power piping valves.
7. ASME B31.9 for building services piping valves.

C. Bronze valves shall be made with dezincification-resistant materials. Bronze valves made with copper alloy (brass) containing more than 15 percent zinc are not permitted.

D. Refer to HVAC valve schedule articles for applications of valves.

E. Valve Pressure-Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.

F. Valve Sizes: Same as upstream piping unless otherwise indicated.

G. Valve Actuator Types:
1. Handlever: For quarter-turn valves smaller than NPS 4.

H. Valves in Insulated Piping:

1. Include 2-inch stem extensions.
2. Extended operating handle of nonthermal-conductive material, and protective sleeves that allow operation of valves without breaking the vapor seals or disturbing insulation.
3. Memory stops that are fully adjustable after insulation is applied.

I. Valve Bypass and Drain Connections: MSS SP-45.

2.2 BRONZE BALL VALVES

A. Bronze Ball Valves, Two-Piece with Full Port and Stainless-Steel Trim:

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

    a. Apollo Flow Controls; Conbraco Industries, Inc.
    b. Milwaukee Valve Company.
    c. NIBCO INC.
    d. WATTS.

2. Description:

    a. Standard: MSS SP-110.
    b. SWP Rating: 150 psig.
    c. CWP Rating: 600 psig.
    d. Body Design: Two piece.
    e. Body Material: Bronze.
    f. Ends: Threaded.
    g. Seats: PTFE.
    h. Stem: Stainless steel.
    i. Ball: Stainless steel, vented.
    j. Port: Full.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine valve interior for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.

B. Operate valves in positions from fully open to fully closed. Examine guides and seats made accessible by such operations.

C. Examine threads on valve and mating pipe for form and cleanliness.

D. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Verify that gasket is of proper size, that its material composition is suitable for service, and that it is free from defects and damage.

E. Do not attempt to repair defective valves; replace with new valves.

3.2 VALVE INSTALLATION

A. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.

B. Locate valves for easy access and provide separate support where necessary.

C. Install valves in horizontal piping with stem at or above center of pipe.

D. Install valves in position to allow full stem movement.

E. Install valve tags. Comply with requirements in Section 230553 "Identification for HVAC Piping and Equipment" for valve tags and schedules.

3.3 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

A. 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.

B. Select valves with the following end connections:

1. For Copper Tubing, NPS 2 and Smaller: Threaded ends except where solder-joint valve-end option or press-end option is indicated in valve schedules below.

3.4 HEATING-WATER VALVE SCHEDULE

A. Pipe NPS 2 and Smaller: bronze ball valves, two piece with stainless-steel trim, full port, solder or press connection-joint ends.

B. END OF SECTION 230523.12

SECTION 230523.13 - BUTTERFLY VALVES FOR HVAC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Iron, single-flange butterfly valves.
2. Iron, grooved-end butterfly valves.

1.3 DEFINITIONS

A. CWP: Cold working pressure.

B. EPDM: Ethylene propylene copolymer rubber.

C. NBR: Acrylonitrile-butadiene, Buna-N, or nitrile rubber.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of valve.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Prepare valves for shipping as follows:

1. Protect internal parts against rust and corrosion.
2. Protect threads, flange faces, grooves, and weld ends.
3. Set butterfly valves closed or slightly open.

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 or stems as lifting or rigging points.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR VALVES

A. Source Limitations for Valves: Obtain each type of valve from single source from single manufacturer.

B. ASME Compliance:

1. ASME B16.1 for flanges on iron valves.
2. ASME B16.5 for pipe flanges and flanged fittings, NPS 1/2 through NPS 24.
3. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
4. ASME B31.1 for power piping valves.
5. ASME B31.9 for building services piping valves.

C. AWWA Compliance: Comply with AWWA C606 for grooved-end connections.

D. Valve Pressure-Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.

E. Valve Sizes: Same as upstream piping unless otherwise indicated.

F. Valve Actuator Types:

1. Gear Actuator: For valves NPS 8 and larger.
2. Handlever: For valves NPS 6 and smaller.
3. Chainwheel: Device for attachment to gear, stem, or other actuator of size and with chain for mounting height, according to "Valve Installation" Article.

G. Valves in Insulated Piping: With 2-inch stem extensions with extended necks.

2.2 IRON, SINGLE-FLANGE BUTTERFLY VALVES

A. Iron, Single-Flange Butterfly Valves with Aluminum-Bronze Disc:

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

a. Apollo Flow Controls; Conbraco Industries, Inc.
b. Milwaukee Valve Company.
c. NIBCO INC.
d. WATTS.

2. Description:

a. Standard: MSS SP-67, Type I.
b. NPS 12 and Smaller CWP Rating: 200 psig.
c. NPS 14 and Larger CWP Rating: 150 psig.
d. Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
e. Body Material: ASTM A536, ductile iron.
f. Seat: EPDM.
g. Stem: One- or two-piece stainless steel.
h. Disc: Aluminum bronze.

2.3 DUCTILE-IRON, GROOVED-END BUTTERFLY VALVES

A. Iron, Grooved-End Butterfly Valves, 300 CWP:

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

a. NIBCO INC.
b. Shurjoint-Apollo Piping Products USA Inc.
c. Victaulic Company.

2. Description:

a. Standard: MSS SP-67, Type I.
b. NPS 8 and Smaller CWP Rating: 300 psig.
c. NPS 10 and Larger CWP Rating: 200 psig.
d. Body Material: Coated, ductile iron.
e. Stem: Two-piece stainless steel.
f. Disc: Coated, ductile iron.
g. Seal: EPDM.

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 mating flange faces for damage. 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.

D. Do not attempt to repair defective valves; replace with new valves.

3.2 VALVE INSTALLATION

A. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.

B. Locate valves for easy access and provide separate support where necessary.

C. Install valves in horizontal piping with stem at or above center of pipe.

D. Install valves in position to allow full stem movement.

E. Install valve tags. Comply with requirements in Section 230553 "Identification for HVAC Piping and Equipment" for valve tags and schedules.

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 HEATING-WATER VALVE SCHEDULE

A. Pipe NPS 2-1/2 and Larger:

1. Iron, Single-Flange Butterfly Valves, NPS 2-1/2 to NPS 12: Aluminum-bronze disc, 200 CWP, and EPDM seat.

2. Iron, Single-Flange Butterfly Valves, NPS 14 to NPS 24: Aluminum-bronze disc, 150 CWP, and EPDM seat.
3. Iron, Grooved-End Butterfly Valves, NPS 2-1/2 to NPS 12: 300 CWP.
4. High-Performance Butterfly Valves: Single flange, Class 300.

END OF SECTION 230523.13

SECTION 230523.14 - CHECK VALVES FOR HVAC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
   1. Bronze swing check valves.
   2. Iron swing check valves.
   3. Iron swing check valves with closure control.

1.3 DEFINITIONS

A. CWP: Cold working pressure.

B. EPDM: Ethylene propylene copolymer rubber.

C. NBR: Acrylonitrile-butadiene, Buna-N, or nitrile rubber.

ACTION SUBMITTALS

D. Product Data: For each type of valve.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Prepare valves for shipping as follows:

   1. Protect internal parts against rust and corrosion.
   2. Protect threads, flange faces, grooves, and weld ends.
   3. Block check valves in either closed or open position.

B. Use the following precautions during storage:

   1. Maintain valve end protection.

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

C. Use sling to handle large valves; rig sling to avoid damage to exposed parts. Do not use handwheels or stems as lifting or rigging points.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR VALVES

A. Source Limitations for Valves: Obtain each type of valve from single source from single manufacturer.

B. ASME Compliance:

1. ASME B1.20.1 for threads for threaded-end valves.
2. ASME B16.1 for flanges on iron valves.
3. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
4. ASME B16.18 for solder joint.
5. ASME B31.1 for power piping valves.
6. ASME B31.9 for building services piping valves.

C. AWWA Compliance: Comply with AWWA C606 for grooved-end connections.

D. Bronze valves shall be made with dezincification-resistant materials. Bronze valves made with copper alloy (brass) containing more than 15 percent zinc are not permitted.

E. Valve Pressure-Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.

F. Valve Sizes: Same as upstream piping unless otherwise indicated.

G. Valve Bypass and Drain Connections: MSS SP-45.

2.2 BRONZE SWING CHECK VALVES

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

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. NIBCO, Inc.

b. WATTS
c. Crane; a Crane brand

2. Description:

a. Standard: MSS SP-80, Type 3.
b. CWP Rating: 200 psig (1380 kPa).
c. Body Design: Horizontal flow.
d. Body Material: ASTM B62, bronze.
e. Ends: Threaded.
f. Disc: Bronze.

2.3 IRON SWING CHECK VALVES

A. Iron Swing Check Valves with Metal Seats, Class 125:

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. NIBCO, Inc.
   b. WATTS
   c. Crane; a Crane brand
2. Description:

   a. Standard: MSS SP-71, Type I.
   b. NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 200 psig (1380 kPa).
   c. Body Design: Clear or full waterway.
   d. Body Material: ASTM A126, gray iron with bolted bonnet.
   e. Ends: Flanged.
   f. Trim: Bronze.
   g. Gasket: Asbestos free.

2.4 IRON SWING CHECK VALVES WITH CLOSURE CONTROL

A. Iron Swing Check Valves with Lever- and Spring-Closure Control, Class 125:

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. NIBCO, Inc.
2. Description:

   a. Standard: MSS SP-71, Type I.

b. NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 200 psig (1380 kPa).
c. Body Design: Clear or full waterway.
d. Body Material: ASTM A126, gray iron with bolted bonnet.
e. Ends: Flanged.
f. Trim: Bronze.
g. Gasket: Asbestos free.
h. Closure Control: Factory-installed, exterior lever and spring.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine valve interior for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.

B. Operate valves in positions from fully open to fully closed. Examine guides and seats made accessible by such operations.

C. Examine threads on valve and mating pipe for form and cleanliness.

D. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Verify that gasket is of proper size, that its material composition is suitable for service, and that it is free from defects and damage.

E. Do not attempt to repair defective valves; replace with new valves.

3.2 VALVE INSTALLATION

A. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.

B. Locate valves for easy access and provide separate support where necessary.

C. Install valves in horizontal piping with stem at or above center of pipe.

D. Install valves in position to allow full stem movement.

E. Install check valves for proper direction of flow and as follows:

1. Swing Check Valves: In horizontal position with hinge pin level.

F. Install valve tags. Comply with requirements for valve tags and schedules in Section 230553 "Identification for HVAC Piping and Equipment."

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. Pump-Discharge Check Valves:

a. NPS 2 (DN 50) and Smaller: Bronze swing check valves with bronze disc.
b. NPS 2-1/2 (DN 65) and Larger: Iron swing check valves with lever and weight or with spring or iron, center-guided, metal-seat check 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 Copper Tubing, NPS 2 (DN 50) and Smaller: Threaded ends except where solder-joint valve-end option is indicated in valve schedules.
2. For Steel Piping, NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Flanged ends except where threaded valve-end option is indicated in valve schedules.
3. For Steel Piping, NPS 5 (DN 125) and Larger: Flanged ends.

3.5 HEATING-WATER VALVE SCHEDULE

A. Pipe NPS 2 (DN 50) and Smaller:

1. Bronze Valves: May be provided with solder-joint ends instead of threaded ends.
2. Bronze swing check valves with bronze disc, Class 125.

B. Pipe NPS 2-1/2 (DN 65) and Larger:

1. Iron swing check valves with metal seats, Class 125.

END OF SECTION 230523.14

SECTION 230529 - HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Metal pipe hangers and supports.
2. Trapeze pipe hangers.
3. Metal framing systems.
4. Thermal-hanger shield inserts.
5. Fastener systems.
6. Equipment stands.
7. Equipment supports.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1.4 INFORMATIONAL SUBMITTALS

A. Welding certificates.

1.5 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 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.

2.5 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.

2.6 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.

2.7 EQUIPMENT SUPPORTS

A. Description: Welded, shop- or field-fabricated equipment support made from structural carbon-steel shapes.

2.8 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. Install hangers and supports complete with necessary attachments, inserts, bolts, rods, nuts, washers, and other accessories.

G. Equipment Support Installation: Fabricate from welded-structural-steel shapes.

H. 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.

I. Install lateral bracing with pipe hangers and supports to prevent swaying.

J. 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.

K. Load Distribution: Install hangers and supports so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.

L. 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.

M. 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

This page intentionally left blank

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. Hot Water Piping: White letters on an ANSI Z535.1 safety-green background.
2. Hot Water Piping: White letters on blue 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. Refrigerant: 1-1/2 inches, round.
   b. Hot Water: 1-1/2 inches, round.
   c. Gas: 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

SECTION 230593 - TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Balancing Air Systems:
    a. Constant-volume air systems.
    b.
    c. Multizone systems.
2. Balancing Hydronic Piping Systems:
    a. Variable-flow hydronic systems.
    b. Primary-secondary hydronic systems.
3. Balancing steam systems.
4. Testing, Adjusting, and Balancing Equipment:
    a. Heat exchangers.
    b. Motors.
    c. Condensing units.
    d. Boilers.
    e. Heat-transfer coils.
5. Testing, adjusting, and balancing existing systems and equipment.
6. Sound tests.
7. Vibration tests.
8. Duct leakage tests.
9. 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 CONSTANT-VOLUME AIR SYSTEMS

A. Adjust fans to deliver total indicated airflows within the maximum allowable fan speed listed by fan manufacturer.

1. Measure total airflow.

    a. Set outside-air, return-air, and relief-air dampers for proper position that simulates minimum outdoor-air conditions.
    b. Where duct conditions allow, measure airflow by main Pitot-tube traverse. If necessary, perform multiple Pitot-tube traverses, close to the fan and prior to any outlets, to obtain total airflow.
    c. Where duct conditions are not suitable for Pitot-tube traverse measurements, a coil traverse may be acceptable.

2. 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 artificial loading of filters at the time static pressures are measured.

3. Review Record Documents to determine variations in design static pressures versus actual static pressures. Calculate actual system-effect factors. Recommend adjustments to accommodate actual conditions.
4. Obtain approval from Architect for adjustment of fan speed higher or lower than indicated speed. Comply with requirements in HVAC Sections for air-handling units for adjustment of fans, belts, and pulley sizes to achieve indicated air-handling-unit performance.
5. Do not make fan-speed adjustments that result in motor overload. Consult equipment manufacturers about fan-speed safety factors. Modulate dampers and measure fan-motor amperage to ensure that no overload occurs. Measure

amperage in full-cooling, full-heating, economizer, and any other operating mode to determine the maximum required brake horsepower.

B. Adjust volume dampers for main duct, submain ducts, and major branch ducts to indicated airflows.

1. Measure airflow of submain and branch ducts.
2. Adjust submain and branch duct volume dampers for specified airflow.
3. Re-measure each submain and branch duct after all have been adjusted.

C. Adjust air inlets and outlets for each space to indicated airflows.

1. Set airflow patterns of adjustable outlets for proper distribution without drafts.
2. Measure inlets and outlets airflow.
3. Adjust each inlet and outlet for specified airflow.
4. Re-measure each inlet and outlet after they have been adjusted.

D. Verify final system conditions.

1. Re-measure and confirm that minimum outdoor, return, and relief airflows are within design. Readjust to design if necessary.
2. Re-measure and confirm that total airflow is within design.
3. Re-measure all final fan operating data, rpms, volts, amps, and static profile.
4. Mark all final settings.
5. Test system in economizer mode. Verify proper operation and adjust if necessary.
6. Measure and record all operating data.
7. Record final fan-performance data.

3.6 GENERAL PROCEDURES FOR HYDRONIC SYSTEMS

A. Prepare test reports for pumps, coils, and heat exchangers. Obtain approved submittals and manufacturer-recommended testing procedures. Crosscheck the summation of required coil and heat exchanger flow rates with pump design flow rate.

B. Prepare schematic diagrams of systems' "as-built" piping layouts.

C. In addition to requirements in "Preparation" Article, prepare hydronic systems for testing and balancing as follows:

1. Check liquid level in expansion tank.
2. Check highest vent for adequate pressure.
3. Check flow-control valves for proper position.
4. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.
5. Verify that motor starters are equipped with properly sized thermal protection.

6. Check that air has been purged from the system.

3.7 PROCEDURES FOR PRIMARY-SECONDARY HYDRONIC SYSTEMS

A. Balance the primary circuit flow first.

B. Balance the secondary circuits after the primary circuits are complete.

C. Adjust pumps to deliver total design gpm.

1. Measure total water flow.

    a. Position valves for full flow through coils.
    b. Measure flow by main flow meter, if installed.
    c. If main flow meter is not installed, determine flow by pump TDH or exchanger pressure drop.

2. Measure pump TDH as follows:

    a. Measure discharge pressure directly at the pump outlet flange or in discharge pipe prior to any valves.
    b. Measure inlet pressure directly at the pump inlet flange or in suction pipe prior to any valves or strainers.
    c. Convert pressure to head and correct for differences in gage heights.
    d. Verify pump impeller size by measuring the TDH with the discharge valve closed. Note the point on manufacturer's pump curve at zero flow and verify that the pump has the intended impeller size.
    e. With valves open, read pump TDH. Adjust pump discharge valve until design water flow is achieved.

3. Monitor motor performance during procedures and do not operate motor in an overloaded condition.

D. Adjust flow-measuring devices installed in mains and branches to design water flows.

1. Measure flow in main and branch pipes.
2. Adjust main and branch balance valves for design flow.
3. Re-measure each main and branch after all have been adjusted.

E. Adjust flow-measuring devices installed at terminals for each space to design water flows.

1. Measure flow at terminals.
2. Adjust each terminal to design flow.
3. Re-measure each terminal after it is adjusted.

4. Position control valves to bypass the coil and adjust the bypass valve to maintain design flow.
5. Perform temperature tests after flows have been balanced.

F. For systems with pressure-independent valves at terminals:

1. Measure differential pressure and verify that it is within manufacturer's specified range.
2. Perform temperature tests after flows have been verified.

G. For systems without pressure-independent valves or flow-measuring devices at terminals:

1. Measure and balance coils by either coil pressure drop or temperature method.
2. If balanced by coil pressure drop, perform temperature tests after flows have been verified.

H. Verify final system conditions as follows:

1. Re-measure and confirm that total water flow is within design.
2. Re-measure final pumps' operating data, TDH, volts, amps, and static profile.
3. Mark final settings.

I. Verify that memory stops have been set.

3.8 PROCEDURES FOR HEAT EXCHANGERS

A. Adjust water flow to within specified tolerances.

B. Measure inlet and outlet water temperatures.

C. Measure inlet steam pressure.

D. Check settings and operation of safety and relief valves. Record settings.

3.9 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.

3.10 PROCEDURES FOR BOILERS

A. Hydronic Boilers:

1. Measure and record entering- and leaving-water temperatures.
2. Measure and record water flow.
3. Record relief valve pressure setting.

B. Steam Boilers:

1. Measure and record entering-water temperature.
2. Measure and record feed water flow.
3. Measure and record leaving-steam pressure and temperature.
4. Record relief valve pressure setting.

3.11 PROCEDURES FOR HEAT-TRANSFER COILS

A. Measure, adjust, and record the following data for each water coil:

1. Entering- and leaving-water temperature.
2. Water flow rate.
3. Water pressure drop for major (more than 20 gpm) equipment coils, excluding unitary equipment such as reheat coils, unit heaters, and fan-coil units.
4. Dry-bulb temperature of entering and leaving air.
5. Wet-bulb temperature of entering and leaving air for cooling coils.
6. Airflow.

B. Measure, adjust, and record the following data for each electric heating coil:

1. Nameplate data.
2. Airflow.
3. Entering- and leaving-air temperature at full load.
4. Voltage and amperage input of each phase at full load.
5. Calculated kilowatt at full load.
6. Fuse or circuit-breaker rating for overload protection.

C. 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.

D. Measure, adjust, and record the following data for each refrigerant coil:

1. Dry-bulb temperature of entering and leaving air.
2. Wet-bulb temperature of entering and leaving air.
3. Airflow.

3.12 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.

3.13 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.

3.14 PROCEDURES FOR TESTING, ADJUSTING, AND BALANCING EXISTING SYSTEMS

A. Perform a preconstruction inspection of existing equipment that is to remain and be reused.

1. Measure and record the operating speed, airflow, and static pressure of each fan.
2. Measure motor voltage and amperage. Compare the values to motor nameplate information.
3. Check the refrigerant charge.
4. Check the condition of filters.
5. Check the condition of coils.
6. Check the operation of the drain pan and condensate-drain trap.
7. Check bearings and other lubricated parts for proper lubrication.
8. Report on the operating condition of the equipment and the results of the measurements taken. Report deficiencies.

B. Before performing testing and balancing of existing systems, inspect existing equipment that is to remain and be reused to verify that existing equipment has been cleaned and refurbished. Verify the following:

1. New filters are installed.
2. Coils are clean and fins combed.
3. Drain pans are clean.
4. Fans are clean.
5. Bearings and other parts are properly lubricated.
6. Deficiencies noted in the preconstruction report are corrected.

C. Perform testing and balancing of existing systems to the extent that existing systems are affected by the renovation work.

1. Compare the indicated airflow of the renovated work to the measured fan airflows, and determine the new fan speed and the face velocity of filters and coils.
2. Verify that the indicated airflows of the renovated work result in filter and coil face velocities and fan speeds that are within the acceptable limits defined by equipment manufacturer.
3. If calculations increase or decrease the airflow rates and water flow rates by more than 5 percent, make equipment adjustments to achieve the calculated rates. If increase or decrease is 5 percent or less, equipment adjustments are not required.
4. Balance each air outlet.

3.15 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.

3.16 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.

3.17 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. Pump curves.
2. Fan curves.
3. Manufacturers' test data.
4. Field test reports prepared by system and equipment installers.
5. Other information relative to equipment performance; 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 (mm), and bore.
    i. Center-to-center dimensions of sheave and amount of adjustments in inches (mm).
    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 (mm), and bore.
    f. Center-to-center dimensions of sheave and amount of adjustments in inches (mm).

3. Test Data (Indicated and Actual Values):

    a. Total airflow rate in cfm (L/s).
    b. Total system static pressure in inches wg (Pa).
    c. Fan rpm.
    d. Discharge static pressure in inches wg (Pa).
    e. Filter static-pressure differential in inches wg (Pa).
    f. Preheat-coil static-pressure differential in inches wg (Pa).
    g. Cooling-coil static-pressure differential in inches wg (Pa).
    h. Heating-coil static-pressure differential in inches wg (Pa).
    i. Outdoor airflow in cfm (L/s).
    j. Return airflow in cfm (L/s).
    k. Outdoor-air damper position.
    l. Return-air damper position.
    m. Vortex 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 (mm) o.c.
f. Make and model number.
g. Face area in sq. ft. (sq. m).
h. Tube size in NPS (DN).
i. Tube and fin materials.
j. Circuiting arrangement.

2. Test Data (Indicated and Actual Values):

a. Airflow rate in cfm (L/s).
b. Average face velocity in fpm (m/s).
c. Air pressure drop in inches wg (Pa).
d. Outdoor-air, wet- and dry-bulb temperatures in deg F (deg C).
e. Return-air, wet- and dry-bulb temperatures in deg F (deg C).
f. Entering-air, wet- and dry-bulb temperatures in deg F (deg C).
g. Leaving-air, wet- and dry-bulb temperatures in deg F (deg C).
h. Water flow rate in gpm (L/s).
i. Water pressure differential in feet of head or psig (kPa).
j. Entering-water temperature in deg F (deg C).
k. Leaving-water temperature in deg F (deg C).
l. Refrigerant expansion valve and refrigerant types.
m. Refrigerant suction pressure in psig (kPa).
n. Refrigerant suction temperature in deg F (deg C).
o. Inlet steam pressure in psig (kPa).

G. Gas- and Oil-Fired Heat Apparatus Test Reports: In addition to manufacturer's factory startup equipment reports, include the following:

1. Unit Data:

a. System identification.
b. Location.
c. Make and type.
d. Model number and unit size.
e. Manufacturer's serial number.
f. Fuel type in input data.
g. Output capacity in Btu/h (kW).
h. Ignition type.
i. Burner-control types.
j. Motor horsepower and rpm.
k. Motor volts, phase, and hertz.

l. Motor full-load amperage and service factor.
m. Sheave make, size in inches (mm), and bore.
n. Center-to-center dimensions of sheave and amount of adjustments in inches (mm).

2. Test Data (Indicated and Actual Values):

a. Total airflow rate in cfm (L/s).
b. Entering-air temperature in deg F (deg C).
c. Leaving-air temperature in deg F (deg C).
d. Air temperature differential in deg F (deg C).
e. Entering-air static pressure in inches wg (Pa).
f. Leaving-air static pressure in inches wg (Pa).
g. Air static-pressure differential in inches wg (Pa).
h. Low-fire fuel input in Btu/h (kW).
i. High-fire fuel input in Btu/h (kW).
j. Manifold pressure in psig (kPa).
k. High-temperature-limit setting in deg F (deg C).
l. Operating set point in Btu/h (kW).
m. Motor voltage at each connection.
n. Motor amperage for each phase.
o. Heating value of fuel in Btu/h (kW).

H. Electric-Coil Test Reports: For electric furnaces, duct coils, and electric coils installed in central-station air-handling units, include the following:

1. Unit Data:

a. System identification.
b. Location.
c. Coil identification.
d. Capacity in Btu/h (kW).
e. Number of stages.
f. Connected volts, phase, and hertz.
g. Rated amperage.
h. Airflow rate in cfm (L/s).
i. Face area in sq. ft. (sq. m).
j. Minimum face velocity in fpm (m/s).

2. Test Data (Indicated and Actual Values):

a. Heat output in Btu/h (kW).
b. Airflow rate in cfm (L/s).
c. Air velocity in fpm (m/s).
d. Entering-air temperature in deg F (deg C).

e. Leaving-air temperature in deg F (deg C).
f. Voltage at each connection.
g. Amperage for each phase.

I. 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 (mm), and bore.
h. Center-to-center dimensions of sheave and amount of adjustments in inches (mm).

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 (mm), and bore.
f. Center-to-center dimensions of sheave, and amount of adjustments in inches (mm).
g. Number, make, and size of belts.

3. Test Data (Indicated and Actual Values):

a. Total airflow rate in cfm (L/s).
b. Total system static pressure in inches wg (Pa).
c. Fan rpm.
d. Discharge static pressure in inches wg (Pa).
e. Suction static pressure in inches wg (Pa).

J. 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 (deg C).
d. Duct static pressure in inches wg (Pa).

e. Duct size in inches (mm).
f. Duct area in sq. ft. (sq. m).
g. Indicated airflow rate in cfm (L/s).
h. Indicated velocity in fpm (m/s).
i. Actual airflow rate in cfm (L/s).
j. Actual average velocity in fpm (m/s).
k. Barometric pressure in psig (Pa).

K. Air-Terminal-Device Reports:

1. Unit Data:

a. System and air-handling unit identification.
b. Location and zone.
c. Apparatus used for test.
d. Area served.
e. Make.
f. Number from system diagram.
g. Type and model number.
h. Size.
i. Effective area in sq. ft. (sq. m).

2. Test Data (Indicated and Actual Values):

a. Airflow rate in cfm (L/s).
b. Air velocity in fpm (m/s).
c. Preliminary airflow rate as needed in cfm (L/s).
d. Preliminary velocity as needed in fpm (m/s).
e. Final airflow rate in cfm (L/s).
f. Final velocity in fpm (m/s).
g. Space temperature in deg F (deg C).

L. System-Coil Reports: For reheat coils and water coils of terminal units, include the following:

1. Unit Data:

a. System and air-handling-unit identification.
b. Location and zone.
c. Room or riser served.
d. Coil make and size.
e. Flowmeter type.

2. Test Data (Indicated and Actual Values):

a. Airflow rate in cfm (L/s).

b. Entering-water temperature in deg F (deg C).
c. Leaving-water temperature in deg F (deg C).
d. Water pressure drop in feet of head or psig (kPa).
e. Entering-air temperature in deg F (deg C).
f. Leaving-air temperature in deg F (deg C).

M. Pump Test Reports: Calculate impeller size by plotting the shutoff head on pump curves and include the following:

1. Unit Data:

a. Unit identification.
b. Location.
c. Service.
d. Make and size.
e. Model number and serial number.
f. Water flow rate in gpm (L/s).
g. Water pressure differential in feet of head or psig (kPa).
h. Required net positive suction head in feet of head or psig (kPa).
i. Pump rpm.
j. Impeller diameter in inches (mm).
k. Motor make and frame size.
l. Motor horsepower and rpm.
m. Voltage at each connection.
n. Amperage for each phase.
o. Full-load amperage and service factor.
p. Seal type.

2. Test Data (Indicated and Actual Values):

a. Static head in feet of head or psig (kPa).
b. Pump shutoff pressure in feet of head or psig (kPa).
c. Actual impeller size in inches (mm).
d. Full-open flow rate in gpm (L/s).
e. Full-open pressure in feet of head or psig (kPa).
f. Final discharge pressure in feet of head or psig (kPa).
g. Final suction pressure in feet of head or psig (kPa).
h. Final total pressure in feet of head or psig (kPa).
i. Final water flow rate in gpm (L/s).
j. Voltage at each connection.
k. Amperage for each phase.

N. Instrument Calibration Reports:

1. Report Data:

a. Instrument type and make.
b. Serial number.
c. Application.
d. Dates of use.
e. Dates of calibration.

3.18 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.

3.19 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 and Plenum Insulation Schedule" article 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 liner of sufficient thickness to comply with energy code and ASHRAE/IESNA 90.1.
2. Factory-insulated flexible ducts.
3. Factory-insulated plenums and casings.
4. Flexible connectors.
5. Vibration-control devices.
6. Factory-insulated access panels and doors.

E. Type I, Commercial, Kitchen Hood Exhaust Duct and Plenum Insulation: Fire-rated blanket or board; thickness as required to achieve 2-hour fire rating.

END OF SECTION 230713

This page intentionally left blank

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.

C. rs, 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 (454 deg C).
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 (minus 18 deg C).
4. Service Temperature Range: 40 to 200 deg F (4 to plus 93 deg C).

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 (Minus 18 to plus 82 deg C).
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 (Minus 46 to plus 104 deg C).
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 (Minus 18 to plus 82 deg C).
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 (Minus 101 to plus 121 deg C).
    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 (Minus 40 to plus 121 deg C).
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 (Minus 40 to plus 121 deg C).
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: Selected by Architect from full availabilty.
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 (ASTM B209M), 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- (0.075-mm-) thick, heat-bonded polyethylene and kraft paper.
d. Moisture Barrier for Outdoor Applications: 3-mil- (0.075-mm-) 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- (1.5-mm-) 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 (75 mm).

3. Thickness: 11.5 mils (0.29 mm).
4. Adhesion: 90 ounces force/inch (1.0 N/mm) in width.
5. Elongation: 2 percent.
6. Tensile Strength: 40 lbf/inch (7.2 N/mm) 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 (75 mm).
3. Thickness: 6.5 mils (0.16 mm).
4. Adhesion: 90 ounces force/inch (1.0 N/mm) in width.
5. Elongation: 2 percent.
6. Tensile Strength: 40 lbf/inch (7.2 N/mm) 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 (50 mm).
3. Thickness: 6 mils (0.15 mm).
4. Adhesion: 64 ounces force/inch (0.7 N/mm) in width.
5. Elongation: 500 percent.
6. Tensile Strength: 18 lbf/inch (3.3 N/mm) 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 (50 mm).
3. Thickness: 3.7 mils (0.093 mm).
4. Adhesion: 100 ounces force/inch (1.1 N/mm) in width.
5. Elongation: 5 percent.
6. Tensile Strength: 34 lbf/inch (6.2 N/mm) 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 (0.38 mm) thick, 1/2 inch (13 mm) wide with wing seal or closed seal.
3. Aluminum: ASTM B209 (ASTM B209M), Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch (0.51 mm) thick, 1/2 inch (13 mm) 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 (19 mm) wide, stainless steel or Monel.

C. Wire: 0.062-inch (1.6-mm) 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 insulation application.

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- (75-mm-) wide strips, of same material as insulation jacket. Secure strips with adhesive and outward-clinching staples along both edges of strip, spaced 4 inches (100 mm) o.c.
3. Overlap jacket longitudinal seams at least 1-1/2 inches (38 mm). 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 (100 mm) 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 (50 mm) 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 (50 mm).
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. ntains vapor barrier.
7. tains vapor barrier.
8. 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.
9. 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.
10. 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.
11. 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. tapering it to and around the connection with insulating cement and finish with finishing cement, mastic, and flashing sealant.

E. 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. ulation and jacket.

4. 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.
5. 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 (50 mm) 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.
6. 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 (150 mm) 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 (25 mm), 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 (50-mm) overlap at seams and joints.
2. Embed glass cloth between two 0.062-inch- (1.6-mm-) 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 (38-mm) laps at longitudinal seams and 3-inch- (75-mm-) 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 (25-mm) 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 (50-mm) 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 (300 mm) 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 (50 mm) 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 (850 mm) or less. The 33-1/2-inch- (850-mm-) circumference limit allows for 2-inch- (50-mm-) 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.

C. Items Not Insulated: Unless otherwise indicated, do not install insulation on the following:
   1. Underground piping.
   2. Chrome-plated pipes and fittings unless there is a potential for personnel injury.

3.11 INDOOR PIPING INSULATION SCHEDULE

MINIMUM PIPE INSULATION THICKNESS (in inches)

FLUID OPERATING TEMPERATURE RANGE AND USAGE (°F)	INSULATION CONDUCTIVITY	NOMINAL PIPE OR TUBE SIZE (inches)					
	Conductivity Btu • in./(h • ft2 • °F)b	Mean Rating Tem-perature, °F	< 1	1 to < 11/2	11/2 to < 4	4 to < 8	≥ 8
> 350	0.32 - 0.34	250	4.5	5.0	5.0	5.0	5.0
251 — 350	0.29 — 0.32	200	3.0	4.0	4.5	4.5	4.5
201 — 250	0.27 — 0.30	150	2.5	2.5	2.5	3.0	3.0
141 — 200	0.25 — 0.29	125	1.5	1.5	2.0	2.0	2.0
105 — 140	0.21 — 0.28	100	1.0	1.0	1.5	1.5	1.5
40 — 60	0.21 — 0.27	75	0.5	0.5	1.0	1.0	1.0
< 40	0.20 — 0.26	50	0.5	1.0	1.0	1.0	1.5

3.12 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 (0.8 mm) thick, color selected by Architect.

3.13 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:

1. Painted Aluminum, Stucco Embossed: 0.020 inch (0.51 mm) thick.

END OF SECTION 230719

This page intentionally left blank

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

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.

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. Dual-Temp Heating and Cooling Water Piping: 100 psig at 200 deg F..
2. Glycol Dual-Temp Heating and Cooling Water Piping : 150 psig at 150 deg F.
3. Makeup-Water Piping: 150 psig at 150 deg F.
4. Condensate-Drain Piping: 180 deg F.
5. Blowdown-Drain Piping: 200 deg F.
6. Air-Vent Piping: 200 deg F.
7. 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 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.

2.5 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.

2.6 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.

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 CHEMICAL TREATMENT

A. Perform an analysis of makeup water to determine type and quantities of chemical treatment needed to keep system free of scale, corrosion, and fouling, and to sustain the following water characteristics:

1. pH: 9.0 to 10.5.
2. "P" Alkalinity: 100 to 500 ppm.
3. Boron: 100 to 200 ppm.
4. Chemical Oxygen Demand: Maximum of 100 ppm. Revise this value if closed system contains glycol.
5. Corrosion Inhibitor:

    a. Sodium Nitrate: 1000 to 1500 ppm.
    b. Molybdate: 200 to 300 ppm.
    c. Chromate: 200 to 300 ppm.
    d. Sodium Nitrate Plus Molybdate: 100 to 200 ppm each.
    e. Chromate Plus Molybdate: 50 to 100 ppm each.

6. Soluble Copper: Maximum of 0.20 ppm.
7. Tolyiriazole Copper and Yellow Metal Corrosion Inhibitor: Minimum of 10 ppm.
8. Total Suspended Solids: Maximum of 10 ppm.
9. Ammonia: Maximum of 20 ppm.
10. Free Caustic Alkalinity: Maximum of 20 ppm.
11. Microbiological Limits:

    a. Total Aerobic Plate Count: Maximum of 1000 organisms/mL.
    b. Total Anaerobic Plate Count: Maximum of 100 organisms/mL.
    c. Nitrate Reducers: 100 organisms/mL.
    d. Sulfate Reducers: Maximum of zero organisms/mL.
    e. Iron Bacteria: Maximum of zero organisms/mL.

B. Install bypass chemical feeders in each hydronic system where indicated.

1. Install in upright position with top of funnel not more than 48 inches above the floor.
2. Install feeder in minimum NPS 3/4 bypass line, from main with full-size, full-port, ball valve in the main between bypass connections.
3. Install NPS 3/4 pipe from chemical feeder drain to nearest equipment drain and include a full-size, full-port, ball valve.

C. Fill system with fresh water and add liquid alkaline compound with emulsifying agents and detergents to remove grease and petroleum products from piping. Circulate solution for a minimum of 24 hours, drain, clean strainer screens, and refill with fresh water.

D. Add initial chemical treatment and maintain water quality in ranges noted above for the first year of operation.

E. Fill systems that have antifreeze or glycol solutions with the following concentrations:

1. Hot-Water Heating Piping: Minimum of 30 percent propylene glycol.
2. Chilled-Water Piping: Minimum of 30 percent propylene glycol.
3. Dual-Temperature Heating and Cooling Water Piping: Minimum of 30percent propylene glycol.
4. Glycol Cooling-Water Piping: Minimum of 30 percent propylene glycol.

3.8 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 232116 - HYDRONIC PIPING SPECIALTIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Hydronic specialty valves.
2. Air-control devices.
3. Strainers.
4. Connectors.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product:

1. Include construction details and material descriptions for hydronic piping specialties.
2. Include rated capacities, operating characteristics, and furnished specialties and accessories.
3. Include flow and pressure drop curves based on manufacturer's testing for calibrated-orifice balancing valves and automatic flow-control valves.

1.3 CLOSEOUT SUBMITTALS

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

1.4 MAINTENANCE MATERIAL SUBMITTALS

A. Differential Pressure Meter: For each type of balancing valve and automatic flow control valve, include flowmeter, probes, hoses, flow charts, and carrying case.

1.5 QUALITY ASSURANCE

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

B. Safety Valves and Pressure Vessels: Shall bear the appropriate ASME label. Fabricate and stamp air separators and expansion tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

PART 2 - PRODUCTS

2.1 HYDRONIC SPECIALTY VALVES

A. Bronze, Calibrated-Orifice, Balancing Valves:

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

    a. Bell & Gossett; a Xylem brand.
    b. NIBCO INC.
    c. TACO Comfort Solutions, Inc.
    d. Victaulic Company.

2. Body: Bronze, ball or plug type with calibrated orifice or venturi.
3. Ball: Brass or stainless steel.
4. Plug: Resin.
5. Seat: PTFE.
6. End Connections: Threaded or socket.
7. Pressure Gage Connections: Integral seals for portable differential pressure meter.
8. Handle Style: Lever, with memory stop to retain set position.
9. CWP Rating: Minimum 125 psig.
10. Maximum Operating Temperature: 250 deg F.

B. Diaphragm-Operated, Pressure-Reducing Valves: ASME labeled.

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

    a. AMTROL, Inc.
    b. Apollo Flow Controls; Conbraco Industries, Inc.
    c. Armstrong Pumps, Inc.
    d. Bell & Gossett; a Xylem brand.
    e. Victaulic Company.
    f. WATTS.

2. Body: Bronze or brass.
3. Disc: Glass and carbon-filled PTFE.
4. Seat: Brass.
5. Stem Seals: EPDM O-rings.

6. Diaphragm: EPT.
7. Low inlet-pressure check valve.
8. Inlet Strainer: Stainless Steel, removable without system shutdown.
9. Valve Seat and Stem: Noncorrosive.
10. Valve Size, Capacity, and Operating Pressure: Selected to suit system in which installed, with operating pressure and capacity factory set and field adjustable.

C. Diaphragm-Operated Safety Valves: ASME labeled.

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

    a. AMTROL, Inc.
    b. Apollo Flow Controls; Conbraco Industries, Inc.
    c. Armstrong Pumps, Inc.
    d. Bell & Gossett; a Xylem brand.
    e. WATTS.

2. Body: Bronze or brass.
3. Disc: Glass and carbon-filled PTFE.
4. Seat: Brass.
5. Stem Seals: EPDM O-rings.
6. Diaphragm: EPT.
7. Wetted, Internal Work Parts: Brass and rubber.
8. Inlet Strainer: Stainless Steel, removable without system shutdown.
9. Valve Seat and Stem: Noncorrosive.
10. Valve Size, Capacity, and Operating Pressure: Comply with ASME Boiler and Pressure Vessel Code: Section IV, and selected to suit system in which installed, with operating pressure and capacity factory set and field adjustable.

2.2 AIR-CONTROL DEVICES

A. Manual Air Vents:

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

    a. AMTROL, Inc.
    b. Apollo Flow Controls; Conbraco Industries, Inc.
    c. Armstrong Pumps, Inc.
    d. Bell & Gossett; a Xylem brand.
    e. TACO Comfort Solutions, Inc.

2. Body: Bronze.
3. Internal Parts: Nonferrous.

4. Operator: Screwdriver or thumbscrew.
5. Inlet Connection: NPS 1/2.
6. Discharge Connection: NPS 1/8.
7. CWP Rating: 150 psig.
8. Maximum Operating Temperature: 225 deg F.

B. Automatic Air Vents:

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

    a. AMTROL, Inc.
    b. Bell & Gossett; a Xylem brand.
    c. Spirotherm, Inc.
    d. TACO Comfort Solutions, Inc.

2. Body: Bronze or cast iron.
3. Internal Parts: Nonferrous.
4. Operator: Noncorrosive metal float.
5. Inlet Connection: NPS 1/2.
6. Discharge Connection: NPS 1/4.
7. CWP Rating: 150 psig.
8. Maximum Operating Temperature: 240 deg F.

C. Bladder-Type ASME Expansion Tanks:

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

    a. AMTROL, Inc.
    b. Armstrong Pumps, Inc.
    c. Bell & Gossett; a Xylem brand.
    d. TACO Comfort Solutions, Inc.

2. Tank: Welded steel, rated for 125-psig working pressure and 240 deg F maximum operating temperature. Factory test after taps are fabricated and supports installed and are labeled according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
3. Bladder: Securely sealed into tank to separate air charge from system water to maintain required expansion capacity.
4. Air-Charge Fittings: Schrader valve, stainless steel with EPDM seats.

D. Air-Charge Fittings: Schrader valve, stainless steel with EPDM seats.

E. Coalescing-Type Air and Dirt Separators:

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

    a. Armstrong Pumps, Inc.
    b. Bell & Gossett; a Xylem brand.
    c. Spirotherm, Inc.

2. Tank: Fabricated steel tank; ASME constructed and stamped for 125-psig (862-kPa) working pressure and 270 deg F (130 deg C) maximum operating temperature.
3. Coalescing Medium: [Copper].
4. Air Vent: Threaded to the top of the separator.
5. Inline Inlet and Outlet Connections: Threaded for NPS 2 (DN 50) and smaller; Class 150 flanged connections for NPS 2-1/2 (DN 65) and larger.
6. Blowdown Connection: Threaded to the bottom of the separator.
7. Size: Match system flow capacity.

2.3 STRAINERS

A. Y-Pattern Strainers:

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

    a. Keckley Company.
    b. Metraflex Company (The).
    c. Titan Flow Control, Inc.
    d. WATTS.

2. Body: ASTM A126, Class B, cast iron or bronze with bolted cover and bottom drain connection.
3. End Connections: Threaded ends for NPS 2 and smaller; flanged ends for NPS 2-1/2 and larger.
4. Strainer Screen: Stainless-steel, 40-mesh strainer, or perforated stainless-steel basket.
5. CWP Rating: 125 psig.

2.4 CONNECTORS

A. Stainless-Steel Bellow, Flexible Connectors:

1. Body: Stainless-steel bellows with woven, flexible, bronze, wire-reinforcing protective jacket.
2. End Connections: Threaded or flanged to match equipment connected.

3. Performance: Capable of 3/4-inch misalignment.
4. CWP Rating: 150 psig.
5. Maximum Operating Temperature: 250 deg F.

B. Spherical, Rubber, Flexible Connectors:

1. Body: Fiber-reinforced rubber body.
2. End Connections: Steel flanges drilled to align with Classes 150 and 300 steel flanges.
3. Performance: Capable of misalignment.
4. CWP Rating: 150 psig.
5. Maximum Operating Temperature: 250 deg F.

PART 3 - EXECUTION

3.1 VALVE APPLICATIONS

A. Install shutoff-duty valves at each branch connection to supply mains and at supply connection to each piece of equipment.

B. Install check valves at each pump discharge and elsewhere as required to control flow direction

C. Install safety valves at hot-water generators and elsewhere as required by ASME Boiler and Pressure Vessel Code. Install drip-pan elbow on safety-valve outlet and pipe without valves to the outdoors; pipe drain to nearest floor drain or as indicated on Drawings. Comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1, for installation requirements.

D. Install pressure-reducing valves at makeup-water connection to regulate system fill pressure.

3.2 HYDRONIC SPECIALTIES INSTALLATION

A. Install manual air vents at high points in piping, at heat-transfer coils, and elsewhere as required for system air venting.

B. Install automatic air vents at high points of system piping in mechanical equipment rooms only. Install manual vents at heat-transfer coils and elsewhere as required for air venting.

C. Install piping from boiler air outlet, air separator, or air purger to expansion tank with a 2 percent upward slope toward tank.

D. Install in-line air separators in pump suction. Install drain valve on air separators NPS 2 and larger.

E. Install tangential air separator in pump suction. Install blowdown piping with gate or full-port ball valve; extend full size to nearest floor drain.

F. Install expansion tanks on the floor. Vent and purge air from hydronic system, and ensure that tank is properly charged with air to suit system Project requirements.

END OF SECTION 232116

SECTION 232123 - HYDRONIC PUMPS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Close-coupled, in-line centrifugal pumps.
2. Separately coupled, vertically mounted, in-line centrifugal pumps.

1.2 DEFINITIONS

A. ECM: Electronically commutated motor.

B. EPDM: Ethylene propylene diene monomer.

C. EPR: Ethylene propylene rubber.

D. FKM: Fluoroelastomer polymer.

E. HI: Hydraulic Institute.

F. NBR: Nitrile rubber or Buna-N.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of pump.

1. Include certified performance curves and rated capacities, operating characteristics, furnished specialties, final impeller dimensions, and accessories for each type of product indicated.
2. Indicate pump's operating point on curves.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plans, or BIM model, drawn to scale, showing the items described in this Section, and coordinated with all building trades.

B. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For pumps 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. Mechanical Seals: One (1) mechanical seal(s) for each pump.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

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

2.2 CLOSE-COUPLED, IN-LINE CENTRIFUGAL PUMPS

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. Bell & Gossett; a Xylem brand
2. Grundfos Pumps Corporation
3. TACO Comfort Solutions, Inc.

B. Source Limitations: Obtain pumps from single source from single manufacturer.

C. Description: Factory-assembled and -tested, centrifugal, overhung-impeller, close-coupled, in-line pump as defined in HI 1.1-1.2 and HI 1.3; designed for installation with pump and motor shafts mounted horizontally or vertically.

D. Pump Construction:

1. Casing: Radially split, cast iron, with threaded gauge tappings at inlet and outlet, replaceable bronze wear rings, and threaded companion-flange connections.

2. Impeller: ASTM B584, cast bronze; statically and dynamically balanced, keyed to shaft, and secured with a locking cap screw. For constant-speed pumps, trim impeller to match specified performance.
3. Pump Shaft Sleeve: Type 304 stainless steel.
4. Seal: Mechanical seal consisting of carbon rotating ring against a ceramic seat held by a stainless steel spring, and EPDM rubber bellows and gasket. Include water slinger on shaft between motor and seal.
5. Seal Flushing: Flush, cool, and lubricate pump seal by directing pump discharge water to flow over the seal.

E. Shaft Coupling: Rigid, axially-split spacer coupling to allow service of pump seal without disturbing pump or motor.

F. Motor: Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

1. Enclosure : Open drip proof.
2. NEMA Premium Efficient motors as defined in NEMA MG 1.
3. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
4. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.
5. Variable-speed motor.
6. Provide integral pump motor variable-speed controller.

2.3 SEPARATELY COUPLED, VERTICALLY MOUNTED, IN-LINE CENTRIFUGAL PUMPS

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. Bell & Gossett; a Xylem brand
2. TACO Comfort Solutions, Inc.

B. Source Limitations: Obtain pumps from single source from single manufacturer.

C. Description: Factory-assembled and -tested, centrifugal, overhung-impeller, separately coupled, in-line pump as defined in HI 1.1-1.2 and HI 1.3; designed for installation with pump and motor shafts mounted vertically.

D. Pump Construction:

1. Casing: Radially split, cast iron, with threaded gauge tappings at inlet and outlet**,** replaceable bronze wear rings, and threaded companion-flange connections.
2. Impeller: ASTM B584, cast bronze; statically and dynamically balanced, keyed to shaft, and secured with a locking cap screw. For pumps that are not frequency-drive controlled, trim impeller to match specified performance.
3. Pump Shaft: Carbon steel, Type 304 stainless steel shaft sleeve.
4. Seal: Mechanical seal consisting of carbon rotating ring against a ceramic seat held by a stainless steel spring, and EPDM bellows and gasket.

E. Shaft Coupling: Interlocking frame with interconnecting springs capable of absorbing vibration.

F. Motor: Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

1. Enclosure: Open drip proof
2. NEMA Premium Efficient motors as defined in NEMA MG 1.
3. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
4. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.
5. Variable-speed motor.
6. Provide integral pump motor variable-speed controller.

2.4 PUMP SPECIALTY FITTINGS

A. Suction Diffuser:

1. Angle pattern.
2. 175-psig pressure rating, cast-iron body and end cap, pump-inlet fitting.
3. Bronze 16-mesh wire startup and Type 304 stainless steel permanent strainers with 3/16-inch.
4. Carbon steel straightening vanes.
5. Drain plug.
6. Factory-fabricated support.

2.5 INTEGRAL PUMP MOTOR VARIABLE-SPEED CONTROLLERS

A. Where specified or scheduled, provide pumps with an integral pump motor speed controller.

1. Motor: Operates as constant- or variable-speed pump with speed regulated by an integrated variable-speed drive.
2. Integrated Pump Controller: Supports direct communication with the building management system (BMS) with built-in support for the following protocols: BACnet MS/TP.
3. Commissioning and pump set up access to pump controls via the following:

    a. A web interface (data exchange).
    b. A user interface located on the face of speed controller to adjust modes and mode values.
    c. An electronic display that reads real-time mode set values, flow, head, speed, and power and that locks out unauthorized adjustment of pump.

4. RPM (speed) regulation can be accomplished by the following:

    a. Manual (via user interface or HTML).
    b. Remote via 0 to 10 V dc.
    c. Data protocol communications with the BMS.

5. Pump Electronics: Standard with multiple digital inputs and one external digital output to be available for additional mechanical room control and pump status monitoring.
6. Controller: Mounted on or adjacent to the motor. Provide enclosure rated to UL Type 12.
7. Electronically Protected Pumps: Rated for continuous duty and with built-in startup circuit. Provide overcurrent, line surge and current limit protection, thermal monitoring, heat sink status and over temperature protection.
8. Pump capable of being monitored continuously via integrated Internet link.

2.6 ELECTRONICALLY COMMUTATED MOTOR (ECM)

A. Provide pumps so they are specified or scheduled with ECM.

1. Synchronous, constant torque, ECM with permanent magnet rotor. Rotor magnets to be time-stable, nontoxic ceramic magnets (Sr-Fe).
2. Driven by a frequency converter with an integrated power factor correction filter. Conventional induction motors will not be acceptable.
3. Each motor with an integrated variable-frequency drive, tested as one unit by manufacturer.
4. Motor speed adjustable over full range from 0 rpm to maximum scheduled speed.
5. Variable motor speed to be controlled by a 0- to 10 V-dc or 4- to 20-mA input.

6. Integrated motor protection verified by UL to protect the pump against over-/undervoltage, overtemperature of motor and/or electronics, overcurrent, locked rotor, and dry run (no-load condition).

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine equipment foundations and anchor-bolt locations for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for piping systems to verify actual locations of piping connections before pump installation.

C. Examine foundations and inertia bases for suitable conditions where pumps will be installed.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 ALIGNMENT

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

B. Comply with requirements in HI standards for alignment of pump and motor shaft. Add shims to the motor feet and bolt motor to base frame. Do not use grout between motor feet and base frame.

C. Comply with pump and coupling manufacturers' written instructions.

D. After alignment is correct, tighten foundation bolts evenly but not too firmly. Completely fill baseplate with nonshrink, nonmetallic grout while metal blocks and shims or wedges are in place. After grout has cured, fully tighten foundation bolts.

3.3 PIPING CONNECTIONS

A. Where installing piping adjacent to pump, allow space for service and maintenance.

B. Connect piping to pumps. Install valves that are same size as piping connected to pumps.

C. Install suction and discharge pipe sizes equal to or greater than diameter of pump nozzles.

D. Install triple-duty valve on discharge side of pumps.

E. Install suction diffuser and shutoff valve on suction side of pumps.

1. Use startup strainer for initial system startup. Install permanent strainer element before turnover of system to Owner.

F. Install flexible connectors on suction and discharge sides of base-mounted pumps between pump casing and valves.

G. Install pressure gauges on pump suction and discharge or at integral pressure-gauge tapping, or install single gauge with multiple-input selector valve.

3.4 ELECTRICAL CONNECTIONS

A. Install electrical devices furnished by manufacturer, but not factory mounted, in accordance with NFPA 70 and NECA 1.

B. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.
1. Nameplate shall be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least 1/2 inch high.

3.5 CONTROL CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

3.6 STARTUP SERVICE

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

1. Complete installation and startup checks in accordance with manufacturer's written instructions.
2. Check piping connections for tightness.
3. Clean strainers on suction piping. Use startup strainer for initial startup.
4. Perform the following startup checks for each pump before starting:

a. Verify bearing lubrication.
b. Verify that pump is free to rotate by hand and that pump for handling hot liquid is free to rotate with pump hot and cold. If pump is bound or drags, do not operate until cause of trouble is determined and corrected.
c. Verify that pump is rotating in correct direction.

5. Prime pump by opening suction valves and closing drains, and prepare pump for operation.
6. Start motor.
7. Open discharge valve slowly.

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. Perform tests and inspections with the assistance of a factory-authorized service representative.

C. Hydronic pumps will be considered defective if they do 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 hydronic pumps.

END OF SECTION 232123

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, fitting, 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 operation and compliance with warranties of connected equipment.
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-410A:

1. Suction Lines for Air-Conditioning Applications: 300 psig.
2. Suction Lines for Heat-Pump Applications: 535 psig.
3. Hot-Gas and Liquid Lines: 535 psig.

B. 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.
3. Hot-Gas and Liquid Lines: 535 psig.

2.2 COPPER TUBE AND FITTINGS

A. Rigid 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.

e.

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-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.

B. 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.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS FOR REFRIGERANT R-410A and R32

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, Rigid Type ACR, annealed- or drawn-temper tubing and wrought-copper fittings with brazed joints or pressure-seal-joint fittings.

C. Safety-Relief-Valve Discharge Piping:

1. Copper, Type ACR, annealed- or drawn-temper tubing and wrought-copper fittings with brazed joints or pressure-seal-joint fittings.

3.2 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.

3.3 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. Install refrigerant piping in protective conduit where installed belowground.

M. Install refrigerant piping in rigid or flexible conduit in locations where exposed to mechanical injury.

N. 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.

O. 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.

P. 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.

Q. Install piping with adequate clearance between pipe and adjacent walls and hangers or between pipes for insulation installation.

R. Identify refrigerant piping and valves according to Section 230553 "Identification for HVAC Piping and Equipment."

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.

3.4 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. 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.

E. 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.

F. Steel pipe can be threaded, but threaded joints must be seal brazed or seal welded.

G. Welded Joints: Construct joints according to AWS D10.12M/D10.12.

H. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

I. 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.

3.5 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.

3.6 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.

3.7 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.

3.8 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

This page intentionally left blank

SECTION 232513 - WATER TREATMENT FOR CLOSED-LOOP HYDRONIC SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. This section specifies cleaning and treatment of circulating HVAC water systems, including the following.

1. Cleaning compounds.
2. Chemical treatment for closed loop hydronic systems.
3. Water treatment equipment.

1.2 PERFORMANCE REQUIREMENTS

A. Minimize corrosion, scale buildup, and biological growth for optimum efficiency of mechanical equipment without creating a hazard to operating personnel or the environment.

B. Base water treatment program on quality of water available at project site, HVAC system equipment material characteristics and functional performance characteristics, operating personnel capabilities, and requirements and guidelines of authorities having jurisdiction.

C. Chemically treat and maintain closed-loop hydronic system water to meet following standards:

1. Suspended solids: None.
2. Iron Corrosion Rate: stable rate, 0.5 mils per year maximum, no pitting.
3. Copper Corrosion Rate: stable rate, 0.2 mils per year maximum, no pitting.
4. Total Iron Concentration: 0.5 mg/L Fe maximum.
5. Total Copper Concentration: 0.2 mg/L Cu maximum.
6. pH: 8.5 – 9.5, accuracy ±0.1
7. Conductivity <2500 μS/cm (micro siemens/cm)
8. "P" Alkalinity: Maintain a value within 100 to 500 ppm.
9. Boron: Maintain a value within 100 to 200 ppm.
10. Chemical Oxygen Demand: Maintain a maximum value of 100 ppm.
11. TDS: Maintain a maximum value of 10 ppm.
12. Microbiological Limits:

a. Total Aerobic Plate Count: Maintain a maximum value of 1000 organisms/ml.
b. Total Anaerobic Plate Count: Maintain a maximum value of 100 organisms/ml.
c. Nitrate Reducers: Maintain a maximum value of 100 organisms/ml.
d. Sulfate Reducers: Maintain a maximum value of 0 organisms/ml.
e. Iron Bacteria: Maintain a maximum value of 0 organisms/ml.

1.3 ACTION SUBMITTALS

A. Product data for each type of chemical supplied. Include manufacturer's technical product data, material safety data sheets and manufacturer's instructions for proper application of chemicals.
   1. Bypass feeders.
   2. Water meters.
   3. Inhibitor injection timers.
   4. pH controllers.
   5. Chemical solution tanks.
   6. Injection pumps.
   7. Chemical-treatment test equipment.
   8. Chemical material safety data sheets.
   9. Inhibited propylene glycol.

B. Shop Drawings: Pretreatment and chemical-treatment equipment, showing tanks, maintenance space required, and piping connections to hydronic systems.
   1. Include plans, elevations, sections, and attachment details.
   2. Include diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Water-Analysis Provider Qualifications: Verification of experience and capability of HVAC water-treatment service provider.

B. Water-Treatment Program: Written sequence of operation on an annual basis for the application equipment required to achieve water quality defined in "Performance Requirements" Article.

C. Water Analysis: Illustrate water quality available at Project site.

D. Field test reports indicating and interpreting test results relative to compliance with specified requirements.

1.5 CLOSEOUT SUBMITTALS

A. Operations and Maintenance Manual: Include the following:

1. Material Safety Data Sheets for chemical supplied.
2. Manufacturer's instructions for proper application of chemicals.
3. Maintenance schedules for application and testing.
4. System volume(s).
5. Water Analysis Report
6. Operations and Maintenance Manuals for equipment and systems

1.6 QUALITY ASSURANCE

A. Supplier Qualifications: A recognized chemical water treatment supplier with warehousing facilities in the Project's vicinity and that is or employs an experienced consultant, available at reasonable times during the course of the Work to consult with Contractor, Architect, and Owner about water treatment.

B. Chemical Standards: Meet state and local environmental regulations.

1.7 QUALIFICATIONS

A. Water treatment company specializing in performing the work specified in this Section with minimum five years experience. Company shall be capable of analyzing water qualities, installing water-treatment equipment, and applying water treatment as specified in this Section.

1.8 REGULATORY REQUIREMENTS

A. Conform to applicable code for addition of non-potable chemicals to building mechanical systems, and to public sewage systems.

1.9 MAINTENANCE SERVICE

A. Scope of Maintenance Service: Provide chemicals and service program to maintain water conditions for a period of one year from date of Substantial Completion.

1. Provide technical service visits to perform field inspections and make water analysis on site six months and eleven months after completion. Detail findings in writing on proper practices, chemical treating requirements, and corrective actions needed. Submit two copies of field service report after each visit.
2. Provide laboratory and technical assistance services during this maintenance period.

3. Include two hour training course for operating personnel, instructing them on installation, care, maintenance, testing, and operation of water treatment systems. Arrange course at start up of systems.
4. Provide on-site inspections of equipment during scheduled or emergency shutdown to properly evaluate success of water treatment program, and make recommendations in writing based upon these inspections.

PART 2 - PRODUCTS

2.1 CLEANING CHEMICALS

A. Cleaning Solution: neutral pH cleaning solution which is capable of removing oil, grease, and rust from metal surfaces of system and passivating cleaned metal surfaces of system. Cleaning solution shall include:

1. Low foaming non-ionic surfactant for penetrating oily and greasy deposit surfaces.
2. Solvent for dissolving oil and grease.
3. Dispersant for dissolving rust.
4. Reducing agent for corrosion control.
5. Ferrous and non-ferrous metal corrosion inhibitors.

B. All chemicals to be acceptable for discharge to sanitary sewer.

2.2 TREATMENT CHEMICALS

A. Furnish chemicals recommended by water treatment system manufacturer for treating water to meet specified water quality. Provide only chemicals that are compatible with piping materials, seals, and accessories.

2.3 MANUAL CHEMICAL-FEED EQUIPMENT

A. Bypass Feeders: Steel, with corrosion-resistant exterior coating, minimum 3-1/2-inch fill opening in the top, and NPS 3/4 bottom inlet and top side outlet. Quarter turn or threaded fill cap with gasket seal and diaphragm to lock the top on the feeder when exposed to system pressure in the vessel.

1. Capacity: 2 gal.
2. Minimum Working Pressure: 175 psig.

B. Provide test kits for all treatment programs.

2.4 AUTOMATIC GLYCOL FEEDER

A. Manufacturer: subject to compliance with requirements, provide products by one of the following:

1. Wessels Company
2. Neptune

B. General: provide and install a completely pre-fabricated/preassembled package glycol feeder system with: single point power connection, injection pump, fluid holding tank, interconnecting piping and wiring, and control panel.

C. Pump

1. Material: Bronze
2. Fluid flow rate: per scheduled data
3. Discharge pressure: per scheduled data

D. Tank: shall be constructed of polyethylene with a four-leg steel stand with attachment bolts at each leg. Tank shall have upper and lower steel support banding. Steel support stand to be painted with corrosion resistant enamel.

E. Piping

1. Piping to be rated for system pressure and use within a pressurized system.
2. Pump suction piping: to be constructed of PVC tubing and fittings. PVC shutoff valve and strainer to be furnished.
3. Pump discharge piping: constructed of schedule 40 brass and brass fittings. Discharge to come equipped with pressure switch, pressure gage, isolation valve, check valve, and relief valve. Relief valve to be piped back to the holding tank.

F. Control Panel

1. 115 volt, single phase power connection
2. NEMA 4X enclosure
3. HOA switch with running light and starter.

G. Level switch: low level switch shall engage a low level alarm. Alarm shall be issued to the central BAS system as well as a local, audible, alarm.

2.5 STAINLESS-STEEL PIPES AND FITTINGS

1. Stainless-Steel Tubing: Comply with ASTM A 269, Type 316.
2. Stainless-Steel Fittings: Complying with ASTM A 815/A 815M, Type 316, Grade WP-S.

3. Two-Piece, Full-Port, Stainless-Steel Ball Valves: ASTM A 351, Type 316 stainless-steel body; ASTM A 276, Type 316 stainless-steel stem and vented ball, carbon-filled TFE seats, threaded body design with adjustable stem packing, threaded ends, and 250-psig SWP and 600-psig CWP ratings.

2.6 CHEMICAL TREATMENT TEST EQUIPMENT

A. Provide white enamel test cabinet with local and fluorescent light, capable of accommodating 4 - 10 ml zeroing titrating burettes and associated reagents.

1. Provide test kits for all treatment programs.

B. Corrosion Test-Coupon Assembly: Two station rack constructed of corrosive-resistant material, complete with piping, valves, and mild steel and copper coupons. Locate copper coupon downstream from mild steel coupon in the test-coupon assembly.

PART 3 - EXECUTION

3.1 WATER ANALYSIS

A. Perform an analysis of supply water to determine the type and quantities of chemical treatment needed to maintain the water quality as specified in "Performance Requirements" Article. Submit analysis report to owner for review and include in Operations and Maintenance Manual submission.

3.2 INSTALLATION

A. Install treatment equipment level and plumb, in accordance with manufacturer's instructions.

B. Provide one bypass feeder on each system. Install isolating and drain valves and necessary piping. Install around balancing valve downstream of circulating pumps unless indicated otherwise.

C. Provide 3/4 inch water coupon rack around circulating pumps. Maintain access to coupon rack.

D. Install piping adjacent to equipment to allow service and maintenance.

3.3 CLEANING - GENERAL

A. Systems shall be operational, filled, started, and vented prior to cleaning. Use water meter to record capacity in each system.

B. Place terminal control valves in open position during cleaning.

C. Manual and automatic valves are in full open position.

D. By-pass valves are operated to ensure full flow through entire system.

E. Safety devices, including pressure relief valves, flow switches, and pressure switches are functioning.

F. Temporary fine mesh strainers for system pump and control valve strainer baskets are installed and cleaned as required.

3.4 CLEANING PROCEDURE

A. Step 1: Fill system with domestic water, establish circulation, and heat system contents to a temperature of 140°F.

B. Step 2: After two hours of circulation, collect water samples from at least three different locations in system. If these samples contain suspended solids, clean out strainer baskets, drain system, and repeat steps 1 & 2.

C. Step 3: Blend in prepared concentrated cleaning solution, establish circulation, and maintain system temperature at 140°F for at least three days.

D. Step 4: Dump spent cleaning solution to disposal, fill system with domestic water, circulate system contents for at least two hours, and dump spent rinse water to disposal.

E. Step 5: Fill system with domestic water and repeat step 4 until water samples collected from system are free of oil, grease, and suspended solids.

F. Step 6: Drain system completely, including all system low points and perform visual inspections of metal surfaces at three different locations.

G. Complete steps 4, 5 & 6 within a 24 hour period.

H. If metal surfaces contain oil/grease or silt, fill the system with domestic water and repeat steps 3, 4, 5 & 6.

I. Immediately after inspection is completed, install strainers, fill system with glycol solution, blend in concentrated corrosion inhibitor solution until its concentration in system is at an acceptable level for film formation, and pass system water through corrosion coupon rack.

3.5 ADJUSTING

A. Sample water at two-week intervals after each system startup for a period of three months, and prepare certified test report for each required water performance characteristic. Where applicable, comply with industry standard test procedures.

3.6 DEMONSTRATION

A. Provide services of water treatment firm’s representative for half a day to instruct Owner's personnel in operation, maintenance, and testing procedures of chemical water treatment system.

B. Train Owner's maintenance personnel on procedures and schedules related to startup and shutdown, troubleshooting, servicing, and preventive maintenance.

1. Review manufacturer's safety data sheets for handling of chemicals.

2. Review data in maintenance manuals, especially data on recommended parts inventory and supply sources and on availability of parts and service. Refer to Division 01 Section Closeout Procedures.

END OF SECTION 232513

SECTION 233113 - METAL DUCTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Single-wall rectangular ducts and fittings.
2. Single-wall round ducts and fittings.
3. Sheet metal materials.
4. Duct liner.
5. Sealants and gaskets.
6. 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.

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 and bottom 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 and ceilings.

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. eria indicated in "Duct Schedule" Article.

C. 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".

D. Wind Performance: Ducts are to withstand the effects of wind determined in accordance with to ASCE/SEI 7.

E. Airstream Surfaces: Surfaces in contact with airstream comply with requirements in ASHRAE 62.1.

F. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment," and Section 7 - "Construction and System Startup."

G. ASHRAE/IES Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6.4.4 - "HVAC System Construction and Insulation."

H. 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 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."

E. ndards - Metal and Flexible."

1. Transverse Joints in Ducts Larger Than 60 Inches in Diameter: Flanged.

F. 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.

G. 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."

2.4 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. 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.

D. Tie Rods: Galvanized steel, 1/4-inch- minimum diameter for lengths 36 inches or less; 3/8-inch- minimum diameter for lengths longer than 36 inches.

2.5 DUCT LINER

A. Fibrous-Glass Duct Liner: Comply with ASTM C1071, NFPA 90A, or NFPA 90B; and with NAIMA AH124, "Fibrous Glass Duct Liner Standard."

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

a. Johns Manville; a Berkshire Hathaway company.
b. Knauf Insulation.
c. Owens Corning.

2. Source Limitations: Obtain fibrous-glass duct liner from single manufacturer.
3. Maximum Thermal Conductivity:

a. Type I, Flexible: 0.27 Btu x in./h x sq. ft. x deg F at 75 deg F mean temperature.
b. Type II, Rigid: 0.23 Btu x in./h x sq. ft. x deg F at 75 deg F mean temperature.

4. Antimicrobial Erosion-Resistant Coating: Apply to the surface of the liner that will form the interior surface of the duct to act as a moisture repellent and erosion-resistant coating. Antimicrobial compound is to be tested for efficacy by an NRTL and registered by the EPA for use in HVAC systems.
5. Solvent-Based Liner Adhesive: Comply with NFPA 90A or NFPA 90B and with ASTM C916.

B. Flexible Elastomeric Duct Liner: Preformed, cellular, closed-cell, sheet materials complying with ASTM C534/C534M, Type II, Grade 1; and with NFPA 90A or NFPA 90B.

1. Source Limitations: Obtain flexible elastomeric duct liner from single manufacturer.
2. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested in accordance with UL 723; certified by an NRTL.
3. Liner Adhesive: As recommended by insulation manufacturer and complying with NFPA 90A or NFPA 90B.

C. Insulation Pins and Washers:

1. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.135-inch- diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch galvanized carbon-steel washer.
2. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- thick galvanized steel; with beveled edge sized as required to hold insulation securely in place, but not less than 1-1/2 inches in diameter.

D. Shop Application of Duct Liner: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 7-11, "Flexible Duct Liner Installation."

1. Adhere a single layer of indicated thickness of duct liner with at least 90 percent adhesive coverage at liner contact surface area. Attaining indicated thickness with multiple layers of duct liner is prohibited.
2. Apply adhesive to transverse edges of liner facing upstream that do not receive metal nosing.
3. Butt transverse joints without gaps, and coat joint with adhesive.
4. Fold and compress liner in corners of rectangular ducts or cut and fit to ensure butted-edge overlapping.
5. Do not apply liner in rectangular ducts with longitudinal joints, except at corners of ducts, unless duct size and dimensions of standard liner make longitudinal joints necessary.
6. Apply adhesive coating on longitudinal seams in ducts with air velocity of 2500 fpm or greater.
7. Secure liner with mechanical fasteners 4 inches from corners and at intervals not exceeding 12 inches transversely; at 3 inches from transverse joints and at intervals not exceeding 18 inches longitudinally.
8. Secure transversely oriented liner edges facing the airstream with metal nosings that have either channel or "Z" profiles or are integrally formed from duct wall. Fabricate edge facings at the following locations:

a. Fan discharges.

b. Intervals of lined duct preceding unlined duct.
c. Upstream edges of transverse joints in ducts where air velocities are higher than 2500 fpm or where indicated.

9. Secure insulation between perforated sheet metal inner duct of same thickness as specified for outer shell. Use mechanical fasteners that maintain inner duct at uniform distance from outer shell without compressing insulation.

    a. Sheet Metal Inner Duct Perforations: 3/32-inch diameter, with an overall open area of 23 percent.

10. Terminate inner ducts with buildouts attached to fire-damper sleeves, dampers, turning vane assemblies, or other devices. Fabricated buildouts (metal hat sections) or other buildout means are optional; when used, secure buildouts to duct walls with bolts, screws, rivets, or welds.

2.6 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.

2.7 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. e indicated.

D. Install ducts in maximum practical lengths with fewest possible joints.

E. Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections.

F. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.

G. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.

H. Install ducts with a clearance of 1 inch, plus allowance for insulation thickness.

I. Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.

J. Where ducts pass through non-fire-rated interior partitions and exterior walls and are exposed to view, cover the opening between the partition and duct or duct insulation with sheet metal flanges of same metal thickness as the duct. Overlap openings on four sides by at least 1-1/2 inches.

K. Install fire, combination fire/smoke, and smoke dampers where indicated on Drawings and as required by code, and by local authorities having jurisdiction.

L. Install heating coils, cooling coils, air filters, dampers, and all other duct-mounted accessories in air ducts where indicated on Drawings.

M. 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."

N. 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.

O. 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 ADDITIONAL INSTALLATION REQUIREMENTS FOR TYPE 1 COMMERCIAL KITCHEN GREASE HOOD EXHAUST DUCT

A. Install ducts in accordance with NFPA 96, "Ventilation Control and Fire Protection of Commercial Cooking Operation"; SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; and SMACNA's "Kitchen Ventilation Systems and Food Service Equipment Fabrication and Installation Guidelines" unless otherwise indicated.

B. Install all ducts without dips and traps that may hold grease, and sloped a minimum of 2 percent to drain grease back to the hood.

C. All joints are to be welded and are to be telescoping, bell, or flange joint as per NFPA 96.

D. Install fire-rated access panel assemblies at each change in direction and at maximum intervals of 20 feet in horizontal ducts, and at every floor for vertical ducts, or as indicated on Drawings.

E. Do not penetrate fire-rated assemblies except as allowed by applicable building codes and authorities having jurisdiction.

3.4 ADDITIONAL INSTALLATION REQUIREMENTS FOR EXHAUST DUCTS SERVING COMMERCIAL DISHWASHERS

A. Construct ducts of aluminum unless otherwise indicated.

B. Install dishwasher exhaust ducts and other exhaust ducts from wet, high-humidity locations without dips and traps that may hold water. Slope ducts a minimum of 2 percent back to dishwasher or toward drain.

C. Provide a drain pocket at each low point and at the base of each riser with a 1-inch trapped copper drain from each drain pocket to open site floor drain.

D. Minimize number of transverse seams.

E. Do not locate longitudinal seams on bottom of duct.

3.5 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."

3.6 HANGER AND SUPPORT INSTALLATION

A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 5, "Hangers and Supports."

B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.

1. Where practical, install concrete inserts before placing concrete.
2. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
3. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches thick.
4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches thick.
5. Do not use powder-actuated concrete fasteners for seismic restraints.

C. Hanger Spacing: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2,

"Minimum Hanger Sizes for Round Duct," for maximum hanger spacing; install hangers and supports within 24 inches of each elbow and within 48 inches of each branch intersection.

D. Hangers Exposed to View: Threaded rod and angle or channel supports.

E. Support vertical ducts with steel angles or channel secured to the sides of the duct with welds, bolts, sheet metal screws, or blind rivets; support at each floor and at a maximum intervals of 16 feet.

F. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

3.7 DUCTWORK CONNECTIONS

A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

3.8 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.

3.9 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.

3.10 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.

3.11 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 Dishwashers, Dishwasher Hoods, and Other High-Humidity Locations:

a. Aluminum sheet.
b. Exposed to View: No. 4 finish.
c. Concealed: No. 2D finish.
d. Welded longitudinal seams; welded or flanged transverse joints with watertight EPDM gaskets.
e. Pressure Class: Positive or negative 2-inch wg.
f. Airtight/watertight.

4. 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. Outdoor-Air (Not Filtered, Heated, or Cooled) Ducts:

1. Ducts Connected to Air-Handling Units:

a. Pressure Class: Positive or negative 2-inch wg.
b. Minimum SMACNA Seal Class: A.

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. Liner:

1. Supply-Air Ducts: Flexible elastomeric, 1 inch thick.
2. Return-Air Ducts: Flexible elastomeric, 1 inch thick.
3. Exhaust-Air Ducts: Flexible elastomeric, 1 inch thick.
4. Supply Fan Plenums: Flexible elastomeric, 1 inch thick.
5. Return- and Exhaust-Fan Plenums: Flexible elastomeric, 1 inches thick.
6. Transfer Ducts: Flexible elastomeric, 1 inch thick.

H. 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.

I. Branch Configuration:

1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-6, "Branch Connection."

a. Rectangular Main to Rectangular Branch: 45-degree entry.
b. Rectangular Main to Round Branch: 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

SECTION 233300 - AIR DUCT ACCESSORIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. 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.

1.3 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.

1.4 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.

1.5 CLOSEOUT SUBMITTALS

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

1.6 MAINTENANCE MATERIAL SUBMITTALS

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

1. Fusible Links: Furnish quantity equal to 10 percent of amount installed.

PART 2 - PRODUCTS

2.1 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. Comply with requirements for electrical devices and connections specified in Section 230923 "Direct Digital Control (DDC) System for HVAC."
2. 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 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Non-insulated flexible ducts.
2. Insulated flexible ducts.

1.3 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.

1.4 INFORMATIONAL SUBMITTALS

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

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

SECTION 233423 - HVAC POWER VENTILATORS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
   1. Ceiling-mounted ventilators.
   2. Centrifugal ventilators - roof downblast.
   3. Centrifugal ventilators - roof upblast and sidewall.

1.3 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.

1.4 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.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For HVAC power ventilators to include in normal and 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. Belts: One set(s) for each belt-driven unit.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

2.2 CEILING-MOUNTED VENTILATORS

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: Steel, lined with acoustical insulation.

C. Fan Wheel: Centrifugal wheels directly mounted on motor shaft. Fan shrouds, motor, and fan wheel removable for service.

D. Back-draft damper: Integral.

E. Grille: Plastic, louvered grille with flange on intake and thumbscrew or spring retainer attachment to fan housing.

F. Electrical Requirements: Junction box for electrical connection on housing and receptacle for motor plug-in.

G. Accessories:

1. Variable-Frequency Motor Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
2. Manual Starter Switch: Single-pole rocker switch assembly with cover and pilot light.
3. Time-Delay Switch: Assembly with single-pole rocker switch, timer, and cover plate.
4. Motion Sensor: Motion detector with adjustable shutoff timer.
5. Ceiling Radiation Damper: Fire-rated assembly with ceramic blanket, stainless steel springs, and fusible link.
6. Filter: Washable aluminum to fit between fan and grille.
7. Isolation: Rubber-in-shear vibration isolators.
8. Manufacturer's standard roof jack or wall cap, and transition fittings.

2.3 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. Belt Drives:

1. Resiliently mounted to housing.
2. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
3. Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings.
4. Fan Pulleys: Cast iron or cast steel with split, tapered bushing; dynamically balanced at factory.
5. Motor Pulleys: Adjustable pitch for use with motors through 5 hp. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions. Provide fixed pitch for use with motors larger than 5 hp.
6. Fan and motor isolated from exhaust airstream.

E. Accessories:

1. Variable-Frequency Motor Controller: Solid-state control to reduce speed from 100 to less than 50 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. Dampers: Counterbalanced, parallel-blade, backdraft dampers mounted in curb base; factory set to close when fan stops.
5. Motorized Dampers: Parallel-blade dampers mounted in curb base with electric actuator; wired to close when fan stops.
6. Spark-resistant, all-aluminum wheel construction.
7. Mounting Pedestal: Galvanized steel with removable access panel.

F. Prefabricated Roof Curbs: Galvanized steel; mitered and welded corners; 1-1/2-inch-thick, rigid, fiberglass insulation adhered to inside walls; and 1-1/2-inch wood nailer. Size as required to suit roof opening and fan base.

1. Configuration: Self-flashing without a cant strip, with mounting flange.
2. Overall Height: 24 inches.
3. Sound Curb: Curb with sound-absorbing insulation.
4. Hinged sub-base to provide access to damper or as cleanout for grease applications.
5. Pitch Mounting: Manufacture curb for roof slope.
6. Metal Liner: Galvanized steel.
7. Mounting Pedestal: Galvanized steel with removable access panel.

2.4 CENTRIFUGAL VENTILATORS - ROOF UPBLAST OR SIDEWALL

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: Removable spun-aluminum dome top and outlet baffle; square, one-piece aluminum base with venturi inlet cone.

1. Upblast Units: Provide spun-aluminum discharge baffle to direct discharge air upward, with rain and snow drains.
2. Provide grease collector.

C. Fan Wheels: Aluminum hub and wheel with backward-inclined blades.

D. Belt Drives:

1. Resiliently mounted to housing.
2. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
3. Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings; minimum ABMA9, L(10) of 100,000 hours .
4. Fan Pulleys: Cast iron or cast steel with split, tapered bushing; dynamically balanced at factory.
5. Motor Pulleys: Adjustable pitch for use with motors through 5 hp. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions. Provide fixed pitch for use with motors larger than 5 hp.
6. Fan and motor isolated from exhaust airstream.

E. Accessories:

1. Variable-Frequency Motor Controller: Solid-state control to reduce speed from 100 to less than 50 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. Dampers: Counterbalanced, parallel-blade, backdraft dampers mounted in curb base; factory set to close when fan stops.
5. Motorized Dampers: Parallel-blade dampers mounted in curb base with electric actuator; wired to close when fan stops.
6. Spark-resistant, all-aluminum wheel construction.
7. Mounting Pedestal: Galvanized steel with removable access panel.
8. Wall Mount Adapter: Attach wall-mounted fan to wall.
9. Restaurant Kitchen Exhaust: UL 762 listed for grease-laden air exhaust.

F. Prefabricated Roof Curbs: Galvanized steel; mitered and welded corners; 1-1/2-inch-thick, rigid, fiberglass insulation adhered to inside walls; and 1-1/2-inch wood nailer. Size as required to suit roof opening and fan base.

1. Configuration: Self-flashing without a cant strip, with mounting flange.

2. Overall Height: 18 inches.

G. Prefabricated Kitchen Exhaust Roof Curbs: Galvanized steel; mitered and welded corners; ventilation openings on all sides to ventilate curb interstitial space. Size as required to suit roof opening and fan base.

1. Configuration: Self-flashing without a cant strip, with mounting flange.
2. Overall Height: 18 inches.
3. Sound Curb: Curb with sound-absorbing insulationand galvanized metal liner.

4. Hinged sub-base to provide access to damper or as cleanout for grease applications.
5. Pitch Mounting: Manufacture curb for roof slope.
6. Metal Liner: Galvanized steel.
7. Mounting Pedestal: Galvanized steel with removable access panel.
8. Vented Curb: For kitchen exhaust; 12-inch- high galvanized steel; unlined, with louvered vents in vertical sides.
9. NFPA 96 code requirements for commercial cooking operations.
10. Kitchen Hood Exhaust: UL 762 listed for grease-laden air.

2.5 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. Ceiling Units: Suspend units from structure; use steel wire or metal straps.

D. Support suspended units from structure using threaded steel rods and elastomeric hangers having a static deflection of 1 inch.

E. Install units with clearances for service and maintenance.

F. 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 belt tension.
7. Adjust damper linkages for proper damper operation.
8. Verify lubrication for bearings and other moving parts.
9. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.
10. Disable automatic temperature-control operators, energize motor and adjust fan to indicated rpm, and measure and record motor voltage and amperage.
11. Shut unit down and reconnect automatic temperature-control operators.
12. 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. Adjust belt tension.

C. Replace fan and motor pulleys as required to achieve design airflow.

D. Lubricate bearings.

3.7 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain centrifugal fans.

END OF SECTION 233423

SECTION 233500 - PAINT BOOTH

PART 1 GENERAL

1.1 Section Includes

A. Indoor vehicle paint spray booth.

1.2 Administrative Requirements

A. Coordination:
   1. Coordinate work with other installers to provide necessary conduits for proper installation of wiring, piping for air, duct routing including but not limited to the following:
   2. Electrical power feeds and disconnecting means.
   3. BMS control integration.
   4. Structural framing.
   5. Compressed air piping connections.
   6. Fire alarm wiring and interlock.

B. Preinstallation Meetings: Convene meeting at least three weeks prior to start of this work.
   1. Review schedule of installation, proper procedures and conditions, and coordination with related work.

1.3 Submittals

A. Product Data: Paint spray booth manufacturer shall provide the following information with shop drawing/product data submission.
   1. Dimensioned arrangement drawings for paint spray system including a plan and elevation view of the assembled unit with overall dimensions, lift points, unit shipping split locations and dimensions, installation and operating weights, and installation, operation and service clearances.
   2. Vibration Isolation Base Details: Detail fabrication, including anchorages and attachments to structure and to support equipment. Include auxiliary motor slides and rails, and base weights.
   3. Duct layout indicating pressure classifications and sizes on plans.
   4. Hangers and supports, including methods for building attachment, vibration isolation, and duct attachment.
   5. All electrical, piping, and ductwork requirements, including sizes, connection locations, and connection method recommendations.

6. Each component of the unit shall be identified, and mechanical specifications shall be provided for unit and accessories describing construction, components, and options.
7. All performance data, including capacities and airside pressure drops, for components.
8. Fan curves shall be provided for fans with the design operating points indicated. Data shall be corrected to actual operating conditions, temperatures, and altitudes.
9. An electrical MCA – MOP schedule shall be provided for each electrical circuit to which field-power must be supplied. Schedule to detail unit tag, circuit description, voltage/phase/hertz, Minimum Circuit Ampacity (MCA), and calculated Maximum Overcurrent Protection (MOP).
10. Sound data shall be provided using ARI 260 test methods. Unit discharge, inlet, and radiated sound power levels in dB shall be provided for 63, 125, 250, 500, 1000, 2000, 4000, and 8000 Hz.
11. Wiring diagrams specific to project/application including power, control, factory and field wiring.

B. Certificate: Certify that products of this section meet or exceed specified requirements.

C. Delegated Design Documents: Drawings and calculations for entire system being installed sealed by Designer.

D. Designer's qualification statement.

E. Manufacturer's qualification statement.

F. Operation and Maintenance Data:
1. Parts catalog with complete list of equipment replacement parts; identify each entry with equipment description and identifying code.
2. Operation and maintenance manual.
3. Schematic drawings of equipment and wiring diagrams of installed electrical equipment with list of corresponding symbols to identify markings on system.

G. Executed warranty.

H. Specimen warranty.

I. Maintenance Materials: Furnish the following for Owner's use in maintenance of project:
1. Spare Parts: One of each belt.
2. Extra Stock Materials: One complete set of filters.
3. Tools: One each of special tools required for maintenance.

1.4 Quality Assurance

A. Designer Qualifications: Perform design under direct supervision of Professional Engineer experienced in design of this type of work and licensed in the State in which the Project is located.

B. Manufacturer Qualifications: Company specializing in manufacturing products specified in this section, with at least three years of documented experience.

C. Fabricator Qualifications: Company specializing in fabricating products specified in this section, with at least three years of documented experience.

D. Installer Qualifications: Company specializing in performing work of the type specified and with at least three years of documented experience.

E. Documents at Project Site: Maintain at project site one copy of manufacturer's instructions, erection drawings, and shop drawings.

1.5 Storage, and Handling

A. Store all components under cover and protected from damage.

1.6 Warranty

A. See Section 017800 - Closeout Submittals for additional warranty requirements.

B. Manufacturer Warranty: Provide 2-year manufacturer warranty for paint spray booth. Complete forms in Owner's name and register with manufacturer.

C. Installer Warranty: Provide 2-year warranty for paint spray booth commencing on the Date of Substantial Completion. Complete forms in Owner's name and register with installer.

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 units 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/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

E. UL Compliance: Comply with UL 1995.

2.2 Manufacturers

A. Basis of design: Provide product by the following or approved equal.
   1. Saima of North America: Accudraft.

B. Source Limitations: Furnish products produced by single manufacturer and obtained from single supplier.

2.3 Systems

A. Description:
   1. Complete vehicle paint booth including, main entry doors, cabin structure, intake and exhaust filtration, lighting, personnel doors, observation windows, MAUs, exhaust fans, controls, and internal piping.

B. Design Criteria:
   1. Interior Clearances: 14′ wide x 9′2″ high x 29′8″ long
   2. Product Entry Door: approx. 9′ wide x 9′ high – Quantity: 1
   3. Personnel Doors with Windows: 3′ wide x 7′ high – Quantity: 1
   4. Airflow Direction: Downdraft
   5. Climate Requirements: Heat Only
   6. 20,000 CFM

C. Cabin Construction:
   1. Booth panels consisting of 20-gauge, rock wool insulated pre-coated vertical wall panels white Inside/Blue Outside. Panels to have a rigid internal frame to provide support for the structure while minimizing the width of the booth by eliminating the need for external steel posts that protrude beyond the footprint of the wall panels. Factory applied coating is vinyl to help protect against scratching and to increase resistance to water and chemical exposure. Panels are joined using simple joint construction to eliminate gaps and facilitate easy assembly. All hardware (nuts, bolts, etc.) is galvanized steel to resist corrosion. Ceiling System is bolt together with a white powder coat finish and flanged for bolt together assembly. Ceiling Grid panels use a blanket filter insert with knife edge to seal completely and ceiling grid panels are secured over the top of the wall panels to minimize the possibility of a bad seal. Carry an ETL Listing encompassing code compliance for all applicable codes related to paint spray booths included, but not limited to: NFPA, Electrical and EPA.

D. Airflow Configuration:

1. Clean air is introduced into the booth through an intake plenum located in the ceiling of the enclosure. Exhaust is achieved through a raised galvanized steel basement (10,000lb capacity) with filtration grates across the floors structure. Air is pulled vertically from the top of the booth through the working height at an average velocity of approximately 50fpm (measured in the cross-section). The intake plenum is designed with high efficiency intake filters to remove dust and dirt before it enters the paint booth. Pressurizing a spray booth allows direct entry of clean (and temperature altered) air directly to the work area allowing for a positive environment relative to the surrounding shop area. This causes the booth to repel particulate generated in the shop away from the spray area. Directing air from an MAU directly to the workspace also allows the booth to operate at a given temperature without affecting the surrounding shop area, keeping ongoing utility costs down. The booth is designed with the maximized filter quantity (Intake and Exhaust) to assure efficient particulate filtration from the intake and exhaust filters and to allow air to flow evenly through the cross section of the booth.

E. Hazard Classification:
   1. Spray booth interior shall be rated as a Class I, Division I, Group D hazardous location from floor-to-ceiling, wall-to-wall. Electrical contained outside of the booth but within 3' of any opening shall be rated Class 1 Div. 2.

F. Cabin Mounting:
   1. Cabin to be mounted to concrete slab in accordance with manufacturers instillation instructions.

G. Vehicle Doors:
   1. Bi-Fold Product Entry Door Openings are 9' wide x 9' high. Doors are insulated and finished to match the booth cabin. All doors are made of tubular steel frame that is inside of the door. Hinge Mounting Points are tapped steel on the booth hinge panels and door frames. Doors will have full Vetrino style safety glass. All door glass is held in place by heavy-duty rubber gasket that seals to both sides of the door and glass. Closing Rods are run on the inside of the product doors and attached to the handles with threaded connection points. The closing handles are white with a high visibility red rubberized coating.

H. Personnel Doors:
   1. Personnel door will be consistent in finish with the booth (interior / exterior). Personnel door will have pressure latches that allow for emergency egress from the space. Door will be dual skin to correspond with the booth walls and have full Vetrino style Safety Glass viewing windows. Door gaskets will be a heavy-duty gasket and placed on the gasket flange around the door to prevent wear on the gasket due to contact at entry.

I. Ventilation System:
   1. 20,000 CFM Direct Fired Gas Heated Outdoor Mounted Make-up Air Unit to replace the exhaust air taken from the paint spray booth.
      a. Horizontal Outdoor Unit Arrangement with End Discharge
      b. VFD Control Package: Paint Curing System with Recirculation
      c. 20,000 SCFM / 0.5 Duct SP / 0.84 Total ESP / BHP: 19.83
      d. Electric Current: 440-480/60/3 3-wire
      e. ETL Label
      f. Outdoor Safety Switch (Disconnect) and Motor Starters
      g. Unit Location: Outdoor Installation
      h. 15 HP Motor - ODP - High Efficiency EPACT
      i. Estimated 1.5MBTU direct fired burner
      j. Gas Pressure: 7"-14" WC (Natural Gas or Propane)
      k. Gas Manifold: FOCUS Controls
      l. Burner control unit with pre-installed purge card and flame amplifier
      m. Temperature Control System: Modulation Signal from Booth
      n. Control Panel, No conditioner required
      o. Type FOCUS Control Panel
      p. Pleated Deep Pocket High Efficiency Bag Filters for removing large particles suspended in incoming air before being moved across the burner tray
      q. G-90 Galvanized Casing – to match booth color
      r. Burner On/Off Intake Air Ductstat
      s. Air Flow Switch interlocked to Burner Control Module
      t. NFPA 86 Requirements
      u. Belimo Motor for valve positioning
      v. True Pilot for full turn-off of main flame at desired temperature
      w. Outdoor rated disconnect
   2. 20,000 CFM axial exhaust fan.
      a. 36" Tube Axial Exhaust Fan
      b. 5 h.p. tri-voltage 208/230/460 volts, 3 phase, 60 hz TEFC high efficiency motor with variable pitch drive sheave
      c. Motors feature a heavy gauge steel frame, double sealed ball bearings that are mechanically locked on the shaft end, and bolt on motor base for easy removal. The service factors for the motor are 1.15 for 3-phase power and 1.0 on 1-phase power. UL recognized and CSA certified.
      d. Outdoor rated motor disconnect

J. Controls:
   1. Control System is FOCUS, windows-based control system with 15" touchscreen interface. The FOCUS control system is an automated control system with the following modes of operation:

2. Spray – non-timed mode with a heat/cool temperature and humidity settings
3. Flash – timed mode for automated flashing of coatings. Allows for a pre-set time and temperature combination. Once the operation times out, the panel automatically returns to spray mode for the application of subsequent material applications. Flash mode can also be integrated with optional auxiliary air blowers to speed up flashing of waterborne basecoats.
4. Pre-Dry – timed mode to allow the cabin to evacuate any suspended particulate from the space around the piece in process before automatically sending the system to bake/cure mode and engaging any applicable recirculation. Purge uses a preset temperature to begin elevating the temperature of the air/substrate in route to the final bake.
5. Dry 1 – timed mode that allows for increase in temperature using recirculation or changes in air speed (as applicable) to raise the cabin air temperature (along with substrate) to achieve rapid cure times for coatings.
6. Dry 2 – timed mode that allows for an initial spike (in Dry 1) in temperature to help speed the heating of the substrate before settling the temperature (Dry 2) at the desired cure temperature. This allows for a more efficient curing process saving energy and money
7. Cool Down – time and temperature programmed mode allows the space, and part, to cool down prior to being occupied by the operator. Once the mode is complete the cabin lights will come on and the motors will cease operation allowing for removal of the product.
8. The control panel (and system) comes with the following components.
9. Type 12 industrial panel with main disconnect, and door mounted disconnect handle.
10. Motor starters and variable frequency drives (VFD's) with branch circuit, and overload protection per NEC Article 430
11. Lighting branch circuits and contactor with overloads for individual circuits.
12. Control power supply/transformer with primary and secondary fusing 24vdc
13. Air Pressure Transducer with air sensors for operating of automatic pressure control (as required by EPA 6H related to positive pressure spray environments)
14. Terminal Strip and Wire Gutters for easy connection of field wiring
15. Operator Interface Screen is a touchpad with LED indicator fields
16. Complete control panel is UL 508A listed.
17. The major feature of the FOCUS control panel is the Windows based control and a touch screen interface. The touchscreen allows for smooth operator interface while presenting continuous data for system operations. The FOCUS displays the following information: exhaust speed, intake speed, temperature (setpoint and present value), humidity, door alarm status, timed operation status, mode of operation, date and time, cabin pressure and the active program. Various other data including estimated utility usage is available in additional menus and online with a data connection.

18. The control system continuously monitors all systems for safety, and function. LED displays will display running information and faults. The FOCUS assures that the ventilation system is in a state of operation across all modes using required interlocks as noted in NFPA 33/NFPA86 National Standard for Spray Application Using Flammable or Combustible Materials.

K. Paint Curing System:
1. Paint Curing System with 80/20 Recirculation
2. The air replacement unit is designed to discharge 180-degree F air for accelerated curing cycle. This design introduces 20% fresh air from outside the building or booth during cure and recirculates 80% air from the spray booth cabin.

L. Air Balancing System:
1. Auto-Pressure System: Designed to automatically keep the paint booth balanced when in operation. It is required by EPA 6H standards on all positively pressured booths. This system consists of a variable frequency drive that controls the exhaust fan motor with input from a pressure transducer and sensing probes. The system monitors the interior booth pressure and will adjust the exhaust fan RPM's to what is needed for the volume of exhaust air based on what the incoming intake air is. The result is a booth that is balanced automatically and will stay in balance as the filters load up with paint over spray. System will increase useful filter life, provide a constant airflow through the booth and the ability to control booth pressure.
2. Idle Mode: The air replacement unit is designed with a variable frequency drive and damper package. This design reduces airflow to 50% during the Idle mode. This system always uses outside air during the energy saving mode, to ensure good clean air to the booth. Along with this system is an airflow switch that detects air being used by an operator. After a period of two minutes of inactivity, the control system will reduce the output of the intake system to conserve electricity and air. Once the Operator re-engages compressed air usage, the AMU ramps up for full spray mode.

M. VFD's:
1. (1) 15hp VFD Drive and (1) 5hp VFD Drive . Provides the following:
2. Soft start – Eliminates electric surge when booth is started. Saves up to 50% on electric utility
3. Automatic Pressure Regulation – Automatically maintains the digital pressure setting you set on the control panel
4. Standby Power-Savings Mode – Standby mode drops booth to idle after 90 seconds of no spray gun activity

N. Lighting: (12 ea.) Upper Gable and (6) Lower Wall Lighting fixtures will be inside access, four tube, NFPA and OSHA compliant fixtures with clear tempered glass windows that accept four 4-foot, 4 tube LED fixtures that are listed for use in a hazardous area and inside accessible. All wiring and devices are rated for use in hazardous spaces where required. All recessed, light fixtures with gaskets shall be rated Class I Division II Group D. All fixtures shall have battery backup for emergency lighting and be hinged and include a micro-switch interlock to prohibit spraying in the event a light lens is open.

O. Filtration:
1. Exhaust Plenum Style: Raised grated steel exhaust filtered basement to include grates and pans for rolled media. 18gr fiberglass exhaust media.
2. Intake Plenum Style: Internal Ceiling Style intake chamber with filter cells for blanket media. Blanket Style Tackified Intake filters with retainers that bolt into the ceiling panels to ensure sealing against particulate blow-by. Minimum rating 90% efficiency at 10 micron.

P. Safeties: Safety package to be included: Dwyer liquid manometer, exhaust airflow switch, door interlocks with solenoid per NFPA, fire alarm shutdown terminals.

Q. Accessories:
1. Pneumatically actuated ramp. Pneumatic units lower the platform to allow vehicles to be loaded and the platform raised back to level once work is initiated.
2. Xcelerator tower air auxiliary system. Wall-mounted jet modules supply concentrated air and heat to freshly sprayed waterborne base coats allowing much faster drying times.
3. Observation Windows in Side-Wall Panels:
4. (7 ea.) Vetrino Style observation windows approximately 89″ x 20″ shall be located on the side walls of the booth.

R. Mixing room:
1. Interior Dimensions: 8′ wide x 9′ high x 10′ deep
2. Cabin Construction: Booth panels consist of 20-gauge G90 Galvanized steel sheets with durable non-flammable rock wool insulation and vinyl coating interior and exterior.
3. Airflow Configuration & Performance: Negative pressure. Incoming air is drawn through the ceiling. Ceiling filtration is a 5-micron rated filtration system. (1 Micron = 1 thousandth of a Millimeter). Exhaust is achieved through a filtration grate located at the bottom of one wall panel.
4. Structural Configuration: (1 ea.) 4-Door Vetrino Style access approx. 3′ wide x 8′ high and will be consistent in finish with the booth (interior / exterior). Door will have pressure latches that allow for emergency egress from the space. Doors will be dual skin to correspond with the booth walls and have Safety Glass viewing

windows. Door gaskets will be a heavy-duty gasket and placed on the gasket flange around the door to prevent wear on the gasket due to contact at entry.

5. Exhaust Fan: ½ HP Motor, 1,000 CFM, 0.75 ESP.
6. Lighting: (3 ea.) Lighting fixtures. Lighting fixtures will be inside access, four tube, NFPA and OSHA compliant fixtures with clear tempered glass windows that accept four 4-foot, 4 tube LED fixtures that are listed for use in a hazardous area and inside accessible.
7. Controls: On / Off with timed lighting delay.
8. Observation Windows in Side-Wall Panels:
9. (4 ea.) Vetrino Style observation windows approximately 89" x 20" shall be located in side walls.

PART 3 EXECUTION

3.1 Examination

A. Examine products before installation. Reject products that are wet, moisture damaged, or mold damaged.

B. Examine roughing-in for piping and tubing to verify actual locations of connections before equipment installation.

C. Examine roughing-in for ductwork to verify actual locations of connections before equipment installation.

D. Examine roughing-in for wiring and conduit to verify actual locations of connections before equipment installation.

E. Examine walls, floors, and roofs for suitable conditions where equipment will be installed.

F. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work.

G. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 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 unit, allow space for service and maintenance.

C. Connect piping to unit mounted on vibration isolators with flexible connectors.

D. 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.

3.3 DUCT CONNECTIONS

A. Comply with duct installation requirements specified in other HVAC Sections. Drawings indicate general arrangement of ducts. The following are specific connection requirements:

B. Install ducts to termination at top of roof curb.

C. Remove roof decking only as required for passage of ducts. Do not cut out decking under entire roof curb.

D. Install return-air duct continuously through roof structure.

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.

3.5 Tests and Inspections:

A. After installing units and after electrical circuitry has been energized, test units for compliance with requirements.

B. Inspect for and remove shipping bolts, blocks, and tie-down straps.

C. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.

D. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

E. Units will be considered defective if it does not pass tests and inspections.

F. Prepare test and inspection reports.

3.6 STARTUP SERVICE

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

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:

C. After installing units and after electrical circuitry has been energized, test units for compliance with requirements.

D. Inspect for and remove shipping bolts, blocks, and tie-down straps.

E. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.

F. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

G. Unit will be considered defective if it does not pass tests and inspections.

H. Prepare test and inspection reports.

3.8 Closeout Activities

A. Demonstrate proper operation of equipment to Owner's designated representative.

B. Training: Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain system.
   1. Accommodate up to four attendees.
   2. Training Reference: Operation and maintenance manual and additional training materials as required.
   3. Provide minimum of 8 hours of training.
   4. Instructor: Manufacturer's training personnel.

END OF SECTION

SECTION 233505 – WELDING FUME EXHAUST

PART 1 GENERAL

1.1 Section Includes:

A. Welding fume exhaust system.

B. Welding fume exhaust ductwork.

C. Welding fume exhaust damper.

1.2 Administrative Requirements

A. Coordination:
1. Coordinate work with other installers to provide necessary conduits for proper installation of wiring, piping for air, duct routing including but not limited to the following:
2. Electrical power feeds and disconnecting means.
3. BMS integration.
4. Structural framing.
5. Fire alarm wiring and interlock.

B. Preinstallation Meetings: Convene meeting at least three weeks prior to start of this work.
1. Review schedule of installation, proper procedures and conditions, and coordination with related work.

1.3 Submittals

A. Product Data: Welding fume exhaust system shall provide the following information with shop drawing/product data submission.
1. Dimensioned arrangement drawings for paint spray system including a plan and elevation view of the assembled unit with overall dimensions, lift points, unit shipping split locations and dimensions, installation and operating weights, and installation, operation and service clearances.
2. Vibration Isolation Base Details: Detail fabrication, including anchorages and attachments to structure and to support equipment. Include auxiliary motor slides and rails, and base weights.
3. Duct layout indicating pressure classifications and sizes on plans.
4. Hangers and supports, including methods for building attachment, vibration isolation, and duct attachment.

5. All electrical, piping, and ductwork requirements, including sizes, connection locations, and connection method recommendations.
6. Each component of the unit shall be identified, and mechanical specifications shall be provided for unit and accessories describing construction, components, and options.
7. All performance data, including capacities and airside pressure drops, for components.
8. Fan curves shall be provided for fans with the design operating points indicated. Data shall be corrected to actual operating conditions, temperatures, and altitudes.
9. An electrical MCA – MOP schedule shall be provided for each electrical circuit to which field-power must be supplied. Schedule to detail unit tag, circuit description, voltage/phase/hertz, Minimum Circuit Ampacity (MCA), and calculated Maximum Overcurrent Protection (MOP).
10. Sound data shall be provided using ARI 260 test methods. Unit discharge, inlet, and radiated sound power levels in dB shall be provided for 63, 125, 250, 500, 1000, 2000, 4000, and 8000 Hz.
11. Wiring diagrams specific to project/application including power, control, factory and field wiring.

B. Certificate: Certify that products of this section meet or exceed specified requirements.

C. Operation and Maintenance Data:
1. Parts catalog with complete list of equipment replacement parts; identify each entry with equipment description and identifying code.
2. Operation and maintenance manual.
3. Schematic drawings of equipment and wiring diagrams of installed electrical equipment with list of corresponding symbols to identify markings on system.

D. Executed warranty.

E. Specimen warranty.

F. Maintenance Materials: Furnish the following for Owner's use in maintenance of project:
1. Spare Parts: One of each belt.
2. Extra Stock Materials: One complete set of filters.
3. Tools: One each of special tools required for maintenance.

1.4 Quality Assurance

A. Designer Qualifications: Perform design under direct supervision of Professional Engineer experienced in design of this type of work and licensed in the State in which the Project is located.

B. Manufacturer Qualifications: Company specializing in manufacturing products specified in this section, with at least three years of documented experience.

C. Fabricator Qualifications: Company specializing in fabricating products specified in this section, with at least three years of documented experience.

D. Installer Qualifications: Company specializing in performing work of the type specified and with at least three years of documented experience.

E. Documents at Project Site: Maintain at project site one copy of manufacturer's instructions, erection drawings, and shop drawings.

1.5 Storage, and Handling

A. Store all components under cover and protected from damage.

1.6 Warranty

A. See Section 017800 - Closeout Submittals for additional warranty requirements.

B. Manufacturer Warranty: Provide 2-year manufacturer warranty for welding exhaust system. Complete forms in Owner's name and register with manufacturer.

C. Installer Warranty: Provide 2-year warranty for paint spray booth commencing on the Date of Substantial Completion. Complete forms in Owner's name and register with installer.

1.7 Maintenance Materials

A. Furnish the following for Owner's use in maintenance of project:
1. Spare Parts: One _____.
2. Extra Stock Materials: One _____.
3. Extra Stock Materials: _____ sq ft of each kind of _____.
4. Tools: One each of special tools required for maintenance of _____.

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 units 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/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

E. UL Compliance: Comply with UL 1995.

2.2 Manufacturers

A. Basis of design: Provide product by the following or approved equal.

B. The Lincoln Electric Company

C. Source Limitations: Furnish products produced by single manufacturer and obtained from single supplier.

2.3 Welding Fume Exhaust System

A. Filtration Unit
1. Filter bank must include cellulose/nano fiber MERV 16 filters according to ASHRAE 52.2. Minimum total filter media area of 3,800 ft2 per filter bank. Filters to be oriented in the vertical position.
2. To be equipped with a compressed air-based internal filter cleaning mechanism. (Clean, dry, oil-free compressed air to be supplied from an external source).
3. Filter cleaning cycle to be control by monitoring the differential pressure across the filters and take place either “on-line” or “off-line” as needed.
4. Three dustbins to be located under each filter bank to collect dislodged particulate. Dustbins to have a volume of 30 gallons each and have wheels.
5. Frame to be constructed of heavy gauge steel tubes and channels and heavy gauge steel sheeting.
6. Structure to be weather-tight and suitable for outdoor installation.
7. Each filter bank to have two 20-inch diameter inlets located in the back of the unit and two outlets located on top of the unit.
8. All metal components to be painted using the powder coating method.
9. To be made in the USA.

B. Central Exhaust Fans
1. Fans to be sized for providing an airflow value of 650 CFM per arm. Two fans per filter bank.
2. Fan Type: Centrifugal
3. Rating (per fan): 7,400 CFM @ 12 in. WG
4. Drive: Direct (no belts)
5. Motor Horsepower (per fan): 20 HP

6. Motor Enclosure: TEFC
7. Motor Insulation System: Class F
8. Input Power: 460/3/60
9. Location: Top of filter bank. Suitable for outdoor installation.

C. Exhaust Air Scilencers
1. Silencer to mount directly on outlet of fan. No transition flange allowed. Rectangular discharge.
2. Noise criterion: equal to or less than 75 dBA at Position 3 (90 deg. from silencer outlet), distance of 5 ft., and location inside a large space.
3. Silencer finished with industrial enamel paint.

D. System Control
1. Must include a variable frequency drive (VFD) rated for 40 HP and input power of 460V/3-phase. A single VFD will power both fans.
2. Speed of fan to vary based on condition of filters.

2.4 Galvanized Steel Ductwork

A. Furnish and install associated galvanized steel duct work to provide a completely engineered duct system with a balanced amount of airflow to each work station. The ductwork shall be designed in accordance with Industrial Ventilation A Manual of Recommended Practice For Design by ACGIH and designed and installed in accordance with Accepted Industry Practice for Industrial Duct Construction by SMACNA.
1. Ductwork - galvanized spiral ductwork shall be provided per smacna class 1, material class 26, and 10" w.g. neg pressure.
2. Only spiral ductwork shall be permitted to be used unless approved
3. Otherwise.
4. Filtered supply ductwork shall be gauged per standard smacna hvac standards and sized for .08 - .10" of pressure loss per 100 feet of linear equivalent ductwork.
5. Ductwork may be joined with gasketed fittings (as preferred method). Slip fit fittings and sheet metal screws may be used. Use of external mastic shall be minimal and not used to cover over installation deficiencies.

B. Exhaust Ductwork Gauge Chart

CLASS 1 DUCT DIAMETER (IN)								
NEG. PRESSURE (IN W.G.)	REINFORCING SPACING AT (FT)	12 AND UNDER	14	16	18	20	22-28	30-34
4 AND UNDER	12	22	22	22	20	20	18	16
6	12	22	22	20	18	18	16	20/F
10	12	22	20	18	18	16	16	18/F
15	12	22	20	18	16	16	18/F	18/F

ADAPTED AND MODIFIED FROM TABLE 11-3.2 MINIMUM REQUIRED GAGE FOR CLASS 1 - CARBON AND COATED STEEL SPIRAL DUCT - SMACNA ROUND INDUSTRIAL DUCT CONSTRUCTION STANDARDS - THIRD EDITION 2013

DESIGN FOR THIS PROJECT IS 10 INCHES W.G.

F DESIGNATES PIPE STIFFENERS AT 12 FOOT INTERVALS

2.5 Balancing Dampers

A. The manual damper is used to balance the air flow to the modular hood. It is to be installed between the outlet of the extraction arms and the duct main. The manual damper shall be duct sized, constructed of zinc-plated steel and include KEN-LOK® connections with rubber seals.

PART 3 EXECUTION

3.1 Installation

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

B. Install welding fume extraction system and equipment in accordance with the manufacturer’s instructions.

C. Install equipment plumb, square, and straight with no distortion and securely anchored as required.

D. Secure equipment components with material and procedures recommended by the manufacturer.

E. Install ductwork in accordance with Accepted Industry Practice for Industrial Duct Construction by SMACNA.

F. Accessory installation: Install all accessories and fittings in accordance with manufacturer's recommendations.

3.2 Field Quality Control

A. Field testing requirements:
1. Perform tests in field to verify proper operation of the system before they are put in use, using only qualified personnel.
2. Correct any unsafe conditions disclosed by these tests before request of test procedures.
3. Commissioning and balancing of the fan, VFD, and fume extraction arms shall be completed by a manufacturer service technician.

3.3 ADJUSTING

A. Repair or remove and replace defective work, as directed by upon completion of installation.

B. Adjust fixtures, accessories and other moving or operating parts to function smoothly.

3.4 CLEANING

A. Clean equipment, touch up as required.

3.5 System Startup

A. Manufacturer Services: Provide services of manufacturer's field representative to perform systems startup.

B. Prepare and start equipment and systems in accordance with manufacturers' instructions and recommendations.

3.6 Commissioning

A. Functional Tests: Perform full system commissioning:

3.7 Closeout Activities

A. Demonstrate proper operation of equipment to Owner's designated representative.

B. Training: Train Owner's personnel on operation and maintenance of system.
1. Accommodate up to 4 attendees.
2. Training Reference: Operation and maintenance manual and additional training materials as required.

3. Provide minimum of two hours of training to be recorded.
4. Instructor: Manufacturer's training personnel.
5. Location: Owners Site.

3.8 PROTECTION OF FINISHED WORK

A. Provide all necessary protective measures to prevent exposure of equipment to other construction activity.

B. Advise contractor, of procedures and precautions, for protections of material and installed system, from damage by work of other trades.

END OF SECTION

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 plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Ceiling suspension assembly members.
2. Method of attaching hangers to building structure.
3. Size and location of initial access modules for acoustical tile.
4. Ceiling-mounted items including lighting fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.
5. Duct access panels.

B. Source quality-control reports.

PART 2 - PRODUCTS

2.1 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 determination of final location.

C. 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 plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Ceiling suspension assembly members.
2. Method of attaching hangers to building structure.
3. Size and location of initial access modules for acoustical tile.
4. Ceiling-mounted items including lighting fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.
5. Duct access panels.

B. Source quality-control reports.

PART 2 - PRODUCTS

2.1 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 installation, notify Architect for a determination of final location.

C. 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 233723 - HVAC GRAVITY VENTILATORS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
   1. Hooded ventilators.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For gravity ventilators.

   1. Include plans, elevations, sections, details, ventilator attachments to curbs, and curb attachments to roof structure.
   2. Show weep paths, gaskets, flashing, sealant, and other means of preventing water intrusion.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Roof-framing plans and other details, drawn to scale, and coordinated with each other, based on input from installers of the items involved:

B. Seismic Qualification Data: Certificates for ventilators, accessories, and components, from manufacturer.

   1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
   2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
   3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Welding certificates.

1.5 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to the following:

1. AWS D1.2/D1.2M, "Structural Welding Code - Aluminum."
2. AWS D1.3/D1.3M, "Structural Welding Code - Sheet Steel."

1.6 COORDINATION

A. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1.

B. ASHRAE 62.1 Compliance: Section 5, "Systems and Equipment" and Section 7, "Construction and System Start-up."

C. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes, without buckling, opening of joints, overstressing of components, failure of connections, or other detrimental effects.

1. Temperature Change (Range):

a. Ambient: 120 deg F.
b. Material Surfaces: 180 deg F.

D. Water Entrainment: Limit water penetration through unit to comply with ASHRAE 62.1.

2.2 FABRICATION

A. Factory or shop fabricate gravity ventilators to minimize field splicing and assembly. Disassemble units to the minimum extent as necessary for shipping and handling. Clearly mark units for reassembly and coordinated installation.

B. Fabricate frames, including integral bases, to fit in openings of sizes indicated, with allowances made for fabrication and installation tolerances, adjoining material tolerances, and perimeter sealant joints.

C. Fabricate units with closely fitted joints and exposed connections accurately located and secured.

D. Fabricate supports, anchorages, and accessories required for complete assembly.

E. Perform shop welding by AWS-certified procedures and personnel.

2.3 HOODED VENTILATORS

A. Description: Hooded rectangular penthouse for intake relief air.

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

1. Greenheck Fan Corporation.
2. Loren Cook Company.
3. PennBarry.

C. Source Limitations: Obtain hooded ventilators from single manufacturer.

D. Construction:
1. Material: Aluminum, of thickness required to comply with structural performance requirements, but not less than 0.063-inch- thick base and 0.050-inch- thick hood; suitably reinforced.
2. Insulation: None.
3. Bird Screening: Galvanized-steel, 1/2-inch- square mesh wire].

E. Galvanized-Steel Finish:

1. Surface Preparation: Clean surfaces of dirt, grease, and other contaminants. Clean welds, mechanical connections, and abraded areas, and repair galvanizing according to ASTM A780/A780M. Apply a conversion coating suited to the organic coating to be applied over it.
2. Factory Priming for Field-Painted Finish: Where field painting after installation is indicated, apply an air-dried primer immediately after cleaning and pretreating.
3. Baked-Enamel Finish: Immediately after cleaning and pretreating, apply manufacturer's standard finish consisting of prime coat and thermosetting topcoat, with a minimum dry film thickness of 1 mil for topcoat and an overall minimum dry film thickness of 2 mils.

a. Color and Gloss: As indicated by manufacturer's designations.

F. Roof Curbs: Galvanized-steel sheet; with mitered and welded corners; 1-1/2-inch- thick, rigid fiberglass insulation adhered to inside walls; and 1-1/2-inch wood nailer. Size as required to fit roof opening and ventilator base.

1. Configuration: Self-flashing without a cant strip, with mounting flange.
2. Overall Height: 24 inches.

2.4 MATERIALS

A. Aluminum Extrusions: ASTM B221, Alloy 6063-T5 or T-52.

B. Aluminum Sheet: ASTM B209, Alloy 3003 or 5005, with temper as required for forming or as otherwise recommended by metal producer for required finish.

C. Galvanized-Steel Sheet: ASTM A653/A653M, G90 zinc coating, mill phosphatized.

D. Stainless Steel Sheet: ASTM A666, Type 304, with No. 6 finish.

E. Fasteners: Same basic metal and alloy as fastened metal or 300 Series stainless steel unless otherwise indicated. Do not use metals that are incompatible with joined materials.

1. Use types and sizes to suit unit installation conditions.
2. Use hex-head or Phillips pan-head screws for exposed fasteners unless otherwise indicated.

F. Post-Installed Fasteners for Concrete and Masonry: Torque-controlled expansion anchors made from stainless-steel components, with capability to sustain without failure a load equal to 4 times the loads imposed for concrete, or 6 times the load imposed for masonry, as determined by testing according to ASTM E488/E488M, conducted by a qualified independent testing agency.

G. Bituminous Paint: Cold-applied asphalt emulsion complying with ASTM D1187/D1187M.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install gravity ventilators level, plumb, and at indicated alignment with adjacent work.

B. Install goosenecks on curb base where throat size exceeds 9 by 9 inches.

C. Install gravity ventilators with clearances for service and maintenance.

D. Install perimeter reveals and openings of uniform width for sealants and joint fillers, as indicated.

E. Protect galvanized and nonferrous-metal surfaces from corrosion or galvanic action by applying a heavy coating of bituminous paint on surfaces that will be in contact with concrete, masonry, or dissimilar metals.

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

3.2 ADJUSTING

A. Adjust damper linkages for proper damper operation.

END OF SECTION 233723

SECTION 234101 - DUST COLLECTION SYSTEM

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Outdoor, wood dust collector with automatic filter shaker and airlock material discharge.
2. Dust container.
3. Spark detection & extinguishment system for woodworking dust collection system.
4. Dust collector ductwork.

1.2 ACTION SUBMITTALS

A. Dust collection system manufacturer shall provide the following information with each shop drawing/product data submission:

1. Dimensioned arrangement drawings for each dust collection system including a plan and elevation view of the assembled unit with overall dimensions, lift points, unit shipping split locations and dimensions, installation and operating weights, and installation, operation and service clearances.
2. All electrical, piping, and ductwork requirements, including sizes, connection locations, and connection method recommendations.
3. Each component of the unit shall be identified, and mechanical specifications shall be provided for unit and accessories describing construction, components, and options.
4. All performance data, including capacities and airside pressure drops, for components.
5. Fan curves shall be provided for fans with the design operating points indicated. Data shall be corrected to actual operating conditions, temperatures, and altitudes.
6. An electrical MCA – MOP schedule shall be provided for each electrical circuit to which field-power must be supplied. Schedule to detail unit tag, circuit description, voltage/phase/hertz, Minimum Circuit Ampacity (MCA), and calculated Maximum Overcurrent Protection (MOP).
7. Sound data shall be provided using ARI 260 test methods. Unit discharge, inlet, and radiated sound power levels in dB shall be provided for 63, 125, 250, 500, 1000, 2000, 4000, and 8000 Hz.

8. Wiring diagrams specific to project/application including power, control, factory and field wiring.

B. The dust collector system manufacturer shall list any exceptions to the specification.

1.3 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For dust collection system to include in emergency, operation, and maintenance manuals.

B. Include an electronic copy of the IOM.

1.4 QUALITY ASSURANCE

A. Provide equipment, components, and systems in strict accordance with the following:

1. NFPA 664 - Prevention of Fires and Explosions in Wood Processing and Woodworking Facilities.

2. OSHA

1.5 COORDINATION

A. The Mechanical Contractor shall provide all parts, labor, components, controls, electrical connections, associated piping, ductwork and wiring required for mechanical systems as shown on the drawings AND as required by the manufacturer, to ensure a fully operational, standalone system. The Controls Contractor shall provide any monitoring or set points of said systems as indicated by the contract documents.

B. Coordinate sizes and locations of concrete bases with actual equipment provided.

C. Coordinate sizes and locations of structural-steel support members, if any, with actual equipment provided.

D. Coordinate wiring of remote control and power panels.

PART 2 - PRODUCTS

2.1 GENERAL

A. Unit layout and configuration shall be as defined in project plans and schedules.

2.2 DUST COLLECTOR UNIT

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    a. Sternvent
    b. Donaldson
    c. Parker

B. Furnish and install, where shown on the plans, a high efficiency filter type dust collector with integral blower sized for design air flow as shown on the schedule.

C. Dust collector shall be self-cleaning fabric type complete with polyester filter media, backward inclined blower, motorized shaker, rotary airlock discharge, support stand, and controller and external discharge silencer. Manufacturer's literature shall state that dust collector and selected filter spacing is designed for the collection of wood dust.

D. Dust collector shall be airtight, all steel construction with sealed seams and gasketed quick opening doors with 1/4 turn knobs. Housing shall be minimum of 14-ga. mild steel. Unit shall consist of a filter section and a funnel bottom section without slide gates or doors to allow downflow of dust directly through a motorized rotary airlock into the dust container. Inlet shall be located in the funnel section & include a deflection plate.

E. Unit to include multi-pocket filter modules, to deliver in excess of 99.5% efficiency by weight on wood dust. The filters shall have closed bottom and open top pockets, for the wood waste to remain on the outside surfaces of the filter media. Inside of each pocket shall be a rigid insert separator to prevent collapse of filters and loss of effective filter area. Flat shaker fingers located at the bottom of the filter module shall prevent adjoining pockets from touching one another and blanking off. The filter pocket spacing shall be wide spacing to permit the collected dust to be shaken off the exterior of the filters and recommended by the manufacturer for the collection of wood dust. Total airflow to filter fabric area (air to cloth ratio) shall not exceed 10 CFM per square foot.

F. Filter designs with open bottom pockets that allow the wood waste to enter the inside of the filter pockets will not be accepted, because of the potential for wood waste to bridge and not shake down.

G. Each filter module shall be secured in place by two levers, operated over-center, locking mechanisms to assure a positive seal and allow for easy removal of filters from outside of unit. Designs which require entry into unit (confined space) or require hand tools to remove the filters, for filter maintenance, are not acceptable.

H. Filters will be cleaned automatically after a fifteen second delay following the shutdown of the blower, by the oscillating action delivered by the motorized eccentric driven shaker assembly, which imparts a vibratory force throughout the entire surface of each individual

filter pocket to dislodge the dust. Operation of the automatic shaker shall be controlled by a solid state, dual mode timer with adjustable shaker cycle range from 1.8 - 180 seconds.

I. Factory wired NEMA 1 control panel shall be shipped loose, located indoors and field wired to blower, shaker and airlock motors. It shall include a variable frequency drive (VFD) for soft start energy conservation of the blower motor and to set blower speed upon startup of system by an independent balancing agent, magnetic motor starters for shaker & airlock motor, non-fused disconnect switch in cover of enclosure, step down non-fused control transformer, dual mode delay timer for operation of shaker motor, separate adjustable delay timer to allow airlock to operate whenever dust collector fan is on and for 30 seconds after fan is switched off, so that dust can be evacuated from system. Also included shall be pilot lights to indicate status of each motor.

J. A separate control panel with remote start/stop station and shall electrically interlock each woodworking machine with the dust collector so that, when a machine is turned on, the dust collector comes on automatically. All wiring shall be centralized at the circuit breaker panel, for ease of installation and expansion for future machines. The interlock shall not require hard wiring at the machines, modification of the motor starters or special auxiliary contacts. Include an adjustable delay timer that will keep the dust collector on for 15-120 seconds after the last machine is switched off, to minimize dust collector cycling and allow the dust in the duct system to be evacuated.

K. Both control panels shall be either UL or ETL labeled for compliance with 508A. UL labeled components only is not a substitute. The entire circuit must be listed & labeled. Control panels not labeled by dust collector manufacturer shall be labeled, in field, by a certified UL or ETL representative, prior to placing equipment in operation.

L. The non-sparking AMCA Type C direct drive blower shall be located on the clean air side of the filters, top mounted at the factory and be of the backward inclined design with a dynamically balanced impeller. It shall be driven by a 3450 RPM, TEFC motor. The blower shall be tested in accordance with AMCA Standard 210. A factory-supplied cover shall protect the motor cooling fan from ice.

M. Discharge noise from the blower shall be attenuated by an external field supported duct silencer fabricated with 4.75 lb. density inorganic mineral or glass fiber. This media shall be protected from erosion by the airflow using galvanized perforated metal with aerodynamic leading and trailing edges to insure maximum acoustical insertion loss at minimum static pressure drop. Internal integral silencer is not a substitute for the external silencer. Include factory installed bird screen on discharge of silencer.

N. A support stand, with design stamped by a professional engineer to comply with local IBC wind load & seismic requirements shall be furnished by the dust collector manufacturer. It shall be bolt-together design for ease of installation and re-installation if the dust collection system needs to be relocated in the future. It shall be painted the same color as the dust collector and provide required clearance for the heavy duty hopper below

airlock discharge. The airlock shall be 12", have a minimum displacement of 2.75 cu. ft./rev, be powered by a 2 HP TEFC motor and include a flanged collar and an 18" long 12" dia. flexible hose.

O. Interior and exterior carbon steel surfaces shall be coated with two-part epoxy primer and exterior painted with two-part urethane enamel.

2.3 HEAVY DUTY SELF DUMPING HOPPER

A. General: 3.0 CY, 6500 LB. Capacity, water tight 7 Gauge Carbon Steel Box with 3/4" drain plug.

1. 3/8" x 1/2" Laser cut single piece rockers
2. 1/4" Formed Steel Base - 38" W x 50" L58
3. Fork pocket opening 30" W x 2.75" H
4. Shipping weight 1194 lbs.
5. Hippo Hopper model HH48HD or approved equal.

2.4 SPARK DETECTION & EXTINGUISHMENT SYSTEM FOR WOODWORKING DUST COLLECTION SYSTEM

A. Provide spark detection & extinguishment system to National Fire Protection Association standards (NFPA), 69, 664, and 72 guidelines. The system shall be a single zone control system, as manufactured by Hansentek or approved equal. All components shall be Factory Mutual (FM) approved.

B. Installation requires coordination with sheet metal, plumbing, fire alarm and electrical contractors.

C. The system shall comprise of the following components.

1. The AN104 programmable microprocessor panel shall include programmable shutdown, built-in automatic and manual detector sensitivity checking. The system shall provide supervision on all input and output circuits. Fan shutdown relay shall be included, as well as alarm and trouble relays. The system shall have a battery backup power supply & Model #910 24 VDC alarm horn.
2. Two Model #120-1 addressable infrared direct optic spark detectors with built-in test light for calibrated through the lens sensitivity checking & quick release brackets.
3. Model #901-1 spray assembly with spring-loaded, chrome plated nozzle, 24VDC solenoid, water strainer, mounting flange and gasket.
4. Model #921-1 1" NPT supervised water shut off valve

D. The spark detection & extinguishing system shall be installed indoors and located on and penetrating into a straight horizontal section of the main duct, in the area between the first branch and the dust collector. Based on an air & dust velocity of 4000 fpm in the main duct, the sensor (spark detector) to solenoid valve (spray nozzle) distance (SVD) must be a minimum of 20'. Allow for additional straight duct 1-1/2 duct diameter before and after the detectors & spray nozzle. Flow rate shall be a minimum of 19 GPM at 50 PSI.

2.5 DUST COLLECTOR DUCTWORK:

A. Galvanized: ASTM A527 with a G90 rating. Temp rating of 500° F with no breakdown of zinc - Zinc melting point is 740° F

B. Ducting manufacturing techniques:

1. Diameters 3" - 24" pipe, adjustable nipples, and collars attached to other components will have one or both ends die formed-rolled to provide a uniform edge around the circumference of the rolled end. The pipe and adjustable nipples shall have the longitudinal seam laser welded to allow for a tighter slip joint and reduce system pressure losses. All laser welded seams will undergo a light test to ensure there are no voids or imperfections in the system. Pipe lengths using laser welded seams will not exceed a nominal 60" length. An adjustable nipple is used for adjustment during the install process. Pipe is cut to appropriate length and the adjustable nipple secures the pipe for install.

2. Pipe and other components larger than 24" shall utilize either an angle flange or flat flange attached loosely and retained in place using a 3/8" Vanstone lip. The pipe shall have a compressed-interlocking lap form seam and not exceed 78" in length.

3. There will be times when certain components will be air direction sensitive. These components will have an arrow sticker attached showing the proper flow direction.

4. All ducting and its components shall have been tested to 80" WG using the following gauged reference:

a. 3" will use 18ga material thickness

b. 4" through 12" will use 22ga material thickness

c. 13" through 29" will use 20ga material thickness

d. 30" and above will use 18ga material thickness

C. Clamping rolled edged duct:

1. Clamps shall be constructed with an over-center, spring-lever action for quick connecting of two pieces of ducting. A retaining pin shall be inserted in the handle and an eyelet on the clamp as a safety feature to ensure the handle does not prematurely come undone.

2. When closing the clamp, the internal seal shall be compressed in such a manner as to cover both rolled beads for optimum sealing capacity in a full 360° pattern.
3. Sealing gaskets
    a. Buna-N, 70 Duro-Meter hardness with a temperature rating of 250°F maximum and is black in color, used with the adjustable nipple
    b. Silicon rubber, ZZ-R-765 Class 2A and 2B grade 770 AMS-3304E and 3304F and 3303G, FDA approved and is red in color, used with the adjustable nipple
    c. Molded gaskets shall meet the material classification of ASTM D-2000 M2BG510 A24 B34 EO14 EO34 EF11 EF21 and used in systems where the temperature rating is 225°F or less and are black in color. This component shall be made using conductive materials for conductivity.
    d. Sponge o-ring shall meet the material classification of either ASTM D-1056-68 – SBE43 or ASTM D1056-85, 91, 98 – 2B3
4. Clamp seals shall be made of either of the following:
    a. Nitrile to meet or exceed ASTM D 1056 standards with a temperature rating not to exceed 158°F constant temperature (or intermittent temperature of 194°F).
    b. ePTFE to meet or exceed FDA /pharmaceutical standards for food usage and not be degraded by any common chemicals in the 0-14 PH range. Temperature rating shall not exceed 600°F.

D. Conductivity:
1. Metal-to-metal contact shall be obtained at all joint connections. Die-formed rolled edges are uniform in shape which provides the most consistent contact. The ears of the clamp contact with the rolled edges and provide maximum conductivity. Conductivity shall be adhered to per NFPA 77 paragraph 8.4.1.1; states all parts of the continuous metal piping system should have a resistance level that does not exceed 10 ohms.

E. Paint: All ductwork located outside the building shall be painted. Provide one primer coat of Rust-Oleum 4258 red primer and one finish coat of Rust-Oleum 4215. Before painting, prepare all galvanized surfaces as recommended by paint manufacturer's preparation instructions.

PART 3 - EXECUTION

3.1 INSTALLATION

A. System shall be installed in accordance with the manufacturer's installation requirements, per the installation manual and tested, commissioned and end-user trained by a factory trained technician before placing the system in operation.

B. Install metal ducts and casings according to SMACNA's "HVAC Duct Construction Standards, Metal and Flexible." Install duct access doors upstream and downstream of in-duct components for inspection and cleaning.

C. Connect water piping with unions, manual air vents, drain valves and ball valves to allow equipment to be disconnected without draining piping.

END OF SECTION 234101

SECTION 234200 - VEHICLE EXHAUST REMOVAL SYSTEM

PART 1 - GENERAL

1.1 SUMMARY

A. Provide a complete vehicle exhaust system including, but not limited to, fan exhaust stack, silencer, nozzle connections,hoses, and reels for each vehicle, interconnecting rigid duct from hose connection to rooftop fan inlet, and all necessary controls. Include also, insulated equipment roof curbs, stack extensions, and supports.

1.2 PERFORMANCE REQUIREMENTS

A. Tailpipe connection shall be able to effectively capture all exhaust emissions from a connected internal combustion engine even in the event of a power failure.

B. The hose must be able to remain attached to the vehicle during a power failure.

C. Attachment of the hose to the vehicle tailpipe must be able to be easily performed from a standing position.

D. System shall not require disconnection of hose from vehicle when working on vehicle's fuel system or recharging batteries.

E. To protect the apparatus electrical system from any possible damage, the proposed system shall not incorporate any type of electromagnetic device that requires the apparatus to be utilized as an electrical ground for the system's operation.

F. Project Altitude: Base airflow ratings on actual site elevations.

G. Operating Limits: Classify fan according to AMCA 99.

1.3 DEFINITIONS

A. The term "Apparatus" and "Vehicle" are used interchangeably in this section and refer to all motor vehicles to be stored in the service garage.

1.4 SUBMITTALS

A. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1. Wiring Diagrams: Power, signal, and control wiring. Differentiate between manufacturer-installed and field-installed wiring.
2. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints for designing vibration isolation bases.
3. Vibration Isolation Base Details: Detail fabrication, including anchorages and attachments to structure and to support equipment. Include auxiliary motor slides and rails, and base weights.
4. Duct layout indicating pressure classifications and sizes on plans.
5. Hangers and supports, including methods for building attachment, vibration isolation, seismic restraints, and duct attachment.

B. Coordination Drawings:

1. Provide drawings showing all other pertinent systems installed in the same work space as ductwork and equipment.

C. Maintenance Data: For power ventilators, include data in maintenance manuals specified in Division 1.

D. Record Drawings: Indicate actual routing, fitting details, reinforcement, support, and installed accessories and devices.

1.5 QUALITY ASSURANCE

A. Provide equipment, components, and systems in strict accordance with the following:

B. International Code Council Code Series with New York State Supplements.

C. Electrical Components, Devices and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

D. The system manufacturer must be certified by the Air Movement and Control Association (AMCA) and shall be licensed to use the AMCA-Certified Ratings Seal.

F. NEMA Compliance: Motors and electrical accessories shall comply with NFPA standards.

G. The exhaust fan shall be UL (Underwriters Laboratories) listed and manufactured in accordance with UL Standard UL-705.

H. The electrical controller shall be UL (Underwriters Laboratories) listed and manufactured in accordance with UL Standard UL-508 for enclosure industrial control panels and incorporate a limited energy control circuit.

1.7 COORDINATION

A. Coordinate size and location of structural-steel support members.

B. Coordinate locations. And routing with other trades and owner provide apparatus and equipment.

1.8 WARRANTY

A. The Contractor shall provide an extended warranty for all installed components (including, but not limited to, all parts and labor) for a minimum period of (5) years following the acceptance on the completed product by the owner.

PART 2 – PRODUCTS

2.1 MANUFACTURERS

A. Available manufacturers: Subject to compliance with requirements, provide product by one of the following manufacturers:

1. Monoxivent (Basis of Design)
2. Plymovent
3. Harvey Industries.
4. No Smoke King.

2.2 HOSE

A. Rated for 350 degrees (F) continuous and 550 degrees (F) intermittent temperatures to insure durability.
B. 4 in diameter, 25 ft long, high quality rubber, impregnated polyester with fully enclosed helix and manufactured with additional outer wearstrip.

2.3 HOSE REEL

A. Automatic spring exhaust hose reels, designed for manual extension and spring return of high temperature flexible exhaust hose. Sized for hose diameter, length, and weight.
B. Zinc coated steel frame, min. 0.125" thick steel
C. Powder coated drum end plates, min. 0.092" thick steel
D. Zinc coated steel drum, mi. 0.47" thick steel

2.4 EXHAUST HOSE QUICK DISCONNECT

A. Quick disconnect fitting designed to connect different tailpipe adapters to the exhaust hose.
B. Two piece assembly with spring loaded hook and clasp connection.
C. Heavy Duty Galvanized sheet metal collars with raised lip for slip connection to exhaust hose.

2.5 EXHAUST PIPE ADAPTER

D. Rubber nozzle for vehicle exhaust pipe connections, including twin exhaust pipes.
E. Moulded, high temperature resistant rubber
F. Vise grip to strengthen connection to exhaust pipe
G. Ambient cooling air intake

2.6 EXHAUST FAN

A. General: The exhaust fan shall be a three-phase, belt-driven, spark-resistant blower specifically designed for the purpose of exhausting all gases generated by internal combustion engines (both Diesel and Gasoline fueled). The blower must provide minimum conveying velocities of 2,000-2,500 FPM and capture velocities of 3,000-4,000 FPM. Provide for outdoor, roof mounting with stack discharge:

1. Roof curb with spring fan isolation base
2. Min. 10 ft. above roof stack with silencer
3. Inlet and outlet flexible connectors
4. Drive cover.

5. Motorized isolation damper
6. On/off magnetic starter with a remote push button stop/start and additional set of dry contact points for connection to Building BMS.
7. Inlet reducer.

B. Available manufacturers: Subject to compliance with requirements, provide product by one of the following manufacturers:

1. Monoxivent
2. Plymovent.
3. Harvey Industries.
4. Greenheck
5. Twin City Fan Company.

C. Construction:

1. Powder-coated steel housing and wheels with shaft seals. Continuous weld.
2. The fan impeller shall be fabricated from an aluminum alloy and shall be designed as a blade type wheel.

D. The fan shall be capable of providing a minimum of 300 CFM per vehicle at the systems static pressure.

E. Motors:

1. Frame size: NEMA 145T
2. Motor Type: TEFC (IP 55)
3. Enclosure: Totally enclosed, fan cooled.
4. The fan motor shall be mounted external to the contaminated exhaust stream on a rigid welded base.

F. Source Quality Control

1. Sound-power rating information for blower may only be available from manufacturers on request.
2. Sound-power Level Ratings: Comply with AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Label fans with the AMCA-Certified Rating Seal.
3. Fan Performance Ratings: Establish flow rate, pressure, power, air density, speed of rotation, and efficiency by factory tests and ratings according to

AMCA 210, "Methods of Testing Fans for Ratings." The fan shall be tested by an AMCA approved test facility.

2.7 DUCTWORK

A. Ductwork is to be Type SMACNA -10" pressure class product and must meet or exceed criteria for construction and performance as outlined in Round Industrial Duct Construction Standards.

B. Materials of construction for all ductwork and fittings shall be a minimum of G-60 Galvanized sheet metal in accordance with ASTM-A525 and A527.

C. All ductwork subject to positive or negative pressure shall be round spiral pipe construction.

D. Duct gauge shall be a minimum of 22-gauge standard spiral pipe.

E. Duct length shall be provided in continuous and unjointed lengths wherever possible. Spiral duct sections shall not be less than 10 feet long except when interrupted by fittings.

F. All exhaust fittings shall be round and have a wall thickness 2 gauges heavier than the lightest allowable gauge of the downstream section of duct to which they are connected.

G. Branch entrances shall be factory-fabricated fittings of factory-fabricated duct/tap assemblies. All joint connections that are not continuous welded shall be supplied with a transition coupling from the downstream end only.

H. Fittings shall be constructed so that airstreams converge at angles of 45 degrees. Standard seam joints shall be continuous welded on all fittings. All welded joints shall be coated with a protective paint inside and out to prevent damage to the galvanized surface.

I. Turning elbows shall be die-stamped and used for all diameters and pressures. They shall be fabricated of 20-gauge galvanized steel and constructed as two-piece with continuous welded seam construction.

J. Provide Teflon Collar bands for all non-welded ductwork joints.

K. Tapered body fittings shall be used wherever particulate fallout is anticipated and where airflow is introduced to the transport duct manifold.

L. Duct conveying velocity shall be a minimum of 2,000 to 2,500 feet per minute transport velocity. Capture velocity shall be a minimum of 3,000 to 4,000 feet per minute.

M. Ductwork external to the building shall be sized for the exhaust fan inlet and outlet.

2.6 CONTROLS

A. Description: The fan shall be controlled by a variable frequency drive, with a remote push button start/stop switch, which are all provided but the manufacturer of the vehicle exhaust system.
B. All components shall be provided, and interconnections made to ensure a fully functional system that operates standalone.
C. The controller shall have multiple control points for connection to Building Management System (BMS).

PART 3 – EXECUTION

3.1 INSTALLATION

A. All pertinent penetration of the roof and exterior or interior walls shall be the responsibility of this contract. Coordinate all penetrations with the General Contractor.
B. Install all equipment level and plumb.

C. Support suspended units from structure using threaded steel rods and spring hangers.

D. Coordinate location and installation with the General Contractor and truss manufacturer.

E. Duct installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of ducts, fittings, and accessories.

F. Construct and install each duct system for the specific duct pressure classification indicated.

G. Install ducts in length not less than 10 feet, unless interrupted by fittings.

H. Install ducts with fewest possible joints.

I. Install fabricated fittings for change in directions, changes in size and shape, and connections.

J. Install couplings tight to duct wall surface with a minimum of projections into duct.

K. Install ducts, unless otherwise indicated, vertically and horizontally, parallel and perpendicular to building lines; avoid diagonal runs.

L. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.

M. Install ducts with a clearance of 1 inch.

N. Coordinate layout with lighting and other equipment in ceiling area.

O. Support horizontal ducts within 24 inches of each elbow and within 48 inches of each branch intersection.

P. Install required insulation on vehicle exhaust ductwork.

3.2 CONNECTIONS

A. Coordinate duct installation and specialty arrangements with schematics on Drawings and with requirements specified in duct systems. If Drawings are explicit enough, these requirements may be reduced or omitted.

B. Duct installation and connection requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of ducts and duct accessories.

C. For branch, outlet and inlet, and terminal unit connections, comply with SMACNA's "HVAC Duct Construction Standards-Metal and Flexible."

3.3 FIELD QUALITY CONTROL

A. Disassemble, reassemble, and seal segments of systems as required to accommodate leakage testing and as required for compliance with test requirements.

B. Conduct tests, in presence of Architect, at static pressures equal to maximum design pressure of system or section being tested. If pressure classifications are not indicated, test entire system at maximum system design pressure. Do not pressurize systems above maximum design operating pressure. Give seven days' advance notice for testing.

C. Determine leakage from entire system or section of system by relating leakage to surface area of test section.

D. Maximum Allowable Leakage: Comply with requirements for Leakage Classification 3 for round and flat-oval ducts, Leakage Classification 12 for rectangular ducts in pressure classifications less than and equal to 2-inch wg (both positive and negative pressures), and Leakage Classification 6 for pressure classifications from 2- to 10-inch wg.

E. Remake leaking joints and retest until leakage is less than maximum allowable.

F. Leakage Test: Perform tests according to SMACNA's "HVAC Air Duct Leakage Test Manual."

G. Fan Startup:

1. Refer to specification Section 233423 "HVAC Ventilators" for fan startup procedures and field quality control

3.4 ADJUSTING

A. Adjust damper linkage for proper damper operation.

B. Lubricate bearings.

C. Refer to Division 15 Section "Testing, Adjusting, and Balancing" for detailed procedures.

3.5 CLEANING

A. On completion of installation, internally clean fan according to manufacturer's written instructions. Remove foreign and construction debris. Vacuum fan wheel and cabinet.

B. After completing system installation, including outlet fittings and devices, inspect exposed finish. Remove burrs, dirt, and construction debris and repair damaged finishes.

C. After completing system installation, including outlet fittings and devices, inspect the system. Vacuum ducts before final acceptance to remove dust and debris.

3.6 SEQUENCE OF OPERATION

A. The system shall perform per the following sequence of operation:

1. The exhaust blower shall be enabled whenever the Push to Start button is pressed to operate.
2. The fan shall continue to operate until the Stop Button is pressed to stop the fan.

3.7 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's personnel to operate, adjust, and maintain exhaust extraction system.

1. Provide training by factory-authorized personnel in the use, operation and troubleshooting of all components of the vehicle exhaust system.
2. Review data in maintenance manuals. Refer to Division 1 Section "Closeout Procedures."
3. Review data in maintenance manuals. Refer to Division 1 Section "Operation and Maintenance Data."
4. Schedule training with Owner, through Architect, with at least seven days, advance notice.

END OF SECTION 234200

SECTION 235123 - GAS VENTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Listed double-wall vents.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for product.

B. Shop Drawings: For vents.

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. Detail fabrication and assembly of hangers and seismic restraints.

1.4 INFORMATIONAL SUBMITTALS

A. Welding certificates.

B. Sample Warranty: For special warranty.

1.5 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to the following:

1. AWS D1.1/D1.1M, "Structural Welding Code - Steel," for hangers and supports.

2. AWS D9.1/D9.1M, "Sheet Metal Welding Code," for shop and field welding of joints and seams in vents.

B. Certified Sizing Calculations: Manufacturer shall certify venting system sizing calculations.

PART 2 - PRODUCTS

2.1 LISTED SPECIAL GAS VENTS

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

1. Cleaver-Brooks.
2. Heatfab Saf-T Vent.
3. M&G DuraVent, Inc.; a member of the M&G Group.
4. Van-Packer Company, Inc.

B. Description: Double-wall metal vents tested according to UL 1738 and rated for 480 deg F continuously, with positive or negative flue pressure complying with NFPA 211.

C. Construction: Inner shell and outer jacket separated by at least a 1/2-inch airspace.

D. Inner Shell: ASTM A959, Type 29-4C stainless steel.

E. Outer Jacket: Stainless steel.

F. Accessories: Tees, elbows, increasers, draft-hood connectors, terminations, adjustable roof flashings, storm collars, support assemblies, thimbles, firestop spacers, and fasteners; fabricated from similar materials and designs as vent-pipe straight sections; all listed for same assembly.

1. Termination: In accordance with fuel fired equipment manufacturers recommendations.

2.2 COMBUSTION AIR INTAKES

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

1. Cleaver-Brooks.
2. Heatfab Saf-T Vent.
3. M&G DuraVent, Inc.; a member of the M&G Group.
4. Van-Packer Company, Inc.

B. Description: Single wall metal intake tested

C. Material: Stainless Steel

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of work.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 APPLICATION

A. Listed Special Gas Vent: Condensing gas appliances.

3.3 INSTALLATION OF LISTED VENTS

A. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Section 077200 "Roof Accessories."

B. Comply with minimum clearances from combustibles and minimum termination heights according to product listing or NFPA 211, whichever is most stringent.

C. Seal between sections of positive-pressure vents according to manufacturer's written installation instructions, using sealants recommended by manufacturer.

D. Support vents at intervals recommended by manufacturer to support weight of vents and all accessories, without exceeding appliance loading.

E. Lap joints in direction of flow.

3.4 CLEANING

A. After completing system installation, including outlet fittings and devices, inspect exposed finish. Remove burrs, dirt, and construction debris, and repair damaged finishes.

END OF SECTION 235123

SECTION 235216 - CONDENSING BOILERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes gas-fired, fire-tube floor-mounted wall-hung condensing boilers, trim, and accessories for generating hot water.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for boilers.
2. Include rated capacities, operating characteristics, and furnished specialties and accessories.

B. Shop Drawings: For boilers, boiler trim, and accessories.

1. Include plans, elevations, sections, and mounting 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.

1.4 CLOSEOUT SUBMITTALS

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

1.5 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to repair or replace components of boilers that fail in materials or workmanship within specified warranty period. Where

"prorated" is indicated, the boiler manufacturer will cover the indicated percentage of cost of replacement parts. With "prorated" type, covered cost decreases as age of equipment increases.

1. Warranty Period for Floor-Mounted Fire-Tube Condensing Boilers:

    a. Heat Exchanger and Tank: Free from defects in material and workmanship.
    b. Warranty Coverage: Prorated Year 0 to 5 - 100 percent; Year 6 to 7 - 50 percent; Year 8 to 9 - 30 percent; Year 10 - 10 percent for 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 a qualified testing agency, and marked for intended location and application.

B. ASME Compliance: Fabricate and label boilers to comply with ASME Boiler and Pressure Vessel Code.

C. ASHRAE/IES 90.1 Compliance: Boilers shall have minimum efficiency in accordance with Table 6.8.1-6 and other requirements in Ch. 6 of ASHRAE/IES 90.1.

D. ASHRAE 90.2 Compliance: Boilers shall have minimum efficiency in accordance with Ch. 6 of ASHRAE 90.2.

E. DOE Compliance: Minimum efficiency shall comply with 10 CFR 431, Subpart E, Appendix N.

F. Mounting Base: For securing boiler to concrete base For securing boiler to structural wall.

G. A.ASME CSD-1 Controls and Safety Devices for Automatically Fired Boilers.

H. B.NYS Industrial Code Rule 4; New York Codes, Rules & Regulations, Title 12, Part 4 - Low pressure Boilers.

2.2 FLOOR-MOUNTED, FORCED-DRAFT, FIRE-TUBE CONDENSING BOILERS

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

1. AERCO; A WATTS Brand.
2. Fulton Boiler Works, Inc.
3. Laars Heating Systems Company; a subsidiary of Bradford White Corporation.
4. Lochinvar, LLC.
5. Viessmann Manufacturing Company, Inc.

B. Description: Factory-fabricated, -assembled, and -tested, fire-tube, forced-draft, condensing boiler with heat exchanger sealed pressure tight, built on a steel base, including insulated jacket; flue-gas vent; combustion-air intake connections; water supply, return, and condensate drain connections; and controls. Units are to be for water-heating service only.

C. Primary Heat Exchanger: Corrosion-resistant Type 316 stainless steel.

D. Secondary Heat Exchanger: Corrosion-resistant Type 316 stainless steel.

E. Combustion Chamber and Flue Pipes: Corrosion-resistant stainless steel.

F. Pressure Vessel: Carbon steel with welded heads and tube connections.

G. Burner: Propane, forced draft.

H. Blower: Centrifugal fan to operate during each burner-firing sequence and to prepurge and postpurge the combustion chamber.

1. Motors: Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

a. Motor Sizes: Large enough so driven load will not require motor to operate in service factor range above 1.0.

I. Gas Train: Combination gas valve with manual shutoff and pressure regulator.

J. Ignition: Direct-spark ignition or silicone carbide hot-surface ignition with 100 percent main-valve shutoff and electronic flame supervision.

K. Casing:

1. Jacket: Sheet metal, with snap-in or interlocking closures.
2. Control Compartment Enclosures: NEMA 250, Type 1A.
3. Finish: Baked-enamel protective finish.
4. Insulation: Minimum 2-inch- thick, polyurethane-foam insulation surrounding the heat exchanger.
5. Combustion-Air Connections: Inlet and vent duct collars.

2.3 TTRIM - FOR HOT-WATER BOILERS

A. Include devices sized to comply with ASME B31.1.

B. Aquastat Controllers: Operating, firing rate, and high limit with automatic reset.

C. Safety Relief Valve: ASME rated.

D. Pressure and Temperature Gauge: Minimum 3-1/2-inch- diameter, combination water-pressure and -temperature gauge. Gauges shall have operating-pressure and -temperature ranges, so normal operating range is about 50 percent of full range.

E. High and low gas-pressure switches.

F. Alarm bell with silence switch.

G. Boiler Air Vent: Automatic.

H. Drain Valve: Minimum NPS 3/4 hose-end gate valve.

I. Circulation Pump: Nonoverloading, in-line pump with split-capacitor motor having thermal-overload protection and lubricated bearings; designed to operate at specified boiler pressures and temperatures.

2.4 CONTROLS

A. Boiler operating controls shall include the following devices and features:

1. Control transformer.
2. Set-Point Adjust: All set points shall be adjustable.
3. Electric, factory-fabricated and factory-installed panel to modulate burner and control burner-firing rate to maintain space temperature in response to thermostat with heat anticipator located in heated space.

    a. Include automatic, alternating-firing sequence for multiple boilers to ensure maximum system efficiency throughout the load range and to provide equal runtime for boilers.

4. Electric, factory-fabricated and factory-installed panel to control burner-firing rate, to reset supply-water temperature inversely with outside-air temperature. At 0 deg F (adjustable) outside-air temperature, set supply-water temperature at 160 deg F (adjustable) at 60 deg F (adjustable) outside-air temperature, set supply-water temperature at 130 deg F adjustable).

a. Include automatic, alternating-firing sequence for multiple boilers to ensure maximum system efficiency throughout the load range and to provide equal runtime for boilers.

B. Burner Operating Controls: To maintain safe operating conditions, burner safety controls limit burner operation.

1. High Cutoff: Manual reset stops burner if operating conditions rise above maximum boiler design temperature.
2. Low-Water Cutoff Switch: Electronic probe shall prevent burner operation on low water. Cutoff switch shall be manual-reset type.
3. Blocked Inlet Safety Switch: Manual-reset pressure switch factory mounted on boiler combustion-air inlet.
4. Audible Alarm: Factory mounted on control panel with silence switch; shall sound alarm for above conditions.

C. Building Automation System Interface: Factory install hardware and software to enable building automation system to monitor, control, and display boiler status and alarms.

1. Hardwired Points:

a. Monitoring: On/off status, common trouble alarm low-water-level alarm.
b. Control: On/off operation, hot-water-supply temperature set-point adjustment.

2. A BACnet communication interface with building automation system shall enable building automation system operator to remotely control and monitor the boiler from an operator workstation. All monitoring and control features, which are available at the local boiler control panel, shall also be available at the remote operator workstation through the building automation system.

3. Provide electronic flame safeguard controls which, upon flame failure, respond in 2-4 seconds to cut fuel supply through the burner and main fuel valve.

2.5 ELECTRICAL POWER

A. Controllers, Electrical Devices, and Wiring: Electrical devices and connections are shown on Drawings and specified in electrical Sections.

B. Single-Point Field Power Connection: Factory-installed and -wired switches, motor controllers, transformers, and other electrical devices necessary shall provide a single-point field power connection to boiler.

1. House in NEMA 250, Type 1 enclosure.
2. Wiring shall be numbered and color coded to match wiring diagram.

3. Install factory wiring outside of an enclosure in araceway.
4. Field power interface shall be to fused disconnect switch.
5. Provide branch power circuit to each motor and to controls with a disconnect switch or circuit breaker.
6. Provide each motor with overcurrent protection.

2.6 CONDENSATE-NEUTRALIZATION UNITS

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

1. SFA Saniflo USA.
2. Skidmore Pump.
3. Wessels Company.

B. Description: Factory-fabricated and -assembled condensate-neutralizing tank assembly of corrosion-resistant plastic material with threaded or flanged inlet and outlet pipe connections. Device functions to prevent acidic condensate from damaging grain system. It is to be piped to receive acidic condensate discharged from condensing boiler and neutralize it by chemical reaction with replaceable neutralizing agent. Neutralized condensate is then piped to suitable drain.

C. Capsule features:

1. All corrosion-resistant material.
2. Suitable for use on all natural gas and propane boilers.
3. Includes initial charge of neutralizing agent.
4. Neutralizing agent to be easily replaceable when exhausted.
5. Inlet and outlet pipe connections.

D. Capsule Configuration:

1. Low-profile design for applications where boiler condensate drain is close to the floor.
2. Easily removed and opened for neutralizing agent replacement.
3. Multiple units may be used for larger capacity.

2.7 SOURCE QUALITY CONTROL

A. UL Compliance: Test gas-fired boilers having input of more than 400,000 Btu/h for compliance with UL 795. Boilers shall be listed and labeled by a testing agency acceptable to authorities having jurisdiction.

B. UL Compliance, Oil-Fired: Test oil-fired boilers for compliance with UL 726. Boilers shall be listed and labeled by a testing agency acceptable to authorities having jurisdiction.

C. UL Compliance, Gas-Fired: Test gas-fired boilers for compliance with UL 2764. Boilers shall be listed and labeled by a testing agency acceptable to authorities having jurisdiction.

D. CSA Compliance: Test boilers for compliance with ANSI Z21.13-2017/CSA 4.9.

E. Performance Testing: Test and label boilers for efficiency to comply with AHRI 1500.

F. Burner and Hydrostatic Test: Factory adjust burner to eliminate excess oxygen, carbon dioxide, oxides of nitrogen emissions, and carbon monoxide in flue gas and to achieve combustion efficiency; perform hydrostatic test.

G. Test and inspect factory-assembled boilers, before shipping, in accordance with 2017 ASME Boiler and Pressure Vessel Code. Factory test boilers for safety and functionality; fill boiler with water, and fire throughout firing range, to prove operation of all safety components.

H. Allow Owner access to source quality-control testing of boilers. Notify Architect 14 days in advance of testing.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in for concrete equipment bases, anchor-bolt sizes and locations, and piping and electrical connections to verify actual locations, sizes, and other conditions affecting performance of the Work.

1. Final boiler locations indicated on Drawings are approximate. Determine exact locations before roughing-in for piping and electrical connections.

B. Examine mechanical spaces for suitable conditions where boilers will be installed.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 BOILER INSTALLATION

A. Equipment Mounting:

1. Install floor-mounted boilers on cast-in-place concrete equipment base(s).

2. Install wall-hung boilers where indicated on Drawings using suitable hangers. Comply with manufacturer's mounting instructions.

B. Install gas-fired boilers according to NYS Fuel Gas Code.

C. Assemble and install boiler trim.

D. Install electrical devices furnished with boiler but not specified to be factory mounted.

E. Install control wiring to field-mounted electrical devices.

3.3 PIPING CONNECTIONS

A. Connect piping to boilers, except safety relief valve connections, with flexible connectors of materials suitable for service.

B. Drawings indicate general arrangement of piping, fittings, and specialties.

C. When installing piping adjacent to boiler, allow space for service and maintenance of condensing boilers. Arrange piping for easy removal of condensing boilers.

D. Install condensate drain piping to condensate-neutralization unit and from neutralization unit to nearest floor drain. Piping shall be at least full size of connection. Install piping with a minimum of 2 percent downward slope in direction of flow.

E. Connect gas piping to boiler gas-train inlet with union. Piping shall be at least full size of gas-train connection. Provide a reducer if required.

F. Connect hot-water piping to supply- and return-boiler tappings with shutoff valve, and union or flange at each connection.

G. Install piping from safety relief valves to nearest floor drain.

3.4 DUCT CONNECTIONS

A. Boiler Venting:

1. Install flue-venting kit and combustion-air intake.
2. Comply with all boiler manufacturer's installation instructions.
3. Field fabricate and install boiler vent and combustion-air intake.
4. Utilize vent and intake duct material, size, and configuration as indicated in boiler manufacturer's instructions and to comply with UL 1738.
5. Comply with all boiler manufacturer's installation instructions.
6. Connect boiler vent full size to boiler connections.

7. Comply with all boiler manufacturer's installation instructions.

3.5 ELECTRICAL CONNECTIONS

A. Install electrical devices furnished by manufacturer, but not factory mounted, according to NFPA 70 and NECA 1.

B. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.

1. Nameplate shall be laminated acrylic or melamine plastic signs.
2. Nameplate shall be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least 1/2 inch high.

3.6 CONTROL CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Install nameplate for each control connection, indicating field control panel designation and I/O control designation feeding connection.

1. Nameplate shall be laminated acrylic or melamine plastic signs.
2. Nameplate shall be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least 1/2 inch high.

3.7 FIELD QUALITY CONTROL

A. Testing Agency, Owner: Owner will engage a qualified testing agency to perform tests and inspections.

B. Testing Agency, Contractor: 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 with the assistance of a factory-authorized service representative:

E. Tests and Inspections:

1. Perform installation and startup checks in accordance with manufacturer's written instructions.

2. Leak Test: Hydrostatic test. Repair leaks and retest until no leaks exist.
3. Operational Test: Start units to confirm proper motor rotation and unit operation. Adjust air-fuel ratio and combustion.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

    a. Check and adjust initial operating set points and high- and low-limit safety set points of fuel supply, water level, and water temperature.
    b. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

F. Boiler will be considered defective if it does not pass tests and inspections.

G. Prepare test and inspection reports.

H. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.8 DEMONSTRATION

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

1. Instructor shall be factory trained and certified.
2. Provide not less than two hours of training.
3. Train personnel in operation and maintenance and to obtain maximum efficiency in plant operation.
4. Provide instructional videos showing general operation and maintenance that are coordinated with operation and maintenance manuals.
5. Obtain Owner sign-off that training is complete.
6. Owner training shall be held at Project site.

END OF SECTION 235216

SECTION 235700 - HEAT EXCHANGERS FOR HVAC

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes and gasketed-plate heat exchangers.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include rated capacities, operating characteristics, and furnished specialties and accessories.

B. Shop Drawings: Signed and sealed by a qualified professional engineer. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

C. hts, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1. Design Calculations: Calculate requirements for selecting seismic restraints and for designing bases.
2. Base Details: Detail fabrication, including anchorages and attachments to structure and to supported equipment.

1.3 INFORMATIONAL SUBMITTALS

A. Product Certificates: For each type of heat exchanger. Source quality-control reports.

B. Field quality-control reports.

C. Sample Warranty: For manufacturer's warranty.

1.4 CLOSEOUT SUBMITTALS

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

1.5 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of heat exchangers that fail in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:
   a. Structural failures, including heat exchanger, storage tank, and supports.
   b. Faulty operation of controls.
   c. Deterioration of metals, metal finishes, and other materials beyond normal use.
2. Warranty Periods: From date of Substantial Completion.
   a. Plate Heat Exchangers:
      1) Gasketed-Plate Type; Five year(s).

PART 2 - PRODUCTS

2.1 GASKETED-PLATE HEAT EXCHANGERS

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

1. Alfa Laval Inc.
2. Bell & Gossett; a Xylem brand
3. Taco Comfort Solutions.
4. Wessels Company.

B. Configuration: Freestanding assembly, consisting of frame support, top and bottom carrying and guide bars, fixed and movable end plates, tie rods, individually removable plates, and one-piece gaskets. Floor-mounted heat exchangers must have integral legs with mounting feet.

C. Construction: Fabricate and label heat exchangers to comply with ASME Boiler and Pressure Vessel Code, Section VIII, "Pressure Vessels," Division 1.

D. Frame:

1. Capacity to accommodate 20 percent additional plates.
2. Painted carbon steel with provisions for anchoring to support.

E. Top and Bottom Carrying and Guide Bars: Painted carbon steel, aluminum, or stainless steel.

F. End-Plate Material: Painted carbon steel.

G. Tie Rods and Nuts: Steel or stainless steel.

H. Plate Material: 0.015 inch (0.4 mm) thick before stamping; Type 304 stainless steel.

I. Gasket Materials: EPDM rubber.

J. Piping Connections: Factory fabricated of materials compatible with heat-exchanger shell. Attach tappings to shell before testing and labeling.

1. NPS 2 (DN 50) and Smaller: Threaded ends in accordance with ASME B1.20.1.
2. NPS 2-1/2 (DN 65) and Larger: Flanged ends in accordance with ASME B16.5 for steel and stainless steel flanges and in accordance with ASME B16.24 for copper and copper-alloy flanges.

K. Enclose plates in solid aluminum or stainless steel removable shroud.

2.2 ACCESSORIES

A. Hangers and Supports:

1. Custom-built steel supports and saddles for mounting on floor.

2. Supports and saddles to ensure both horizontal and vertical support of heat exchanger. Comply with requirements in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

B. Shroud: Aluminum sheet.

C. Miscellaneous Components for Water Unit: Control valve, valves, thermometers, and piping. Include components fitted for electronic control.

D. Miscellaneous Components for Steam Unit: Strainers, steam-control valve, steam trap, valves, pressure gauge, thermometers, and piping. Include components fitted for electronic control.

2.3 SOURCE QUALITY CONTROL

A. Factory Tests: Test and inspect heat exchangers in accordance with ASME Boiler and Pressure Vessel Code, Section VIII, "Pressure Vessels," Division 1. Affix ASME International label.

B. Hydrostatically test heat exchangers to minimum of one and one-half times pressure rating before shipment.

C. Heat exchangers will be considered defective if they do not pass tests and inspections.

D. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas for compliance with requirements for installation tolerances and for structural rigidity, strength, anchors, and other conditions affecting performance of heat exchangers.

B. Examine roughing-in for heat-exchanger piping to verify actual locations of piping connections before equipment installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF HEAT EXCHANGER, GENERAL

A. Equipment Mounting:

1. Install floor-mounted heat exchangers on cast-in-place concrete equipment bases. Install all heat exchangers level and plumb in accordance with manufacturer's recommendations. Install floor-mounted and wall-hung steam heat exchangers at sufficient height, using sufficient length supports, to achieve required steam and condensate pipe pitch. Comply with requirements for equipment bases and foundations.

3.3 INSTALLATION OF GASKETED-PLATE HEAT EXCHANGER

A. Install wall-mounted gasketed-plate heat exchanger on custom-designed wall supports anchored to structure as indicated on Drawings.

B. Install floor-mounted gasketed-plate heat exchangers on cast-in-place concrete equipment base and fasten legs to base.

C. Install metal shroud over installed gasketed-plate heat exchanger in accordance with manufacturer's written instructions.

3.4 PIPING CONNECTIONS

A. Maintain manufacturer's recommended clearances for tube removal, service, and maintenance.

B. Install piping adjacent to heat exchangers to allow space for service and maintenance of heat exchangers. Arrange piping for easy removal of heat exchangers.

C. Install shutoff valves at heat-exchanger inlet and outlet connections.

D. Install pressure-relief valves on heat-exchanger shells where a connection has been provided on shell. When no shell pressure-relief valve connection has been provided, install pressure-relief valve on shell outlet piping before any isolation valves.

E. Install pressure-relief valves on heat-exchanger tube outlet piping before any isolation valves.

F. Pipe pressure-relief valves, full size of valve connection, to floor drain.

G. Install vacuum breaker at heat-exchanger steam inlet connection.

H. Install hose end valve to drain shell.

I. Install thermometer on each heat-exchanger fluid inlet and outlet piping. Comply with requirements for thermometers specified in Section 232113 "Hydronic Piping."

J. Install pressure gauges on each heat-exchanger fluid inlet and outlet piping and steam inlet piping].

3.5 CLEANING

A. After completing system installation, including outlet fitting and devices, inspect exposed finish. Remove burrs, dirt, and construction debris, and repair damaged finishes.

B. Isolate heat exchangers from piping before flushing piping. If a valve is used to isolate equipment, its closure shall be capable of sealing against test pressure without damage to valve. Install blind flanges in flanged joints to isolate equipment.

C. Flush heat-exchanger piping systems with clean water; then remove and clean or replace strainer screens before reopening flow to heat exchangers.

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

C. Heat exchanger will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

3.7 DEMONSTRATION

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

END OF SECTION 235700

SECTION 237416 - PACKAGED ROOF TOP AND ENERGY RECOVERY UNITS

PART 1 - GENERAL

1.1 ACTION SUBMITTALS

A. Product Data:

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 gas furnaces with performance characteristics.
9. Include dampers, including housings, linkages, and operators.

B. Shop Drawings: For each packaged, small-capacity, 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.

1.2 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 trades.

B. Sample Warranty: For manufacturer's warranty.

C. System startup reports.

D. Field quality-control reports.

1.3 CLOSEOUT SUBMITTALS

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

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. Filters: One set of filters for each unit.
2. Gaskets: One set for each access door.
3. Fan Belts: One set for each belt-driven fan.

1.5 WARRANTY

A. Warranty: Manufacturer agrees to repair or replace components of outdoor, semi-custom, air-handling unit that fail in materials or workmanship within specified warranty period.

1. Warranty Period: 3 years from date of Substantial Completion.
2. Warranty Period for Heat Exchangers: Manufacturer's standard, but not less than 10 years from date of Substantial Completion
3. 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 units 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 GENERAL DESCRIPTION

A. Furnish as shown on plans, Daikin Applied Rebel Single zone Heating and Cooling Unit(s) model DPS. Unit performance and electrical characteristics shall be per the job schedule.

B. Configuration: Fabricate as detailed on prints and drawings:
1. Return plenum / economizer section
2. Filter section
3. Cooling coil section
4. Supply fan section
5. Condensing unit section
6. Energy recovery section

C. The complete unit shall be cETLus listed.

D. The unit shall be ASHRAE 90.1-2016 compliant and labeled.

E. Each unit shall be specifically designed for outdoor rooftop application and include a weatherproof cabinet. Each unit shall be completely factory assembled and shipped in one piece. Packaged units shall be shipped fully charged with R-410 Refrigerant and oil.

F. The unit shall undergo a complete factory run test prior to shipment. The factory test shall include a refrigeration circuit run test, a unit control system operations checkout, a unit refrigerant leak test and a final unit inspection.

G. All units shall have decals and tags to indicate caution areas and aid unit service. Unit nameplates shall be fixed to the main control panel door. Electrical wiring diagrams shall be attached to the control panels. Installation, operating and maintenance bulletins and start-up forms shall be supplied with each unit.

H. up forms shall be supplied with each unit.

I. Performance: All scheduled EER, IEER, capacities and face areas are minimum accepted values. All scheduled amps, kW, and HP are maximum accepted values that allow scheduled capacity to be met.

2.4 CABINET, CASING, AND FRAME

A. Panel construction shall be double-wall construction for all panels. All floor panels shall have a solid galvanized steel inner liner on the air stream side of the unit to protect insulation during service and maintenance. Insulation shall be a minimum of 2" thick with an R-value of 13.0, and shall be 2 part injected foam. Panel design shall include no exposed insulation edges. Unit cabinet shall be designed to operate at total static pressures up to 5.0 inches w.g.

B. Panel construction shall be double-wall construction for all panels. All floor panels shall have a solid galvanized steel inner liner on the air stream side of the unit to protect insulation during service and maintenance. Insulation shall be a minimum of 1" thick with an R-value of 7.0, and shall be 2 part injected foam. Panel design shall include no exposed insulation edges. Unit cabinet shall be designed to operate at total static pressures up to 5.0 inches w.g.

C. l construction for all panels. All floor panels shall have a solid galvanized steel inner liner on the air stream side of the unit to protect insulation during service and maintenance. Insulation shall be a minimum of 1" thick with an R-value of 7.0, and shall be 2 part injected foam. Panel design shall include no exposed insulation edges. Unit cabinet shall be designed to operate at total static pressures up to 5.0 inches w.g.

D. Exterior surfaces shall be constructed of painted galvanized steel, for aesthetics and long-term durability. Paint finish will include a base primer with a high-quality polyester resin topcoat. Finished, unabraded panel surfaces shall be exposed to an ASTM B117 salt spray environment and exhibit no visible red rust at a minimum of 3,000 hours exposure. Finished, abraded surfaces shall be tested per ASTM D1654, having a mean scribe creepage not exceeding 1/16” at 1,000 hours minimum exposure to an ASTM B117 salt spray environment. Measurements of results shall be quantified using ASTM D1654 in conjunction with ASTM D610 and ASTM D714 to evaluate blister and rust ratings.

E. etics and long-term durability. Paint finish will include a base primer with a high-quality polyester resin topcoat. Finished, unabraded panel surfaces shall be exposed to an ASTM B117 salt spray environment and exhibit no visible red rust at a minimum of 3,000 hours exposure. Finished, abraded surfaces shall be tested per ASTM D1654, having a mean scribe creepage not exceeding 1/16" at 1,000 hours minimum exposure to an ASTM B117 salt spray environment. Measurements of results shall be quantified using ASTM D1654 in conjunction with ASTM D610 and ASTM D714 to evaluate blister and rust ratings.

F. 17 salt spray environment. Measurements of results shall be quantified using ASTM D1654 in conjunction with ASTM D610 and ASTM D714 to evaluate blister and rust ratings.

G. ASTM D1654 in conjunction with ASTM D610 and ASTM D714 to evaluate blister and rust ratings.

H. Service doors shall be provided on the fan section, filter section, control panel section, and heating vestibule in order to provide user access to unit components. All service access doors shall be mounted on multiple, stainless steel hinges and shall be secured by a latch system. Removable service panels secured by multiple mechanical fasteners are not acceptable.

I. The unit base shall overhang the roof curb for positive water runoff and shall seat on the roof curb gasket to provide a positive, weathertight seal. Lifting brackets shall be provided on the unit base to accept cable or chain hooks for rigging the equipment.

2.5 OUTDOOR/RETURN AIR SECTION

A. Unit shall be provided with an outdoor air economizer section. The economizer section shall include outdoor, return, and exhaust air dampers. The economizer operation shall be fully integral to the mechanical cooling and allow up to 100% of mechanical cooling if needed to maintain the cooling discharge air temperature. The outdoor air hood shall be factory installed and constructed from galvanized steel finished with the same durable paint finish as the main unit. The hood shall include moisture eliminator filters to drain water away from the entering air stream. The outside and return air dampers shall be sized to handle 100% of the supply air volume. The dampers shall be parallel blade design. Damper blades shall be gasketed with side seals to provide an air leakage rate of 1.5 cfm / square foot of damper area at 1" differential pressure in according with testing defined in AMCA 500. A barometric exhaust damper shall be provided to exhaust air out of the back of the unit. A bird screen shall be provided to prevent infiltration of rain and foreign materials. Exhaust damper blades shall be lined with vinyl gasketing on contact edges. Control of the dampers shall be by a factory installed direct coupled actuator. Damper actuator shall be of the modulating, spring return type.

B. filters to drain water away from the entering air stream. The outside and return air dampers shall be sized to handle 100% of the supply air volume. The dampers shall be parallel blade design. Damper blades shall be gasketed with side seals to provide an air leakage rate of 1.5 cfm / square foot of damper area at 1" differential pressure in according with testing defined in AMCA 500. A barometric exhaust damper shall be provided to exhaust air out of the back of the unit. A bird screen shall be provided to prevent infiltration of rain and foreign materials. Exhaust damper blades shall be lined with vinyl gasketing on contact edges. Control of the dampers shall be by a factory installed direct coupled actuator. Damper actuator shall be of the modulating, spring return type.

C. ird screen shall be provided to prevent infiltration of rain and foreign materials. Exhaust damper blades shall be lined with vinyl gasketing on contact edges. Control of the dampers shall be by a factory installed direct coupled actuator. Damper actuator shall be of the modulating, spring return type.

D. d to prevent infiltration of rain and foreign materials. Exhaust damper blades shall be lined with vinyl gasketing on contact edges. Control of the dampers shall be by a factory installed direct coupled actuator. Damper actuator shall be of the modulating, spring return type.

E. Unit shall be provided with a 100% outdoor air hood. The 100% outdoor air hood shall allow outdoor air to enter from the back of the unit, at the draw-through filter section. The outdoor air hood shall be factory installed and constructed from galvanized steel finished with the same durable paint finish as the main unit. The hood shall include a bird screen to prevent infiltration of foreign materials and a rain lip to drain water away from the entering air stream.

F. ucted from galvanized steel finished with the same durable paint finish as the main unit. The hood shall include a bird screen to prevent infiltration of foreign materials and a rain lip to drain water away from the entering air stream.

G. Daikin Applied UltraSeal low leak dampers shall be provided. Damper blades shall be fully gasketed and side sealed and arranged vertically in the hood. Damper leakage shall be less than 1.5 CFM/Sq. Ft. of damper area at 1.0 inch static pressure differential. Leakage rate to be tested in accordance with AMCA Standard 500. Damper blades shall be operated from multiple sets of linkages mounted on the leaving face of the dampers. Control of the dampers shall be from a factory installed actuator.

H. to be tested in accordance with AMCA Standard 500. Damper blades shall be operated from multiple sets of linkages mounted on the leaving face of the dampers. Control of the dampers shall be from a factory installed actuator.

I. Control of the outdoor dampers shall be by a factory installed actuator. Damper actuator shall be of the modulating type. Damper to open when when supply fan starts, and close when supply fan stops.

2.6 ENERGY RECOVERY

A. The rooftop unit shall be provided with an AHRI certified rotary wheel air-to-air heat exchanger in a cassette frame complete with seals, drive motor and drive belt. The energy recovery wheel shall be an integral part of the rooftop unit with unitary construction, power supply and controls and does not require field assembly. Bolt-on energy recovery units that require field assembly and section to section gasketing and sealing are not acceptable. The energy recovery wheels supplied must meet the scheduled capacity, and air pressure drop. The wheel capacity, air pressure drop and effectiveness shall be AHRI certified per AHRI Standard 1060. Thermal performance shall be certified by the manufacturer in accordance with ASHRAE Standard 84, Method of Testing Air-to-Air Heat Exchangers and AHRI Standard 1060, Rating Air-to-Air Heat Exchangers For Energy Recovery Ventilation equipment. The rooftop unit shall be designed with a track so the entire energy recovery wheel cassette can slide out from the rooftop unit to facilitate cleaning. The unit shall have 2" Merv 8 filters for the outdoor air before the wheel to help keep the wheel clean and reduce maintenance. A dirty filter switch and alarm shall be provided on the Energy wheel filter rack. The total energy recovery wheel shall have an aluminum substrate and a 3 angstrom desiccant and shall have an adjustable purge for field balancing. The rooftop unit with the energy recovery wheel shall incorporate the economizer operation. Units with economizers and energy recovery wheels shall have a bypass damper. When the unit is in the economizer mode of operation the energy recovery wheel shall stop and the bypass dampers shall be opened. The outdoor air shall be drawn through the bypass dampers to reduce the pressure drop of the outdoor airstream.

B. it to facilitate cleaning. The unit shall have 2" Merv 8 filters for the outdoor air before the wheel to help keep the wheel clean and reduce maintenance. A dirty filter switch and alarm shall be provided on the Energy wheel filter rack. The total energy recovery wheel shall have an aluminum substrate and a 3 angstrom desiccant and shall have an adjustable purge for field balancing. The rooftop unit with the energy recovery wheel shall incorporate the economizer operation. Units with economizers and energy recovery wheels shall have a bypass damper. When the unit is in the economizer mode of operation the energy recovery wheel shall stop and the bypass dampers shall be opened. The outdoor air shall be drawn through the bypass dampers to reduce the pressure drop of the outdoor airstream.

C. onomizers and energy recovery wheels shall have a bypass damper. When the unit is in the economizer mode of operation the energy recovery wheel shall stop and the bypass dampers shall be opened. The outdoor air shall be drawn through the bypass dampers to reduce the pressure drop of the outdoor airstream.

D. ergy recovery wheels shall have a bypass damper. When the unit is in the economizer mode of operation the energy recovery wheel shall stop and the bypass dampers shall be opened. The outdoor air shall be drawn through the bypass dampers to reduce the pressure drop of the outdoor airstream.

2.7 EXHAUST FAN

A. Exhaust fan shall be a single width, single inlet (SWSI) airfoil centrifugal fan. The fan wheel shall be Class II construction with aluminum fan blades that are continuously welded to the hub plate and end rim. The exhaust fan shall be a direct drive fan mounted to the motor shaft. Belts and sheaves are not acceptable due to the additional maintenance.

B. The fan motor shall be a totally enclosed EC motor that is speed controlled by the rooftop unit controller. The motor shall include thermal overload protection and protect the motor in the case of excessive motor temperatures. The motor shall have phase failure protection and prevent the motor from operation in the event of a loss of phase. Motors shall be premium efficiency.

2.8 FILTERS

A. Unit shall be provided with a draw-through filter section. The filter rack shall be designed to accept a 2″ prefilter and a 4″ final filter. The unit design shall have a hinged access door for the filter section. The manufacturer shall ship the rooftop unit with 2″ MERV 8 and 4" MERV 14 filters.

2.9 COOLING COIL

A. The indoor coil section shall be installed in a draw through configuration, upstream of the supply air fan. The coil section shall be complete with a factory piped cooling coil and an ASHRAE 62.1 compliant double sloped drain pan.

B. The direct expansion (DX) cooling coils shall be fabricated of seamless high efficiency copper tubing that is mechanically expanded into high efficiency aluminum plate fins. Coils shall be a multi-row, staggered tube design with a minimum of 3 rows. All cooling coils shall have an interlaced coil circuiting that keeps the full coil face active at all load conditions. All coils shall be factory leak tested with high pressure air under water.

C. an interlaced coil circuiting that keeps the full coil face active at all load conditions. All coils shall be factory leak tested with high pressure air under water.

D. The cooling coil shall have an electronic controlled expansion valve. The unit controller shall control the expansion valve to maintain liquid subcooling and the superheat of the refrigerant system.

E. The refrigerant suction lines shall be fully insulated from the expansion valve to the compressors.

F. The drain pan shall be stainless steel and positively sloped. The slope of the drain pan shall be in two directions and comply with ASHRAE Standard 62.1. The drain pan shall have a minimum slope of 1/8" per foot to provide positive draining. The drain pan shall extend beyond the leaving side of the coil. The drain pan shall have a threaded drain connection extending through the unit base.

2.10 HOT GAS REHEAT

A. Unit shall be equipped with a fully modulating hot gas reheat coil with hot gas coming from the unit condenser

B. Hot gas reheat coil shall be a Micro Channel design. The aluminum tube shall be a micro channel design with high efficiency aluminum fins. Fins shall be brazed to the tubing for a direct bond. The capacity of the reheat coil shall allow for a 20°F temperature rise at all operating conditions.

C. The modulating hot gas reheat systems shall allow for independent control of the cooling coil leaving air temperature and the reheat coil leaving air temperature. The cooling coil and reheat coil leaving air temperature setpoints shall be adjustable through the unit controller. During the dehumidification cycle the unit shall be capable of 100% of the cooling capacity. The hot gas reheat coil shall provide discharge temperature control within +/- 2°F.

D. ature setpoints shall be adjustable through the unit controller. During the dehumidification cycle the unit shall be capable of 100% of the cooling capacity. The hot gas reheat coil shall provide discharge temperature control within +/- 2°F.

E. Each coil shall be factory leak tested with high-pressure air under water.

2.11 SUPPLY FAN

A. Supply fan shall be a single width, single inlet (SWSI) airfoil centrifugal fan. The fan wheel shall be Class II construction with fan blades that are continuously welded to the hub plate and end rim. The supply fan shall be a direct drive fan mounted to the motor shaft. Belts and sheaves are not acceptable due to the additional maintenance.

B. All fan assemblies shall employ solid steel fan shafts. Heavy-duty pillow block type, self-aligning, grease lubricated ball bearings shall be used. Bearings shall be sized to provide a L-50 life at 250,000 hours. The entire fan assembly shall be isolated from the fan bulkhead with a flexible collar and mounted on 1" spring isolators.

C. All fan assemblies shall be statically and dynamically balanced at the factory, including a final trim balance, prior to shipment.

D. Supply fan and motor assembly combinations larger than 8 hp or 22" diameter shall be internally isolated on 1" deflection, spring isolators and include removable shipping tie downs.

E. The fan motor shall be a totally enclosed EC motor that is speed controlled by the rooftop unit controller. The motor shall include thermal overload protection and protect the motor in the case of excessive motor temperatures. The motor shall have phase failure protection and prevent the motor from operation in the event of a loss of phase. Motors shall be premium efficiency.

F. loss of phase. Motors shall be premium efficiency.

G. The motor shall be T Frame and open drip proof. Overload protection and speed control is provided by the factory installed VFD and rooftop unit controller. The motor shall have phase failure protection and prevent the motor from operation in the event of a loss of phase. Motors shall be premium efficiency.

H. The supply fan shall be capable of airflow modulation from 30% to 100% of the scheduled designed airflow. The fan shall not operate in a state of surge at any point within the modulation range.

2.12 HEATING SECTION

A. A hot water heating coil shall be factory installed in the heat section. The hot water heat section shall be installed downstream of the supply air fan. A factory-tested diffuser shall be used in order to provide air distribution across the coil. The rooftop unit shall include a piping vestibule. The coil connection shall terminate in the vestibule. All coil connections shall be copper, steel connections shall not be allowed in order to prevent dielectrics and corrosion.

B. Coils shall be fabricated of seamless 3/8" diameter copper tubing that is mechanically expanded into high efficiency rippled and corrugated aluminum plate fins. All coil vents and drains shall be factory installed. Hot water coil shall be fully cased to allow for easy replacement.

C. less 3/8" diameter copper tubing that is mechanically expanded into high efficiency rippled and corrugated aluminum plate fins. All coil vents and drains shall be factory installed. Hot water coil shall be fully cased to allow for easy replacement.

D. The coil shall have freeze protection and shall be controlled by the unit DDC controller. With the detection of a freeze condition the heating coil valve shall be driven fully open. The unit controller shall indicate an alarm.

E. Coil shall be factory leak tested with high pressure air under water.

2.13 CONDENSING SECTION

A. Outdoor coils shall be cast aluminum, micro-channel coils. Plate fins shall be protected and brazed between adjoining flat tubes such that they shall not extend outside the tubes. A sub-cooling coil shall be an integral part of the main outdoor air coil. Each outdoor air coil shall be factory leak tested with high-pressure air under water.

B. Fan motors shall be an ECM type motor for proportional control. The unit controller shall proportionally control the speed of the condenser fan motors to maintain the head pressure of the refrigerant circuit from ambient condition of 0~120°F. Mechanical cooling shall be provided to 0º F. The motor shall include thermal overload protection and protect the motor in the case of excessive motor temperatures. The motor shall have phase failure protection and prevent the motor from operation in the event of a loss of phase.

C. The condenser fan shall be low noise blade design. Fan blade design shall be a dynamic profile for low tip speed. Fan blade shall be of a composite material.

D. The unit shall have scroll compressors. One of the compressors shall be an inverter compressor providing proportional control. The unit controller shall control the speed of the compressor to maintain the discharge air temperature. The inverter compressor shall have a separate oil pump and low oil safety protection.

E. Pressure transducers shall be provided for the suction pressure and head pressure. Temperature sensor shall be provided for the suction temperature and the refrigerant discharge temperature of the compressors. All of the above devices shall be an input to the unit controller and the values be displayed at the unit controller.

F. shall be provided for the suction temperature and the refrigerant discharge temperature of the compressors. All of the above devices shall be an input to the unit controller and the values be displayed at the unit controller.

G. Refrigerant circuit shall have a bypass valve between the suction and discharge refrigerant lines for low head pressure compressor starting and increased compressor reliability. When there is a call for mechanical cooling the bypass valve shall open to

equalizing the suction and discharge pressures. When pressures are equalized the bypass valve shall close and the compressor shall be allowed to start.

H. n there is a call for mechanical cooling the bypass valve shall open to equalizing the suction and discharge pressures. When pressures are equalized the bypass valve shall close and the compressor shall be allowed to start.

I. Each circuit shall be dehydrated and factory charged with R-410A Refrigerant and oil.

2.14 ELECTRICAL

A. Unit wiring shall comply with NEC requirements and with all applicable UL standards. All electrical components shall be UL recognized where applicable. All wiring and electrical components provided with the unit shall be number and color-coded and labeled according to the electrical diagram provided for easy identification. The unit shall be provided with a factory wired weatherproof control panel. Unit shall have a single point power terminal block for main power connection. A terminal board shall be provided for low voltage control wiring. Branch short circuit protection, 115-volt control circuit transformer and fuse, system switches, and a high temperature sensor shall also be provided with the unit. Each compressor and condenser fan motor shall be furnished with contactors and inherent thermal overload protection. Supply fan motors shall have contactors and external overload protection. Knockouts shall be provided in the bottom of the main control panels for field wiring entrance.

B. ll be provided for low voltage control wiring. Branch short circuit protection, 115-volt control circuit transformer and fuse, system switches, and a high temperature sensor shall also be provided with the unit. Each compressor and condenser fan motor shall be furnished with contactors and inherent thermal overload protection. Supply fan motors shall have contactors and external overload protection. Knockouts shall be provided in the bottom of the main control panels for field wiring entrance.

C. ded for low voltage control wiring. Branch short circuit protection, 115-volt control circuit transformer and fuse, system switches, and a high temperature sensor shall also be provided with the unit. Each compressor and condenser fan motor shall be furnished with contactors and inherent thermal overload protection. Supply fan motors shall have contactors and external overload protection. Knockouts shall be provided in the bottom of the main control panels for field wiring entrance.

D. A single non-fused disconnect switch shall be provided for disconnecting electrical power at the unit. Disconnect switches shall be mounted internally to the control panel and operated by an externally mounted handle.

E. onnect switch shall be provided for disconnecting electrical power at the unit. Disconnect switches shall be mounted internally to the control panel and operated by an externally mounted handle.

2.15 CONTROLS

A. Provide a microprocessor based system to control all refrigeration functions including compressor speed, condenser fan function, unit safety protection, including compressor minimum run and minimum off times, and diagnostics. This system shall operate the unit at peak efficiency utilizing variable head pressure control and electronic expansion valve while maintaining the cooling, or heating in heat pump operation, call per third party control. The microprocessor control shall consist of only direct expansion required temperature sensors, pressure sensors, controller and keypad/display operator interface. Refrigeration sensors and controller shall be factory mounted, wired and tested.

B. ct expansion required temperature sensors, pressure sensors, controller and keypad/display operator interface. Refrigeration sensors and controller shall be factory mounted, wired and tested.

C. ion required temperature sensors, pressure sensors, controller and keypad/display operator interface. Refrigeration sensors and controller shall be factory mounted, wired and tested.

D. The microprocessor controls shall be dependent on starting and stopping of the unit via terminal strip control and logic. The control system shall be capable of providing a remote alarm indication. The microprocessor show provide compressor capacity & status, defrost status (heat pump only), condensate overflow alarm, and dirty filter alarm.

E. All digital and analog inputs and outputs shall be protected against damage from transients or incorrect voltages. All field wiring shall be terminated at a separate, clearly marked terminal strip.

F. learly marked terminal strip.

G. The keypad interface shall allow convenient navigation and access to the commissioning functions. The unit keypad/display character format shall be 4 lines x 20 characters. All control settings shall be password protected against unauthorized changes. For ease of service, the display format shall be English language readout. Coded formats with look-up tables will not be accepted. The user interaction with the display shall provide the following information as a minimum:
   1. Supply and exhaust fan speed control.
   2. ol.

3. Refrigeration alarm details.

2.16 ROOF CURB

A. A prefabricated heavy gauge galvanized steel, mounting curb shall be provided for field assembly on the roof decking prior to unit shipment. The roof curb shall be a full perimeter type with complete perimeter support of the air handling section and condensing section. The curb shall be a minimum of 24" high and include a nominal 2" x 4" wood nailing strip. Gasket shall be provided for field mounting between the unit base and roof curb.

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 units.

B. Examine roughing-in for units to verify actual locations of piping and duct connections before equipment installation.

C. Examine roofs for suitable conditions where units 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 curbs. Coordinate wall penetrations and flashing with wall construction. Secure units 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 unit, allow space for service and maintenance.

C. Connect piping to unit mounted on vibration isolators with flexible connectors.

D. 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. The following are specific connection requirements:

1. Install ducts to termination at top of roof curb.
2. Remove roof decking only as required for passage of ducts. Do not cut out decking under entire roof curb.
3. Install return-air duct continuously through roof structure.

3.5 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 units 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. Units will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

3.6 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 furnace combustion chamber.

4. Inspect for visible damage to compressor, coils, and fans.
5. Inspect internal insulation.
6. Verify that labels are clearly visible.
7. Verify that clearances have been provided for servicing.
8. Verify that controls are connected and operable.
9. Verify that filters are installed.
10. Clean condenser coil and inspect for construction debris.
11. Clean furnace flue and inspect for construction debris.
12. Connect and purge gas line.
13. Remove packing from vibration isolators.
14. Inspect operation of barometric relief dampers.
15. Verify lubrication on fan and motor bearings.
16. Inspect fan-wheel rotation for movement in correct direction without vibration and binding.
17. Adjust fan belts to proper alignment and tension.
18. 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.

19. Inspect and record performance of interlocks and protective devices; verify sequences.
20. Operate unit for an initial period as recommended or required by manufacturer.

21. Calibrate thermostats.
22. Adjust and inspect high-temperature limits.
23. Inspect outdoor-air dampers for proper stroke and interlock with return-air dampers.
24. 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.

25. Inspect controls for correct sequencing of heating, mixing dampers, refrigeration, and normal and emergency shutdown.
26. 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.

27. 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.

28. 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.

29. After startup and performance testing and prior to Substantial Completion, replace existing filters with new filters.

3.7 CLEANING AND ADJUSTING

A. After completing system installation and testing, adjusting, and balancing units and air-distribution systems, clean units internally to remove foreign material and construction dirt and dust. Clean fan wheels, cabinets, dampers, coils, and filter housings, and install new, clean filters.

3.8 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 units 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. Unit will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

3.9 DEMONSTRATION

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

END OF SECTION 237416

SECTION 237423 MAKEUP-AIR UNITS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes outdoor, indirect, gas-fired, heating-only, makeup air units, including the following components:

1. Casings.
2. Outdoor-air intake hood.
3. Roof curbs.
4. Fans, drives, and motors.
5. Air filtration.
6. Dampers.
7. Direct, gas-fired burners.
8. Indirect, gas-fired burners.
9. Unit control panel.
10. Controls.
11. Accessories.

1.2 ACTION SUBMITTALS

A. Product Data: For each outdoor, gas-fired, heating-only, makeup air unit.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes.
2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
3. Include unit dimensions and weight.
4. 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.

5. Include filters with performance characteristics.
6. Include direct, gas-fired burners with performance characteristics.
7. Include dampers, including housings, linkages, and operators.

B. Shop Drawings: For each outdoor gas-fired heating and ventilating 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. Detail fabrication and assembly of gas-fired heating and ventilating units, as well as procedures and diagrams.
4. Include diagrams for power, signal, and control wiring.

1.3 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. Startup service reports.

D. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: gas-fired, makeup air units to include in emergency, 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. Filters: One set(s) for each unit.
2. Gaskets: One set(s) for each access door.

1.6 WARRANTY

A. Warranty: Manufacturer agrees to repair or replace components of gas-fired heating and ventilating units that fail in materials or workmanship within specified warranty period.

1. Warranty Period for Entire Unit: Manufacturer's standard, but not less than 3 year(s) from date of Substantial Completion.

2. Warranty Period for Heat Exchangers: Not less than five 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 units 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/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 – "Heating, Ventilating, and Air-Conditioning."

2.2 MANUFACTURERS

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

1. CaptiveAire Systems.
2. Greenheck Fan Corporation.
3. Modine Manufacturing Company.

2.3 UNIT CASINGS

A. General Fabrication Requirements for Casings:

1. Forming: Form walls, roofs, and floors with at least two breaks at each joint.
2. Casing Joints: Sheet metal screws or pop rivets, factory sealed with water-resistant sealant.
3. Makeup Air Unit Mounting Frame: Formed galvanized-steel channel or structural channel supports, designed for low deflection, welded with integral lifting lugs.

B. Configuration: Horizontal unit with bottom discharge for roof-mounting installation.

C. Double-Wall Construction:

1. Outside Casing Wall: Galvanized steel, minimum 18 gauge thick, with manufacturer's standard finish.
2. Inside Casing Wall:

    a. Inside Casing, Burner Section: Galvanized steel, solid, minimum 14-gauge thick steel.
    b. Inside Casing, All Other Sections: Galvanized steel solid steel.

3. Floor Plate: Galvanized steel, minimum 18 gauge thick.
4. Casing Insulation:

    a. Materials: Glass-fiber blanket or board insulation, Type I or Type II ASTM C1071.
    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.

D. Airstream Surfaces: Surfaces in contact with airstream shall comply with requirements in ASHRAE 62.1.

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 airflow.
    c. Gasket: Neoprene, applied around entire perimeters of panel frames.
    d. Size: Large enough to allow unobstructed access for inspection and maintenance of unit's internal components.

2. Doors:

    a. Fabrication: Formed and reinforced with same materials and insulation thickness as casing.
    b. 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 airflow. Provide safety latch retainers on doors so that doors do not open uncontrollably.
    c. Gasket: Neoprene, applied around entire perimeters of panel frames.
    d. Size: Large enough to allow unobstructed access for inspection and maintenance of unit's internal components.

3. Locations and Applications:

    a. Fan Section: Doors and inspection and access panels.
    b. Access Section: Doors.
    c. Gas-Fired Burner Section: Doors.
    d. Damper Section: Doors.
    e. Filter Section: Doors large enough to allow periodic removal and installation of filters.
    f. Mixing Section: Doors.

2.4 OUTDOOR-AIR INTAKE HOOD

A. Type: Manufacturer's standard hood or louver.

B. Materials: Match cabinet.

C. Bird Screen: Comply with requirements in ASHRAE 62.1.

D. Filter: Aluminum, 1 inch cleanable.

E. Configuration: Designed to inhibit wind-driven rain and snow from entering unit.

2.5 ROOF CURBS

A. Materials: Galvanized steel with corrosion-protection coating, watertight gaskets, and factory-installed wood nailer; complying with NRCA standards.

1. Curb Insulation and Adhesive: Comply with NFPA 90A or NFPA 90B.

    a. Materials: ASTM C 1071, Type I or Type II.
    b. Thickness: 2 inches.

2. Application: Factory applied with adhesive and mechanical fasteners to the internal surface of curb.

    a. Liner Adhesive: Comply with ASTM C 916, Type I.
    b. Mechanical Fasteners: Galvanized steel, suitable for adhesive attachment, mechanical attachment, or welding attachment to duct without damaging liner when applied as recommended by manufacturer and without causing leakage in cabinet.
    c. Liner materials applied in this location shall have air-stream surface coated with a temperature-resistant coating or faced with a plain or coated fibrous mat or fabric depending on service air velocity.
    d. Liner Adhesive: Comply with ASTM C 916, Type I.

B. Curb Height: 24 inches.

2.6 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. Fans: Centrifugal, rated according to AMCA 210; galvanized steel; mounted on solid-steel shaft.

1. Shafts: With field-adjustable alignment.
2. Shaft Bearings: Heavy-duty, self-aligning, permanently lubricated ball bearings or, pillow-block bearings and extended lubrication lines with an L50 rated life of 100,000 hours according to ABMA 9.
3. Housings: Formed- and reinforced-steel panels to form curved scroll housings with shaped cutoff and spun-metal inlet bell.
4. Mounting: For internal vibration isolation. Factory-mount fans with manufacturer's standard vibration isolation mounting devices having a minimum static deflection of 1 inch.
5. Shaft Lubrication Lines: Extended to a location outside the casing.
6. Flexible Connector: Factory fabricated with a fabric strip minimum 3-1/2 inches wide, attached to two strips of minimum 2-3/4-inch-wide by 0.028-inch-thick, galvanized-steel sheet.

    a. Flexible Connector Fabric: Glass fabric, double coated with neoprene. Fabrics, coatings, and adhesives shall comply with UL 181, Class 1.

2.7 AIR FILTRATION

A. Panel Filters:

1. Description: 2 inch MERV 13 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.

B. Side-Access Filter Mounting Frames:

1. Particulate Air Filter Frames: Match inner casing and outer casing material, and insulation thickness. Galvanized steel track.

a. Sealing: Incorporate positive-sealing device to ensure seal between gasketed material on channels to seal top and bottom of filter cartridge frames to prevent bypass of unfiltered air.

2.8 DAMPERS

A. Outdoor 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.

2.9 DIRECT-FIRED GAS BURNER

A. Description: Factory assembled, piped, and wired; and complying with ANSI Z21.47 and with NFPA 54.

B. CSA Approval: Designed and certified by and bearing label of CSA.

C. Burners: Stainless steel.

1. Rated Minimum Turndown Ratio: 30 to 1.
2. Fuel: Natural gas.
3. Ignition: Electronically controlled electric spark with flame sensor.
4. Gas Control Valve: Modulating.
5. Gas Train: Regulated, redundant, 24-V ac gas valve assembly containing pilot solenoid valve, electronic-modulating temperature control valve, pilot filter, pressure regulator, pilot shutoff, and manual shutoff all in one body.

D. Safety Controls:

1. Gas Manifold: Safety switches and controls complying with ANSI standards.
2. Vent Flow Verification: Differential pressure switch to verify open vent.
3. High Limit: Thermal switch or fuse to stop burner.
4. Purge-period timer shall automatically delay burner ignition and bypass low-limit control.
5. Airflow Proving Switch: Differential pressure switch senses correct airflow before energizing pilot.
6. Automatic-Reset, High-Limit Control Device: Stops burner and closes main gas valve if high-limit temperature is exceeded.
7. Safety Lockout Switch: Locks out ignition sequence if burner fails to light after three tries. Controls are reset manually by turning the unit off and on.

8. Control Transformer: 24 V ac.

2.10 INDIRECT-FIRED GAS BURNER

A. Description: Factory assembled, piped, and wired; and complying with ANSI Z21.47 and with NFPA 54.

B. CSA Approval: Designed and certified by and bearing label of CSA.

C. Burners: Stainless steel.

1. Rated Minimum Turndown Ratio: 30 to 1.
2. Fuel: Natural gas.
3. Ignition: Electronically controlled electric spark with flame sensor.
4. Gas Control Valve: Modulating.
5. Gas Train: Regulated, redundant, 24-V ac gas valve assembly containing pilot solenoid valve, hydraulic-modulating temperature control valve, pilot filter, pressure regulator, pilot shutoff, and manual shutoff all in one body.

D. Venting, Gravity: Gravity vented.

E. Heat Exchanger: Stainless steel.

F. Heat-Exchanger Drain Pan: Stainless steel.

G. Safety Controls:

1. Gas Manifold: Safety switches and controls complying with ANSI standards.
2. Vent Flow Verification: Differential pressure switch to verify open vent.
3. High Limit: Thermal switch or fuse to stop burner.
4. Purge-period timer shall automatically delay burner ignition and bypass low-limit control.

2.11 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. Coil guards of painted, galvanized-steel wire.

C. Hail guards of galvanized steel, painted to match casing.

2.12 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.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine 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 piping, ducts, and electrical systems to verify actual locations of connections before equipment installation.

C. Verify cleanliness of airflow path to include inner-casing surfaces, filters, coils, turning vanes, fan wheels, and other components.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Unit Support: Install unit level on structural curbs. Coordinate roof penetrations and flashing with roof construction. Secure units to structural support with anchor bolts. Coordinate sizes and locations of curbs with actual equipment provided.

3.3 PIPING CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Connect gas piping with shutoff valve and union, and with sufficient clearance for burner removal and service. Make final connections of gas piping to unit with

corrugated, stainless-steel tubing flexible connectors complying with ANSI LC 1/CSA 6.26 equipment connections.

C. Where installing piping adjacent to indirect-fired makeup air unit, allow space for service and maintenance.

3.4 DUCTWORK CONNECTIONS

A. Duct Connections: Connect supply ducts to indirect-fired makeup air units with flexible duct connectors. Comply with requirements in other HVAC Sections.

3.5 STARTUP SERVICE

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

B. Complete installation and startup checks according to manufacturer's written instructions and perform the following:

1. Inspect for visible damage to burner combustion chamber.
2. Inspect casing insulation for integrity, moisture content, and adhesion.
3. Verify that clearances have been provided for servicing.
4. Verify that controls are connected and operable.
5. Verify that filters are installed.
6. Purge gas line.
7. Inspect and adjust vibration isolators.
8. Verify bearing lubrication.
9. Inspect fan-wheel rotation for movement in correct direction without vibration and binding.
10. Adjust fan belts to proper alignment and tension.

C. Start unit according to manufacturer's written instructions.

1. Complete startup sheets and attach copy with Contractor's startup report.
2. Inspect and record performance of interlocks and protective devices; verify sequences.
3. Operate unit for run-in period recommended by manufacturer.
4. Perform the following operations for both minimum and maximum firing, and adjust burner for peak efficiency:

    a. Measure gas pressure at manifold.
    b. Measure combustion-air temperature at inlet to combustion chamber.
    c. Measure supply-air temperature and volume when burner is at maximum firing rate and when burner is off. Calculate useful heat to supply air.

5. Calibrate thermostats.
6. Adjust and inspect high-temperature limits.
7. Inspect dampers, if any, for proper stroke and interlock with return-air dampers.
8. Inspect controls for correct sequencing of heating, mixing dampers, refrigeration, and normal and emergency shutdown.
9. Measure and record airflow. Plot fan volumes on fan curve.
10. Verify operation of remote panel, including pilot-operation and failure modes. Inspect the following:

    a. High-limit heat.
    b. Alarms.

11. After startup and performance testing, change filters, verify bearing lubrication, and adjust belt tension.
12. Verify drain-pan performance.
13. Verify outdoor-air damper operation.

3.6 CLEANING AND ADJUSTING

A. After completing system installation and testing, adjusting, and balancing makeup air unit and air-distribution systems and after completing startup service, clean air-handling units 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. Units will be considered defective if they do not pass tests and inspections.

C. 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 heating and ventilating units.

END OF SECTION 237423

SECTION 238132 - SPLIT-SYSTEM AIR-CONDITIONERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes ductless split-system air-conditioning units consisting of separate evaporator-fan and compressor-condenser components.

1.2 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.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

B. Warranty: Sample of special warranty.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For split-system air-conditioning units to include in emergency, operation, and maintenance manuals.

1.5 QUALITY ASSURANCE

A. The units shall be tested by a Nationally Recognized Testing Laboratory (NRTL) and shall bear the ETL label.

B. All wiring shall be in accordance with the National Electrical Code (NEC).

C. The units shall be rated in accordance with Air-conditioning Refrigeration Institute's (AHRI) Standard 210 and bear the ARI Certification label.

D. A dry air holding charge shall be provided in the indoor section.

E. The outdoor unit shall be pre-charged with R-410a or R32 refrigerant for 70 feet of refrigerant tubing.

F. System efficiency shall meet or exceed 13.0 SEER.

1.6 COORDINATION

A. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.

1.7 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 years from date of Substantial Completion.
   b. For Parts: One year from date of Substantial Completion.
   c. For Labor: One year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Trane.
2. Mitsubishi.
3. Daikin
4. Samsung
5. Carrier.

2.2 INDOOR UNIT

A. Unit Cabinet:

1. Enameled steel with removable panels on front and ends in color selected by Architect, and discharge drain pans with drain connection.

B. Fan: Direct drive, centrifugal.

C. Filter: Washable type.

D. Coil: Copper tube, with mechanically bonded aluminum fins and thermal-expansion valve. Comply with ARI 206/110.

E. 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. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.
d. Mount unit-mounted disconnect switches on interior of the unit.

F. Variable-Frequency Controllers

1. 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.

2. Isolated control interface to allow controller to follow control signal over an 11:1 speed range.
3. Internal Adjustability Capabilities:

a. Minimum Speed: 5 to 25 percent of maximum rpm.
b. Maximum Speed: 80 to 100 percent of maximum rpm.
c. Acceleration: 2 seconds to a minimum of 22 seconds.
d. Deceleration: 2 seconds to a minimum of 22 seconds.
e. Current Limit: 50 percent to a minimum of 110 percent of maximum rating.

4. 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.
5. Power-Interruption Protection: Prevents motor from re-energizing after a power interruption until motor has stopped.
6. 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.
7. 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.
8. Door-mounted, digital status lights shall indicate the following conditions:

a. Power on.
b. Run.
c. Overvoltage.
d. Line fault.

e. Overcurrent.
f. External fault.

9. Panel-Mounted Operator Station: Start-stop and auto-manual selector switches with manual-speed-control potentiometer and elapsed-time meter.
10. Meters or digital readout devices and selector switch, mounted flush in controller door and connected, to indicate the following controller parameters:

a. Output frequency (Hertz).
b. Motor speed (rpm).
c. Motor status (running, stop, fault).
d. Motor current (amperes).
e. Motor torque (percent).
f. Fault or alarming status (code).
g. Proportional-integral-derivative feedback signal (percent).
h. DC-link voltage (volts dc).
i. Set-point frequency (Hertz).
j. Motor output voltage (volts).

11. Control Signal Interface:

a. Electric Input Signal Interface: A minimum of two analog inputs (0 to 10 V or 0/4-20 mA) and six programmable digital inputs.
b. Remote signal inputs capable of accepting any of the following speed-setting input signals from the control system:

1) 0 to 10-V dc.
2) 0-20 or 4-20 mA.
3) Potentiometer using up/down digital inputs.
4) Fixed frequencies using digital inputs.
5) RS485.
6) Keypad display for local hand operation.

c. Output signal interface with a minimum of one analog output signal (0/4-20 mA), which can be programmed to any of the following:

1) Output frequency (Hertz).
2) Output current (load).
3) DC-link voltage (volts dc).
4) Motor torque (percent).
5) Motor speed (rpm).
6) Set-point frequency (Hertz).

d. Remote indication interface with a minimum of two dry circuit relay outputs (120-V ac, 1 A) for remote indication of the following:

1) Motor running.
2) Set-point speed reached.
3) Fault and warning indication (overtemperature or overcurrent).
4) High- or low-speed limits reached.

12. 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.
13. 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 LOW AMBIENT 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-410A or R32.

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: Power connection from indoor unit.

B. Refrigerant Line Kits: Soft-annealed copper suction and liquid lines factory cleaned, dried, pressurized, and sealed; factory-insulated suction line with flared fittings at both ends.

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 ground-mounted, compressor-condenser components on polyethylene mounting base.

D. Install roof-mounted, compressor-condenser components on equipment supports. Anchor units to supports with removable, cadmium-plated fasteners.

E. Install and connect precharged refrigerant tubing to component's quick-connect fittings. Install tubing to allow access to unit.

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

SECTION 238129 - VARIABLE-REFRIGERANT-FLOW HVAC SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes complete VRF HVAC system(s) including, but not limited to the following components to make a complete operating system(s) according to requirements indicated:
   1. Indoor, exposed, wall-mounted units.
   2. Indoor, recessed, ceiling-mounted units.
   3. Indoor, vertical/horizontal ducted (multi-position air handler) units.
   4. Outdoor, air-source, heat-pump units.
   5. System controls.
   6. System refrigerant and oil.
   7. System condensate drain piping.

1.3 DEFINITIONS

A. Air-Conditioning System Operation: System capable of operation with all zones in cooling only.

B. Heat-Pump System Operation: System capable of operation with all zones in either heating or cooling, but not with simultaneous heating and cooling zones that transfer heat between zones.

C. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling power-limited circuits.

D. Plenum: A space forming part of the air distribution system to which one or more air ducts are connected. An air duct is a passageway, other than a plenum, for transporting air to or from heating, ventilating, or air-conditioning equipment.

E. Two-Pipe System Design: One refrigerant vapor line and one refrigerant liquid line connect a single outdoor unit or multiple manifold outdoor units in a single system to associated indoor units.

F. VRF: Variable refrigerant flow.

1.4 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 indoor and outdoor units.
2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
3. Include operating performance at design conditions and at extreme maximum and minimum outdoor ambient conditions.
4. Include description of system controllers, dimensions, features, control interfaces and connections, power requirements, and connections.
5. Include system operating sequence of operation in narrative form for each unique indoor- and outdoor-unit control.
6. Include description of control software features.
7. Include total refrigerant required and a comprehensive breakdown of refrigerant required by each system installed.
8. Include refrigerant type and data sheets showing compliance with requirements indicated.
9. For system design software.
10. Indicate location and type of service access.

B. Shop Drawings: For VRF HVAC systems.

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. 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.
4. Include diagrams and details of refrigerant piping and tubing showing installation requirements for manufacturer-furnished divided flow fittings.
5. Include diagrams for power, signal, and control wiring.

C. Samples for Initial Selection: For fully and partially exposed indoor units with factory finishes viewable by occupants.

1. Include a Sample for each unique finish with unit identification, detailed description of application, and cross-referenced floor plans showing locations.

D. Delegated-Design Submittals:
1. Include design calculations with corresponding diagram of refrigerant piping and tubing sizing for each system installed.
2. Include design calculations with corresponding floor plans indicating that refrigerant concentration limits are within allowable limits of ASHRAE 15 and governing codes.
3. Include calculations showing that system travel distance for refrigerant piping and controls cabling are within horizontal and vertical travel distances set by manufacturer. Provide a comparison table for each system installed.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plans, elevations, sections, and details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

B. ections, and 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 floors, roofs and associated members to which equipment, piping, cables, and conduit will be attached.
3. Size and location of initial access modules for acoustical tile.
4. Wall-mounted controllers located in finished space showing relationship to light switches, fire-alarm devices, and other installed devices.
5. Size and location of access doors and panels installed behind walls and inaccessible ceilings for products installed behind walls and requiring access.
6. Items penetrating finished ceiling including the following:

a. Luminaires.
b. Air outlets and inlets.
c. Speakers.
d. Sprinklers.
e. Service access panels.

C. Qualification Data:

1. For Installer: Certificate from VRF HVAC system manufacturer certifying that Installer has successfully completed prerequisite training administered by manufacturer for proper installation of systems, including but not limited to,

equipment, piping, controls, and accessories indicated and furnished for installation.

a. Retain copies of Installer certificates on-site and make available on request.

2. For VRF HVAC system manufacturer.
3. For VRF HVAC system provider.

D. Product Certificates: For each type of product.

The installing contractor shall have been certified by the manufacturer to install VRF systems, having attended and successfully completed a minimum 3- day VRF Service & Installation course at an approved training facility. A copy of this certificate shall be presented to the VRF manufacturer prior to the commencement of installation activity.

E. Product Test Reports: Where tests are required, for each product, for tests performed by manufacturer and witnessed by a qualified testing agency.

F. Source quality-control reports.

G. Field quality-control reports.

H. Sample Warranties: For manufacturer's warranties.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For VRF HVAC systems to include in emergency, operation, and maintenance manuals.

B. Software and Firmware Operational Documentation:

1. Software operating and upgrade manuals.
2. Program Software Backup: On CD or DVD, USB media, or approved cloud storage platform, complete with data files.
3. Device address list.
4. Printout of software application and graphic screens.

1.7 MAINTENANCE MATERIAL SUBMITTALS

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

1. Filters:
    a. One 1 set(s) for each unit with replaceable filters.

1.8 QUALITY ASSURANCE

A. Manufacturer Qualifications:

1. Nationally recognized manufacturer of VRF HVAC systems and products.
2. Shipped VRF HVAC systems with similar requirements to those indicated for a continuous period of five 5 years within time of bid.
3. VRF HVAC systems and products that have been successfully tested and in use on at least three 3 completed projects.
4. Having complete published catalog literature, installation, and operation and maintenance manuals for all products intended for use.
5. Having full-time in-house employees for the following:

    a. Product research and development.
    b. Product and application engineering.
    c. Product manufacturing, testing, and quality control.
    d. Technical support for system installation training, startup, commissioning, and troubleshooting of installations.
    e. Owner training.

B. Factory-Authorized Service Representative Qualifications:

1. Authorized representative of, and trained by, VRF HVAC system manufacturer.
2. In-place facility located within 60miles of Project.
3. Demonstrated past experience with products being installed for period within three 3 consecutive years before time of bid.
4. Demonstrated past experience on five 5 projects of similar complexity, scope, and value.

    a. Each person assigned to Project shall have demonstrated past experience.

5. Staffing resources of competent and experienced full-time employees that are assigned to execute work according to schedule.
6. Service and maintenance staff assigned to support Project during warranty period.
7. Product parts inventory to support ongoing system operation for a period of not less than five 5 years after Substantial Completion.
8. VRF HVAC system manufacturer's backing to take over execution of Work if necessary to comply with requirements indicated. Include Project-specific written letter, signed by manufacturer's corporate officer, if requested.

C. Installer Qualifications: An entity that employs installers and supervisors who are trained and approved by VRF HVAC system manufacturer.

1. Each employee shall be certified by manufacturer for proper installation of systems, including, but not limited to, equipment, piping, controls, and accessories indicated and furnished for installation.
2. Installer certification shall be valid and current for duration of Project.
3. Retain copies of Installer certificates on-site and make available on request.
4. Each person assigned to Project shall have demonstrated past experience.

a. Demonstrated past experience with products being installed for period within five 5 consecutive years before time of bid.
b. Demonstrated past experience on five 5 projects of similar complexity, scope, and value.

D. ISO Compliance: System equipment and components furnished by VRF HVAC system manufacturer shall be manufactured in an ISO 9001 and ISO 14001 facility.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Deliver and store products in a clean and dry place.

B. Comply with manufacturer's written rigging and installation instructions for unloading and moving to final installed location.

C. Handle products carefully to prevent damage, breaking, denting, and scoring. Do not install damaged products.

D. Protect products from weather, dirt, dust, water, construction debris, and physical damage.

1. Retain factory-applied coverings on equipment to protect finishes during construction and remove just prior to operating unit.
2. Cover unit openings before installation to prevent dirt and dust from entering inside of units. If required to remover coverings during unit installation, reapply coverings over openings after unit installation and remove just prior to operating unit.

E. Replace installed products damaged during construction.

1.10 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to repair or replace equipment and components that fail(s) in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:

a. Structural failures.
b. Faulty operation.
c. Deterioration of metals, metal finishes, and other materials beyond normal weathering and use.

2. Warranty Period:

a. For Compressor: Seven 7 year(s) from date of Substantial Completion.
b. For Parts, Including Controls: Five 5 year(s) from date of Substantial Completion.
c. For Labor: No labor coverage provided by VRF manufacturer.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Daikin AC (Americas), Inc.
2. LG Electronics.
3. Samsung HVAC.
4. Trane Company
5. Mitsubishi Electric US, Inc.
6. Hisense
7. Hitachi

B. Source Limitations: Obtain products from single source from single manufacturer including, but not limited to, the following:

1. Indoor and outdoor units, including accessories.
2. Controls and software.
3. Refrigerant isolation valves.
4. Specialty refrigerant pipe fittings.

2.2 SYSTEM DESCRIPTION

A. Direct-expansion (DX) VRF HVAC system(s) with variable capacity in response to varying cooling and heating loads. System shall consist of multiple indoor units, outdoor unit(s), piping, controls, and electrical power to make complete operating system(s) complying with requirements indicated.

1. Two-pipe system design.
2. System(s) operation, air-conditioning heat pump as indicated on Drawings.
3. Each system with one refrigerant circuit shared by all indoor units connected to system.

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. AHRI Compliance: System and equipment performance certified according to AHRI 1230.

D. ASHRAE Compliance:

1. ASHRAE 15: For safety code for mechanical refrigeration.
2. ASHRAE 62.1: For indoor air quality.
3. ASHRAE 135: For control network protocol with remote communication.
4. ASHRAE/IES 90.1 Compliance: For system and component energy efficiency.

E. UL Compliance: Comply with UL 1995.

2.3 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer, to design complete and operational VRF HVAC system(s) complying with requirements indicated.

1. Provide system refrigerant calculations.

a. Refrigerant concentration limits shall be within allowable limits of ASHRAE 15 and governing codes.
b. Indicate compliance with manufacturer's maximum vertical and horizontal travel distances. Prepare a comparison table for each system showing calculated distances compared to manufacturer's maximum allowed distances.

2. Include a mechanical ventilation system and gas detection system as required to comply with ASHRAE 15 and governing codes.

3. System Refrigerant Piping and Tubing:

    a. Arrangement: Arrange piping to interconnect indoor units, HRCUs, and outdoor unit(s) in compliance with manufacturer requirements and requirements indicated.
    b. Routing: Conceal piping above ceilings and behind walls to maximum extent possible.
    c. Sizing: Size piping system, using a software program acceptable to manufacturer, to provide performance requirements indicated. Consider requirements to accommodate future change requirements.

4. System Controls:

    a. Network arrangement.
    b. Network interface with other building systems.
    c. Product selection.
    d. Sizing.

B. Service Access:

1. Provide and document service access requirements.
2. Locate equipment, system isolation valves, and other system components that require service and inspection in easily accessible locations. Avoid locations that are difficult to access if possible.
3. Where serviceable components are installed behind walls and above inaccessible ceilings, provide finished assembly with access doors or panels to gain access. Properly size the openings to allow for service, removal, and replacement.
4. If less than full and unrestricted access is provided, locate components within an 18-inch (450-mm) reach of the finished assembly.
5. Where ladder access is required to service elevated components, provide an installation that provides for sufficient access within ladder manufacturer's written instructions for use.
6. Comply with OSHA regulations.

C. System Design and Installation Requirements:

1. Design and install systems indicated according to manufacturer's recommendations and written instructions.
2. Where manufacturer's requirements differ from requirements indicated, contact Architect for direction. The most stringent requirements should apply unless otherwise directed in writing by Architect.

D. System Adaptability to Future Changes: Arrange and size system refrigerant piping to accommodate future changes to system without having to resize and replace existing refrigerant piping.

1. Future changes to system(s) indicated on Drawings.
2. Each branch circuit shall accommodate addition of three 3indoor unit(s) with unit capacity equal to 54,000 BTUH indoor unit connected to the branch circuit.

E. Isolation of Equipment: Provide isolation valves to isolate each, indoor unit and outdoor unit for service, removal, and replacement without interrupting system operation.

F. System Capacity Ratio: The sum of connected capacity of all indoor units shall be within the following range of outdoor-unit rated capacity:

1. Not less than 60 percent.
2. Not more than 130 percent.
3. Range acceptable to manufacturer.

G. System Turndown: Stable operation down to 20 percent of outdoor-unit capacity.

H. System Auto Refrigerant Charge: Each system shall have an automatic refrigerant charge function to ensure the proper amount of refrigerant is installed in system.

I. Outdoor Conditions:

1. Suitable for outdoor ambient conditions encountered.

a. Design equipment and supports to withstand wind loads of governing code.
b. Design equipment and supports to withstand snow and ice loads of governing code.
c. Provide corrosion-resistant coating for components and supports where located in coastal or industrial climates that are known to be harmful to materials and finishes.

2. Maximum System Operating Outdoor Temperature: 126 deg. F.
3. Minimum System Operating Outdoor Temperature: -25 deg. F.

J. Sound Performance: Sound levels generated by operating HVAC equipment shall be within requirements indicated.

1. Indoor: Within design guidelines of "2015 ASHRAE HANDBOOK- HVAC Applications."
2. Outdoor: Within ordinance of governing authorities.

K. Thermal Movements: Allow for controlled thermal movements from ambient, surface, and system temperature changes.

L. Capacities and Characteristics: As indicated on Drawings.

2.4 INDOOR, EXPOSED, WALL-MOUNTED UNITS

A. Description: Factory-assembled and -tested complete unit with components, piping, wiring, and controls required for mating to piping, power, and controls field connections.

B. Cabinet:

1. Material: Painted steel, or coated steel frame covered by a plastic cabinet, with an architectural acceptable finish suitable for tenant occupancy on exposed surfaces.
2. Insulation: Manufacturer's standard internal insulation to provide thermal resistance and prevent condensation.
3. Mounting: Manufacturer-designed provisions for field installation.
4. Internal Access: Removable panels of adequate size for field access to internal components for inspection, cleaning, service, and replacement.

C. DX Coil Assembly:

1. Coil Casing: Aluminum, galvanized, or stainless steel.
2. Coil Fins: Aluminum, mechanically bonded to tubes, with arrangement required by performance.
3. Coil Tubes: Copper, of diameter and thickness required by performance.
4. Expansion Valve: Electronic modulating type with linear or proportional characteristics.
5. Unit Internal Tubing: Copper tubing with brazed joints.
6. Unit Internal Tubing Insulation: Manufacturer's standard insulation, of thickness to prevent condensation.
7. Field Piping Connections: Manufacturer's standard.
8. Factory Charge: Dehydrated air or nitrogen.
9. Testing: Factory pressure tested and verified to be without leaks.

D. Drain Assembly:

1. Pan: Non-ferrous material, with bottom sloped to low point drain connection.
2. Condensate Removal: Gravity.

a. If a floor drain is not available at unit, provide unit with field-installed condensate pump accessory.

3. Field Piping Connection: Non-ferrous material.

E. Fan and Motor Assembly:

1. Fan(s):

a. Direct-drive arrangement.
b. Single or multiple fans connected to a common motor shaft and driven by a single motor.
c. Fabricated from non-ferrous components or ferrous components with corrosion protection finish.
d. Wheels statically and dynamically balanced.

2. Motor: Brushless dc or electronically commutated with permanently lubricated bearings.
3. Motor Protection: Integral protection against thermal, overload, and voltage fluctuations.
4. Speed Settings and Control: Two (low, high), three (low, medium, high), or more than three speed settings or variable speed with a speed range of least 50 percent.
5. Vibration Control: Integral isolation to dampen vibration transmission.

F. Filter Assembly:

1. Access: Front, to accommodate filter replacement without the need for tools.
2. Efficiency: minimum MERV 3 or based on manufacturers recommendation
3. Washable Media: Manufacturer's standard filter with antimicrobial treatment.

G. Grille Assembly: Manufacturer's standard discharge grille with field-adjustable air pattern mounted in top or front face of unit cabinet.

H. Unit Accessories:

1. Remote Room Temperature Sensor Kit: Wall-mounted, hardwired room temperature sensor kit for use in rooms that do not have room temperature measurement.
2. Condensate Pump: Integral reservoir and control with electrical power connection through unit power.

I. Unit Controls:

1. Enclosure: Manufacturer's standard, and suitable for indoor locations.
2. Factory-Installed Controller: Configurable digital control.

3. Factory-Installed Sensors: Unit inlet air temperature Coil entering refrigerant temperature Coil leaving refrigerant temperature.
4. Field-Customizable I/O Capability:
   a. Digital Inputs: four 4 for use in customizable control strategies.
   b. Digital Outputs: Three 3 for use in customizable control strategies.

5. Features and Functions: Self-diagnostics, time delay, auto-restart, auto operation mode, manual operation mode, filter service notification, power consumption display, drain assembly high water level safety shutdown and notification, run test switch.
6. Communication: Network communication with other indoor units and outdoor unit(s).
7. Cable and Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
8. Field Connection: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.

J. Unit Electrical:

1. Enclosure: Manufacturer's standard, and suitable for indoor locations.
2. Field Connection: Single point connection to power entire unit and integral controls.
3. Control Transformer: Manufacturer's standard. Coordinate requirements with field power supply.
4. Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
5. Raceways: Enclose line voltage wiring in raceways to comply with NFPA 70.

2.5 INDOOR, RECESSED, CEILING-MOUNTED UNITS

A. Description: Factory-assembled and -tested complete unit with components, piping, wiring, and controls required for mating to ductwork, piping, power, and controls field connections.

B. Cabinet:

1. Material: Painted steel, or coated steel frame covered by a plastic cabinet, with an architectural acceptable finish suitable for tenant occupancy on exposed surfaces.
2. Insulation: Manufacturer's standard internal insulation to provide thermal resistance and prevent condensation.
3. Mounting: Manufacturer-designed provisions for field installation.
4. Internal Access: Removable panels of adequate size for field access to internal components for inspection, cleaning, service, and replacement.

C. DX Coil Assembly:

1. Coil Casing: Aluminum, galvanized, or stainless steel.
2. Coil Fins: Aluminum, mechanically bonded to tubes, with arrangement required by performance.
3. Coil Tubes: Copper, of diameter and thickness required by performance.
4. Expansion Valve: Electronic modulating type with linear or proportional characteristics.
5. Internal Tubing: Copper tubing with brazed joints.
6. Internal Tubing Insulation: Manufacturer's standard insulation, of thickness to prevent condensation.
7. Field Piping Connections: Manufacturer's standard.
8. Factory Charge: Dehydrated air or nitrogen.
9. Testing: Factory pressure tested and verified to be without leaks.

D. Drain Assembly:

1. Pan: Non-ferrous material, with bottom sloped to low point drain connection.
2. Condensate Removal: Unit-mounted pump or other integral lifting mechanism, capable of lifting drain water to an elevation above top of cabinet.
3. Field Piping Connection: Non-ferrous material.

E. Fan and Motor Assembly:

1. Fan(s):

    a. Direct-drive arrangement.
    b. Single or multiple fans connected to a common motor shaft and driven by a single motor.
    c. Fabricated from non-ferrous components or ferrous components with corrosion protection finish.
    d. Wheels statically and dynamically balanced.

2. Motor: Brushless dc or electronically commutated with permanently lubricated bearings.
3. Motor Protection: Integral protection against thermal, overload, and voltage fluctuations.
4. Speed Settings and Control: Two (low, high), three (low, medium, high), or more than three speed settings or variable speed with a speed range of least 50 percent.
5. Vibration Control: Integral isolation to dampen vibration transmission.

F. Filter Assembly:

1. Access: Bottom, to accommodate filter replacement without the need for tools.
2. Efficiency: ASHRAE 52.2, MERV 11.
3. Media:

    a. Replaceable: Extended surface, panel, or cartridge with antimicrobial treatment fiber media.
    b. Washable: Manufacturer's standard filter with antimicrobial treatment.

G. Discharge-Air Grille Assembly: Mounted in bottom of unit cabinet.

1. Discharge Pattern: One-, two-, three-, or four-way throw as indicated on Drawings.

    a. Discharge Pattern Adjustment: Field-adjustable limits for up and down range of motion.
    b. Discharge Pattern Closure: Ability to close individual discharges of units with multiple patterns.

2. Motorized Vanes: Modulating up and down flow pattern for uniform room air distribution.
3. Additional Branch Supply Duct Connection: Sheet metal knockout for optional connection to one additional supply branch duct.

H. Return-Air Grille Assembly: Manufacturer's standard grille mounted in bottom of unit cabinet.

I. Outdoor Air Ventilation Connection: Sheet metal knockout for optional connection to outdoor air ventilation duct.

J. Unit Accessories:

1. Outdoor Air Ventilation Kit: Connection, motorized damper, and control to satisfy unit control sequence of operation indicated on Drawings.
2. Remote Room Temperature Sensor Kit: Wall-mounted, hardwired room temperature sensor kit for use in rooms that do not have room temperature measurement.

K. Unit Controls:

1. Enclosure: Manufacturer's standard, and suitable for indoor locations.
2. Factory-Installed Controller: Configurable digital control.
3. Factory-Installed Sensors: Unit inlet air temperature Coil entering refrigerant temperature Coil leaving refrigerant temperature.
4. Field-Customizable I/O Capability:

a. Digital Inputs: four 4 for use in customizable control strategies.
b. Digital Outputs: Three 3 for use in customizable control strategies.

5. Features and Functions: Self-diagnostics, time delay, auto-restart, auto operation mode, manual operation mode, filter service notification, power consumption display, drain assembly high water level safety shutdown and notification, run test switch.
6. Communication: Network communication with other indoor units and outdoor unit(s).
7. Cable and Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
8. Field Connection: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.

L. Unit Electrical:

1. Enclosure: Manufacturer's standard, and suitable for indoor locations.
2. Field Connection: Single point connection to power entire unit and integral controls.
3. Control Transformer: Manufacturer's standard. Coordinate requirements with field power supply.
4. Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
5. Raceways: Enclose line voltage wiring in raceways to comply with NFPA 70.

2.6 INDOOR, VERTICAL/HORIZONTAL DUCTED (MULTI-POSITION AIR HANDLER) UNITS

A. Description: Factory-assembled and -tested complete unit with components, piping, wiring, and controls required for mating to piping, power, and controls field connections.

B. Cabinet:
1. The cabinet shall include a fixed bottom return, a fixed vertical discharge supply and be pre-painted, pre-insulated, 22 gauge galvanized steel.

C. DX Coil Assembly:

1. Coil Casing: Aluminum, galvanized, or stainless steel.
2. Coil Fins: Aluminum, mechanically bonded to tubes, with arrangement required by performance.
3. Coil Tubes: Copper, of diameter and thickness required by performance.
4. Expansion Valve: Electronic modulating type with linear or proportional characteristics.

5. Unit Internal Tubing: Copper tubing with brazed joints.
6. Unit Internal Tubing Insulation: Manufacturer's standard insulation, of thickness to prevent condensation.
7. Field Piping Connections: Manufacturer's standard.
8. Factory Charge: Dehydrated air or nitrogen.
9. Testing: Factory pressure tested and verified to be without leaks.

D. Drain Assembly:

1. Pan: Non-ferrous material, with bottom sloped to low point drain connection.
2. Condensate Removal: Gravity.

3. Field Piping Connection: Non-ferrous material.

E. Fan and Motor Assembly:

1. Fan(s):

a. Direct-drive arrangement.
b. Single or multiple fans connected to a common motor shaft and driven by a single motor.
c. Fabricated from non-ferrous components or ferrous components with corrosion protection finish.
d. Wheels statically and dynamically balanced.

2. Motor: Brushless dc or electronically commutated with permanently lubricated bearings.
3. Motor Protection: Integral protection against thermal, overload, and voltage fluctuations.
4. Speed Settings and Control: Two (low, high), three (low, medium, high), or more than three speed settings or variable speed with a speed range of least 50 percent.
5. Vibration Control: Integral isolation to dampen vibration transmission.

F. Filter Assembly:

1. Access: Front, to accommodate filter replacement without the need for tools.
2. Efficiency: minimum MERV 8 or based on manufacturers recommendation
3. Washable Media: Manufacturer's standard filter with antimicrobial treatment.

G. Unit Accessories:

1. Remote Room Temperature Sensor Kit: Wall-mounted, hardwired room temperature sensor kit for use in rooms that do not have room temperature measurement.

H. Unit Controls:

1. Enclosure: Manufacturer's standard, and suitable for indoor locations.
2. Factory-Installed Controller: Configurable digital control.
3. Factory-Installed Sensors: Unit inlet air temperature Coil entering refrigerant temperature Coil leaving refrigerant temperature.
4. Field-Customizable I/O Capability:
   a. Digital Inputs: Four 4 for use in customizable control strategies.
   b. Digital Outputs: Three 3 for use in customizable control strategies.
5. Features and Functions: Self-diagnostics, time delay, auto-restart, auto operation mode, manual operation mode, filter service notification, power consumption display, drain assembly high water level safety shutdown and notification, run test switch.
6. Communication: Network communication with other indoor units and outdoor unit(s).
7. Cable and Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
8. Field Connection: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.

I. Unit Electrical:

1. Enclosure: Manufacturer's standard, and suitable for indoor locations.
2. Field Connection: Single point connection to power entire unit and integral controls.
3. Control Transformer: Manufacturer's standard. Coordinate requirements with field power supply.
4. Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
5. Raceways: Enclose line voltage wiring in raceways to comply with NFPA 70.

2.7 OUTDOOR, AIR-SOURCE HEAT PUMP UNITS

A. Description: Factory-assembled and -tested complete unit with components, piping, wiring, and controls required for mating to piping, power, and controls field connections.

1. Specially designed for use in systems with heating and cooling.

2. Systems shall consist of one unit, or multiple unit modules that are designed by variable refrigerant system manufacturer for field interconnection to make a single refrigeration circuit that connects multiple indoor units.
3. All units installed shall be from the same product development generation.

B. Cabinet:

1. Galvanized steel and coated with a corrosion-resistant finish.

    a. Coating with documented salt spray test performance of 1000 hours according ASTM B117 surface scratch test (SST) procedure.

2. Mounting: Manufacturer-designed and provided support rail provisions for field installation on roof rails.
3. Internal Access: Removable panels or hinged doors of adequate size for field access to internal components for inspection, cleaning, service, and replacement.

C. Compressor and Motor Assembly:

1. One or more positive-displacement, direct-drive and hermetically sealed scroll compressor(s) with inverter drive and turndown to 15 percent of rated capacity.
2. Protection: Integral protection against the following:

    a. High refrigerant pressure.
    b. Low oil level.
    c. High oil temperature.
    d. Thermal and overload.
    e. Voltage fluctuations.
    f. Phase failure and phase reversal.
    g. Short cycling.

3. Speed Control: Variable to automatically maintain refrigerant suction and condensing pressures while varying refrigerant flow to satisfy system cooling and heating loads.
4. Vibration Control: Integral isolation to dampen vibration transmission.
5. Oil management system to ensure safe and proper lubrication over entire operating range.
6. Crankcase heaters with integral control to maintain safe operating temperature.
7. Fusible plug.

D. Condenser Coil Assembly:

1. Plate Fin Coils:

a. Casing: Aluminum, galvanized, or stainless steel.
b. Fins: Aluminum or copper, mechanically bonded to tubes, with arrangement required by performance.
c. Tubes: Copper, of diameter and thickness required by performance.

2. Aluminum Microchannel Coils:

a. Series of flat tubes containing a series of multiple, parallel-flow microchannels layered between refrigerant header manifolds.
b. Single- or multiple-pass arrangement.
c. Construct fins, tubes, and header manifolds of aluminum alloy.

3. Coating: Corrosion resistant.
4. Hail Protection: Provide condenser coils with louvers, baffles, or hoods to protect against hail damage.

E. Condenser Fan and Motor Assembly:

1. Fan(s): Propeller type.

a. Direct-drive arrangement.
b. Fabricated from non-ferrous components or ferrous components with corrosion protection finish to match performance indicated for condenser coil.
c. Statically and dynamically balanced.

2. Fan Guards: Removable safety guards complying with OSHA regulations. If using metal materials, coat with corrosion-resistant coating to match performance indicated for condenser coil.
3. Motor(s): Brushless dc or electronically commutated with permanently lubricated bearings and rated for outdoor duty.
4. Motor Protection: Integral protection against thermal, overload, and voltage fluctuations.
5. Speed Settings and Control: Variable speed with a speed range of least 75 percent.
6. Vibration Control: Integral isolation to dampen vibration transmission.

F. Drain Pan: If required by manufacturer's design, provide unit with non-ferrous drain pan with bottom sloped to a low point drain connection.

G. Unit Controls:

1. Enclosure: Manufacturer's standard, and suitable for unprotected outdoor locations.

2. Factory-Installed Controller: Configurable digital control.
3. Factory-Installed Sensors:

    a. Refrigerant suction temperature.
    b. Refrigerant discharge temperature.
    c. Outdoor air temperature.
    d. Refrigerant high pressure.
    e. Refrigerant low pressure.
    f. Oil level.

4. Features and Functions: Self-diagnostics, time delay, auto-restart, fuse protection, auto operation mode, manual operation mode, night setback control, power consumption display, run test switch equalize run time between multiple same components.
5. Communication: Network communication with indoor units and other outdoor unit(s).
6. Cable and Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
7. Field Connection: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.

H. Unit Electrical:

1. Enclosure: Metal, similar to enclosure, and suitable for unprotected outdoor locations.
2. Field Connection: Single point connection to power entire unit and integral controls.
3. Disconnecting Means: Factory-mounted circuit breaker or switch, complying with NFPA 70.
4. Control Transformer: Manufacturer's standard. Coordinate requirements with field power supply.
5. Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
6. Raceways: Enclose line voltage wiring in raceways to comply with NFPA 70.

I. Unit Hardware: Zinc-plated steel, or stainless steel. Coat exposed surfaces with additional corrosion-resistant coating if required to prevention corrosion when exposed to salt spray test for 1000 hours according to ASTM B117.

J. Unit Piping:

1. Unit Tubing: Copper tubing with brazed joints.
2. Unit Tubing Insulation: Manufacturer's standard insulation, of thickness to prevent condensation.

3. Field Piping Connections: Manufacturer's standard.
4. Factory Charge: Dehydrated air or nitrogen.
5. Testing: Factory pressure tested and verified to be without leaks.

2.8 SYSTEM CONTROLS

A. General Requirements:

1. Network: Indoor units, and outdoor units shall include integral controls and connect through a TIA-485A or manufacturer-selected BACnet control network.
2. Network Communication Protocol: open control communication between interconnected units.
3. Integration with Building Automation System: ASHRAE 135, BACnet MS/TP and certified by BACnet Testing Lab (BTL), including the following:

    a. Ethernet connection via RJ-45 connectors and port with transmission at 100 Mbps or higher.
    b. Integration devices shall be connected to local uninterruptible power supply unit(s) to provide at least 5 minutes of battery backup operation after a power loss.
    c. Integration shall include control monitoring scheduling change of value notifications.

4. Operator Interface:

    a. Operators shall interface with system and unit controls through the following:

        1) Operator interfaces integral to controllers.
        2) Owner-furnished PC connected to central controller(s).
        3) Web interface through web browser software.
        4) Integration with Building Automation System.

    b. Users shall be capable of interface with controllers for indoor units control to extent privileges are enabled. Control features available to users shall include the following:

        1) On/off control.
        2) Temperature set-point adjustment.

B. VRF HVAC System Operator Software for PC:

1. Software offered by VRF HVAC system manufacturer shall provide system operators with ability to monitor and control VRF HVAC system(s) from a single dedicated Owner-furnished PC.

2. F HVAC system(s) from a single dedicated Owner-furnished PC.
3. Software shall provide operator with a graphic user interface to allow monitoring and control of multiple central controllers from a single device location through point-and-click mouse exchange.
4. Plan views shall show building plans with location of indoor units and identification superimposed on plans.
5. Controls operation mode of indoor units as individual units, by selected groups of indoor units, or as collection of all indoor units. Operation modes available through central controller shall match those operation modes of controllers for indoor units.
6. Schedules operation of indoor units as individual units, by selected groups of indoor units, or as collection of all indoor units. Schedules daily, weekly, and annual events.
7. Changes operating set points of indoor units as individual units, by selected groups of indoor units, or as collection of all indoor units.
8. Optimized start feature to start indoor units before scheduled time to reach temperature set-point at scheduled time based on operating history.
9. Night setback feature to operate indoor units at energy-conserving heating and cooling temperature set-points during unoccupied periods.
10. Supports Multiple Languages: English or Spanish.
11. Supports Imperial and Metric Temperature Units: Fahrenheit and Celsius.
12. Displays service notifications and error codes.
13. Monitors and displays up to 3000 item error history and 10000 item operation history for regular reporting and further archiving.
14. Monitors and displays cumulative operating time of indoor units.
15. Able to disable and enable operation of individual controllers for indoor units.
16. Information displayed on individual controllers shall also be available for display.
17. Information displayed for outdoor units, including refrigerant high and low pressures.

C. Central Controllers:

1. Centralized control for all indoor and outdoor units from a single central controller location.

    a. Include multiple interconnected controllers as required.

2. Controls operation mode of indoor units as individual units, by selected groups of indoor units, or as collection of all indoor units. Operation modes available

through central controller shall match those operation modes of controllers for indoor units.

3. Schedule operation of indoor units as individual units, by selected groups of indoor units, or as collection of all indoor units.

    a. Sets schedule for daily, weekly, and annual events.
    b. Schedule options available through central controller shall at least include the schedule options of controllers for indoor units.

4. Changes operating set points of indoor units as individual units, by selected groups of indoor units, or as collection of all indoor units.
5. Optimized start feature to start indoor units before scheduled time to reach temperature set-point at scheduled time based on operating history.
6. Night setback feature to operate indoor units at energy-conserving heating and cooling temperature set-points during unoccupied periods.
7. Service diagnostics tool.
8. Able to disable and enable operation of individual controllers for indoor units.
9. Information displayed on individual controllers shall also be available for display through central controller.
10. Information displayed for outdoor units, including refrigerant high and low pressures percent capacity.
11. Multiple RJ-45 ports for direct connection to a local PC and an Ethernet network switch.
12. Operator interface through a backlit, high-resolution color display touch panel and web accessible through standard web browser software.

D. Wired Controllers for Indoor Units:

1. Single controller capable of controlling multiple indoor units as group.
2. Auto Timeout Touch Screen LCD: Timeout duration shall be adjustable.
3. Multiple Language: English or Spanish.
4. Temperature Units: Fahrenheit and Celsius.
5. On/Off: Turns indoor unit on or off.
6. Hold: Hold operation settings until hold is released.
7. Operation Mode: Cool, Heat, Auto, Dehumidification, Fan Only, and Setback.
8. Temperature Display: 1-degree increments.
9. Temperature Set-Point: Separate set points for Cooling, Heating, and Setback. Adjustable in 1-degree increments between 65-78 deg. F.
10. Relative Humidity Display: 1 percent increments.
11. Relative Humidity Set-Point: Adjustable in 1 percent increments between 40-60%RH.
12. Fan Speed Setting: Select between available options furnished with the unit.

13. Airflow Direction Setting: If applicable to unit, select between available options furnished with the unit.
14. Seven-day programmable operating schedule with up to eight 8 events per day. Operations shall include On/Off, Operation Mode, and Temperature Set-Point.
15. Auto Off Timer: Operates unit for an adjustable time duration and then turns unit off.
16. Occupancy detection.
17. Service Notification Display: "Filter" dirty.
18. Service Run Tests: Limit use by service personnel to troubleshoot operation.
19. Error Code Notification Display: Used by service personnel to troubleshoot abnormal operation and equipment failure.
20. User and Service Passwords: Capable of preventing adjustments by unauthorized users.
21. Setting stored in nonvolatile memory to ensure that settings are not lost if power is lost. Battery backup for date and time only.
22. Low-voltage power required for controller shall be powered through non-polar connections to indoor unit.

2.9 SYSTEM REFRIGERANT AND OIL

A. Refrigerant:

1. As required by VRF HVAC system manufacturer for system to comply with performance requirements indicated.
2. ASHRAE 34, refrigerant classification.
3. R-410a or R32.

B. Oil:

1. As required by VRF HVAC system manufacturer and to comply with performance requirements indicated.

2.10 SYSTEM CONDENSATE DRAIN PIPING

A. If more than one material is listed, material selection is Contractor's option.

B. Copper Tubing:

1. Drawn-Temper Tubing: According to ASTM B88, Type L (ASTM B88M, Type B) or Type DWV according to ASTM B306.
2. Wrought-Copper Fittings: ASME B16.22.
3. Wrought-Copper Unions: ASME B16.22.

4. Solder Filler Metals: ASTM B32, lead-free alloys, and water-flushable flux according to ASTM B813.

C. CPVC plastic pipe according to ASTM F441/F441M, Schedule 40, with socket-type pipe fittings according to ASTM F438 and solvent cement according to ASTM F493.

D. PVC plastic pipe according to ASTM D1785, Schedule 40, with socket-type pipe fittings according to ASTM D2466 and solvent cement according to ASTM D2564, primer according to ASTM F656.

2.11 SOURCE QUALITY CONTROL

A. Factory Tests: Test and inspect factory-assembled equipment.

B. Equipment will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports for historical record. Submit reports only if requested.

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 products before installation. Reject products that are wet, moisture damaged, or mold damaged.

C. Examine roughing-in for piping and tubing to verify actual locations of connections before equipment installation.

D. Examine roughing-in for ductwork to verify actual locations of connections before equipment installation.

E. Examine roughing-in for wiring and conduit to verify actual locations of connections before equipment installation.

F. Examine walls, floors, roofs, and outdoor pads for suitable conditions where equipment will be installed.

G. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work.

H. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 EQUIPMENT INSTALLATION, GENERAL

A. Clearance:

1. Maintain manufacturer's recommended clearances for service and maintenance.
2. Maintain clearances required by governing code.

B. Loose Components: Install components, devices, and accessories furnished by manufacturer, with equipment, that are not factory mounted.

1. Loose components shall be installed by manufacturer's service representative or system Installer under supervision of manufacturer's service representative.

C. Equipment Restraint Installation: Install equipment with seismic-restraint device. Comply with requirements for seismic-restraint devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."

3.3 INSTALLATION OF INDOOR UNITS

A. Install units to be level and plumb while providing a neat and finished appearance.

B. Unless otherwise required by VRF HVAC system manufacturer, support ceiling-mounted units from structure above using threaded rods; minimum rod size of 3/8 inch (10 mm).

C. Adjust supports of exposed and recessed units to draw units tight to adjoining surfaces.

D. Protect finished surfaces of ceilings, floors, and walls that come in direct contact with units. Refinish or replaced damaged areas after units are installed.

E. In rooms with ceilings, conceal piping and tubing, controls, and electrical power serving units above ceilings.

F. In rooms without ceiling, arrange piping and tubing, controls, and electrical power serving units to provide a neat and finished appearance.

G. Provide lateral bracing if needed to limit movement of suspended units to not more than 0.25 inch (13 mm).

H. For floor- and wall-mounted units that are exposed, conceal piping and tubing, controls, and electrical power serving units within walls.

I. Attachment: Install hardware for proper attachment to supported equipment.

J. Grouting: Place grout under equipment supports and make bearing surface smooth.

3.4 INSTALLATION OF OUTDOOR UNITS

A. Install units to be level and plumb while providing a neat and finished appearance.

B. Install outdoor units on support structures indicated on Drawings.

C. Pad-Mounted Installations: Install outdoor units on cast-in-place concrete equipment bases.

1. Attachment: Install anchor bolts to elevations required for proper attachment to supported equipment.
2. Grouting: Place grout under equipment supports and make bearing surface smooth.

D. Roof-Mounted Installations: Anchor units to supports removable 12 inch tall minimum equipment rails to roof supports with stainless-steel fasteners.

3.5 GENERAL REQUIREMENTS FOR PIPING INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping and tubing systems. Install piping and tubing as indicated unless deviations to layout are approved on coordination drawings.

B. Install piping and tubing in concealed locations unless otherwise indicated and except in equipment rooms and service areas.

C. Install piping and tubing at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

D. Install piping and tubing above accessible ceilings to allow sufficient space for ceiling panel removal.

E. Install piping and tubing to permit valve servicing.

F. Install piping and tubing at indicated slopes.

G. Install piping and tubing free of sags.

H. Install fittings for changes in direction and branch connections.

I. Install piping and tubing to allow application of insulation.

J. Install groups of pipes and tubing parallel to each other, spaced to permit applying insulation with service access between insulated piping and tubing.

K. Install sleeves for piping and tubing penetrations of walls, ceilings, and floors.

L. Install escutcheons for piping and tubing penetrations of walls, ceilings, and floors.

3.6 INSTALLATION OF SYSTEM CONDENSATE DRAIN PIPING

A. General Requirements for Drain Piping and Tubing:

1. Install a union in piping at each threaded unit connection.
2. Install an adjustable stainless-steel hose clamp with adjustable gear operator on unit hose connections. Tighten clamp to provide a leak-free installation.
3. If required for unit installation, provide a trap assembly in drain piping to prevent air circulated through unit from passing through drain piping. Comply with more stringent of the following:

    a. Details indicated on Drawings.
    b. Manufacturer's requirements.
    c. Governing codes.
    d. In the absence of requirements, comply with requirements of ASHRAE handbooks.

4. Extend drain piping from units with drain connections to drain receptors as indicated on Drawings. If not indicated on Drawings, terminate drain connection at nearest accessible location that is not exposed to view by occupants.
5. Provide each 90-degree change in direction with a Y- or T-fitting. Install a threaded plug connection in the dormant side of fitting or future use as a service cleanout.

B. Gravity Drains:

1. Slope piping from unit connection toward drain termination at a constant slope of minimum of ¼-inch per foot.

C. Pumped Drains:

1. If unit condensate pump or lift mechanism is not included with an integral check valve, install a full-size check valve in each branch pipe near unit connection to prevent backflow into unit.

3.7 SOFTWARE

A. Cybersecurity:

1. Software:

a. Coordinate security requirements with IT department.
b. Ensure that latest stable software release is installed and properly operating.
c. Disable or change default passwords to password using a combination of uppercase and lower letters, numbers, and symbols at least eight characters in length. Record passwords and turn over to party responsible for system operation and administration.

2. Hardware:

a. Coordinate location and access requirements with IT department.
b. Enable highest level of wireless encryption that is compatible with Owner's ICT network.
c. Disable dual network connections.

3.8 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage VRF HVAC system manufacturer's service representative to advise and assist installers; witness testing; and observe and inspect components, assemblies, and equipment installations, including controls and connections.

1. Field service shall be performed by a factory-trained and -authorized service representative of VRF HVAC system manufacturer whose primary job responsibilities are to provide direct technical support of its products.

a. Additional factory-authorized representatives may assist with completion of certain activities only if supervised by manufacturer's employee. A factory-authorized representative shall not provide assistance without manufacturer's employee supervision.

2. Manufacturer shall provide on-site visits during the course of construction at installation milestones indicated. System Installer shall coordinate each visit in advance to give manufacturer sufficient notice to plan the visit.

    a. First Visit: Kick-off meeting.
    b. Second Visit: At approximately 25 percent completion of system(s).
    c. Third Visit: At approximately 50 percent completion of system(s).
    d. Fourth Visit: At approximately 75 percent completion of system(s).
    e. Fifth Visit: Final inspection before system startup.

3. Kick-off Meeting:

    a. Meeting shall include system Installer and other related trades with sole purpose of reviewing VRF HVAC system installation requirements and close coordination required to make a successful installation.
    b. Meeting shall be held at Project site and scheduled at a mutually agreed to time that occurs before the start of any part of system installation.
    c. Meeting shall cover the following as a minimum requirement:

        1) Review of latest issue of Contract Documents, Drawings, and Specifications, relevant to VRF HVAC systems.
        2) Manufacturer's installation requirements specific to systems being installed.
        3) Review of all relevant VRF HVAC system submittals, including delegated-design submittals.
        4) Required field activities related installation of VRF HVAC system.
        5) Project team communication protocol, contact information, and exchange of responsibilities for each party involved, including manufacturer, supplier, system Installer, and other related trades.

4. Site Visits: Activities for each site visit shall include the following:

    a. Meet with VRF HVAC system Installer to discuss field activities, issues, and suggested methods to result in a successful installation.
    b. Offer technical support to Installer and related trades as related to VRF system(s) being installed.
    c. Review progress of VRF HVAC system(s) installation for strict compliance with manufacturer's requirements.
    d. Advise and if necessary, assist Installer with updating related refrigerant calculations and system documentation.
    e. Issue a report for each visit, documenting the visit.

        1) Report to include name and contact information of individual making the visit.

2) Date(s) and time frames while on-site.
3) Names and contact information of people meeting with while on-site.
4) Clearly identify and list each separate issue that requires resolution. For each issue, provide a unique identification number, relevant importance, specific location or equipment identification, description of issue, recommended corrective action, and follow-up requirements needed. Include a digital photo for clarification if deemed to be beneficial.

5. Final Inspection before Startup:

a. Before inspection, Installer to provide written request to manufacturer stating the system is fully installed according to manufacturer's requirements and ready for final inspection.
b. All system equipment and operating components shall be inspected. If components are inaccessible for inspection, they shall be made accessible before the final inspection can be completed.
c. Manufacturer shall provide a comprehensive inspection of all equipment and each operating component that comprise the complete system(s). Inspection shall follow a detailed checklist specific to each equipment and operating component.
d. Inspection reports for indoor units shall include, but not be limited to, the following:

1) Unit designation on Drawings.
2) Manufacturer model number.
3) Serial number.
4) Network address, if applicable.
5) Each equipment setting.
6) Mounting, supports, and restraints properly installed.
7) Proper service clearance provided.
8) Wiring and power connections correct.
9) Line-voltage reading(s) within acceptable range.
10) Wiring and controls connections correct.
11) Low-voltage reading(s) within an acceptable range.
12) Controller type and model controlling unit.
13) Controller location.
14) Temperature settings and readings within an acceptable range.
15) Humidity settings and readings within an acceptable range.
16) Condensate removal acceptable.
17) Fan settings and readings within an acceptable range.
18) Unit airflow direction within an acceptable range.
19) If applicable, fan external static pressure setting.

20) Filter type and condition acceptable.
21) Noise level within an acceptable range.
22) Refrigerant piping properly connected and insulated.
23) Condensate drain piping properly connected and insulated.
24) If applicable, ductwork properly connected.
25) If applicable, external interlocks properly connected.
26) Remarks.

e. Inspection reports for outdoor units shall include, but not be limited to, the following:

1) Unit designation on Drawings.
2) Manufacturer model number.
3) Serial number.
4) Network address, if applicable.
5) Each equipment setting.
6) Mounting, supports, and restraints properly installed.
7) Proper service clearance provided.
8) Wiring and power connections correct.
9) Line-voltage reading(s) within acceptable range.
10) Wiring and controls connections correct.
11) Low-voltage reading(s) within an acceptable range.
12) Condensate removal acceptable.
13) Noise level within an acceptable range.
14) Refrigerant piping properly connected and insulated.
15) Condensate drain piping properly connected and insulated.
16) Remarks.

f. Inspection reports for indoor, dedicated outdoor air ventilation units shall include, but not be limited to, the following:

1) Unit designation on Drawings.
2) Manufacturer model number.
3) Serial number.
4) Network address, if applicable.
5) Each equipment setting.
6) Mounting, supports, and restraints properly installed.
7) Proper service clearance provided.
8) Wiring and power connections correct.
9) Line-voltage reading(s) within acceptable range.
10) Wiring and controls connections correct.
11) Low-voltage reading(s) within an acceptable range.
12) Controller type and model controlling unit.

13) Controller location.
14) Temperature settings and readings within an acceptable range.
15) Humidity settings and readings within an acceptable range.
16) Condensate removal acceptable.
17) Fan settings and readings within an acceptable range.
18) Fan external static pressure setting.
19) Filter type and condition acceptable.
20) Noise level within an acceptable range.
21) Refrigerant piping properly connected and insulated.
22) Condensate drain piping properly connected and insulated.
23) Automatic dampers properly installed and operating.
24) Ductwork properly connected.
25) If applicable, external interlocks properly connected.
26) Remarks.

g. Inspection reports for energy recovery ventilators shall include, but not be limited to, the following:

1) Unit designation on Drawings.
2) Manufacturer model number.
3) Serial number.
4) Network address, if applicable.
5) Each equipment setting.
6) Mounting, supports, and restraints properly installed.
7) Proper service clearance provided.
8) Wiring and power connections correct.
9) Line-voltage reading(s) within acceptable range.
10) Wiring and controls connections correct.
11) Low-voltage reading(s) within an acceptable range.
12) Controller type and model controlling unit.
13) Controller location.
14) Temperature settings and readings within an acceptable range.
15) Humidity readings.
16) Condensate removal acceptable.
17) Fan settings and readings within an acceptable range.
18) Fan external static pressure setting.
19) Filter type and condition acceptable.
20) Noise level within an acceptable range.
21) Automatic dampers properly installed and operating.
22) Ductwork properly connected.
23) If applicable, external interlocks properly connected.
24) Remarks.

h. Inspection reports for hydronic units shall include, but not be limited to, the following:

1) Unit designation on Drawings.
2) Manufacturer model number.
3) Serial number.
4) Network address, if applicable.
5) Each equipment setting.
6) Mounting, supports, and restraints properly installed.
7) Proper service clearance provided.
8) Wiring and power connections correct.
9) Line-voltage reading(s) within acceptable range.
10) Wiring and controls connections correct.
11) Low-voltage reading(s) within an acceptable range.
12) Controller type and model controlling unit.
13) Controller location.
14) Temperature settings and readings within an acceptable range.
15) Condensate removal acceptable.
16) Noise level within an acceptable range.
17) Refrigerant piping properly connected and insulated.
18) Hydronic piping properly connected and insulated.
19) Proof of water flow checked for proper operation.
20) Condensate drain piping properly connected and insulated.
21) If applicable, external interlocks properly connected.
22) Remarks.

i. Installer shall provide manufacturer with the requested documentation and technical support during inspection.
j. Installer shall correct observed deficiencies found by the inspection.
k. Upon completing the on-site inspection, manufacturer shall provide a written report with complete documentation describing each inspection step, the result, and any corrective action required.
l. If corrective action is required by Installer that cannot be completed during the same visit, provide additional visits, as required, until deficiencies are resolved, and systems are deemed ready for startup.
m. Final report shall indicate the system(s) inspected are installed according to manufacturer's requirements and are ready for startup.

B. Perform the following tests and inspections with the assistance of manufacturer's service representative:

1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.

2. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Refrigerant Tubing Positive Pressure Testing:

1. Comply with more stringent of VRF HVAC system manufacturer's requirements and requirements indicated.
2. After completion of tubing installation, pressurize tubing systems to a test pressure of not less than 1.5 times VRF HVAC system operating pressure, but not less than 600 psig (4137 kPa), using dry nitrogen.
3. Successful testing shall maintain a test pressure for a continuous and uninterrupted period of 24 hours. Allowance for pressure changes attributed to changes in ambient temperature are acceptable.
4. Prepare test report to record the following information for each test:

    a. Name of person starting test, company name, phone number, and e-mail address.
    b. Name of manufacturer's service representative witnessing test, company name, phone number, and e-mail address.
    c. Detailed description of extent of tubing tested.
    d. Date and time at start of test.
    e. Test pressure at start of test.
    f. Outdoor temperature at start of test.
    g. Name of person ending test, company name, phone number, and e-mail address.
    h. Date and time at end of test.
    i. Test pressure at end of test.
    j. Outdoor temperature at end of test.
    k. Remarks:

5. Submit test reports for Project record.

D. Refrigerant Tubing Evacuation Testing:

1. Comply with more stringent of VRF HVAC system manufacturer's requirements and requirements indicated.
2. After completion of tubing positive-pressure testing, evacuate tubing systems to a pressure of 500 microns.

3. Successful testing shall maintain a test pressure for a continuous and uninterrupted period of one hour(s) with no change.
4. Prepare test report to record the following information for each test:

    a. Name of person starting test, company name, phone number, and e-mail address.
    b. Name of manufacturer's service representative witnessing test, company name, phone number, and e-mail address.
    c. Detailed description of extent of tubing tested.
    d. Date and time at start of test.
    e. Test pressure at start of test.
    f. Outdoor temperature at start of test.
    g. Name of person ending test, company name, phone number, and e-mail address.
    h. Date and time at end of test.
    i. Test pressure at end of test.
    j. Outdoor temperature at end of test.
    k. Remarks:

5. Submit test reports for Project record.
6. Upon successful completion of evacuation testing, system shall be charged with refrigerant.

E. System Refrigerant Charge:

1. Using information collected from the refrigerant tubing evacuation testing, system Installer shall consult variable refrigerant system manufacturer to determine the correct system refrigerant charge.
2. Installer shall charge system following VRF HVAC system manufacturer's written instructions.
3. System refrigerant charging shall be witnessed by system manufacturer's representative.
4. Total refrigerant charge shall be recorded and permanently displayed at the system's outdoor unit.

F. Products will be considered defective if they do not pass tests and inspections.

G. Prepare test and inspection reports.

3.9 STARTUP SERVICE

A. Engage a VRF HVAC system manufacturer's service representative to perform system(s) startup service.

1. Service representative shall be an employee or a factory-trained and -authorized service representative of VRF HVAC system manufacturer.
2. Complete startup service of each separate system.
3. Complete system startup service according to manufacturer's written instructions.

B. Startup checks shall include, but not be limited to, the following:

1. Check control communications of equipment and each operating component in system(s).
2. Check each indoor unit's response to demand for cooling and heating.
3. Check each indoor unit's response to changes in airflow settings.
4. Check each indoor unit, HRCU, and outdoor unit for proper condensate removal.
5. Check sound levels of each indoor and outdoor unit.

C. Installer shall accompany manufacturer's service representative during startup service and provide manufacturer's service representative with requested documentation and technical support during startup service.

1. Installer shall correct deficiencies found during startup service for reverification.

D. System Operation Report:

1. After completion of startup service, manufacturer shall issue a report for each separate system.
2. Report shall include complete documentation describing each startup check, the result, and any corrective action required.
3. Manufacturer shall electronically record not less than two 2 hours of continuous operation of each system and submit with report for historical reference.

a. All available system operating parameters shall be included in the information submitted.

E. Witness:

1. Invite Owner and Commissioning Agent to witness startup service procedures.
2. Provide written notice not less than 20 business days before start of startup service.

3.10 ADJUSTING

A. Adjust equipment and components to function smoothly and lubricate as recommended by manufacturer.

B. Adjust initial temperature and humidity set points. Adjust initial airflow settings and discharge airflow patterns.

C. Set field-adjustable switches and circuit-breaker trip ranges according to VRF HVAC system manufacturer's written instructions, and as indicated.

D. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two 2 visits to Project during other-than-normal occupancy hours for this purpose.

3.11 PROTECTION

A. Protect products from moisture and water damage. Remove and replace products that are wet, moisture damaged, or mold damaged.

B. Protect equipment from physical damage. Replace equipment with physical damage that cannot be repaired to new condition. Observable surface imperfections shall be grounds for removal and replacement.

C. Protect equipment from electrical damage. Replace equipment suffering electrical damage.

D. Cover and seal openings of equipment to keep inside of equipment clean. Do not remove covers until finish work is complete.

3.12 MAINTENANCE SERVICE

A. Initial Maintenance Service: Beginning at Substantial Completion, maintenance service shall include 12 months' full maintenance by skilled employees of system Installer who are manufacturer's authorized service representative. Include two 2 service visits for preventive maintenance, repair or replacement of worn or defective components, lubrication, cleaning, and adjusting as required for proper equipment and system operation. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.

3.13 SOFTWARE SERVICE AGREEMENT

A. Technical Support: Beginning at Substantial Completion, service agreement shall include software support for two years.

B. Upgrade Service: At Substantial Completion, update software to latest version. Install and program software upgrades that become available within two 2 years from date of Substantial Completion. Upgrading software shall include operating system and new or revised licenses for using software.

1. Upgrade Notice: At least 30 days to allow Owner to schedule and access the system and to upgrade computer equipment if necessary.

3.14 DEMONSTRATION

A. Engage a VRF HVAC system manufacturer's employed training instructor or factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain entire system.

B. Instructor:

1. Instructor shall be factory trained and certified by VRF HVAC system manufacturer with current training on the system(s), equipment, and controls that are installed.
2. Instructor's credentials shall be submitted for review by Architect Commissioning Agent Owner before scheduling training.
3. Instructor(s) primary job responsibility shall be Owner training.
4. Instructor(s) shall have not less than three 3 years of training experience with VRF HVAC system manufacturer and past training experience on at least three 3 projects of comparable size and complexity.

C. Schedule and Duration:

1. Schedule training with Owner at least 20 business days before first training session.
2. Training shall occur before Owner occupancy.
3. Training shall be held at mutually agreed date and time during normal business hours.
4. Each training day shall not exceed eight 8 hours of training. Daily training schedule shall allow time for one 1-hour lunch period and 15 -minute break after every two 2 hours of training.
5. Perform not less than eight 8 total hours of training.

D. Location: Owner shall provide a suitable on-site location to host classroom training.

E. Training Attendees: Assume three 3 people.

F. Training Attendance: For record purposes, document training attendees at the start of each new training session. Record attendee's name, signature, phone number, and e-mail address.

G. Training Format: Individual training modules shall include classroom training followed by hands-on field demonstration and training.

H. Training Materials: Provide training materials in electronic format to each attendee.

1. Include instructional videos showing general operation and maintenance that are coordinated with operation and maintenance manuals.
2. Video record each classroom training session and submit an electronic copy to Owner before requesting Owner acceptance of training.

I. Acceptance: Obtain Architect or Owner written acceptance that training is complete, and requirements indicated have been satisfied.

END OF SECTION 238130

SECTION 238216.11 - HYDRONIC AIR COILS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Hydronic air coils.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for each air coil.
2. Include rated capacities, operating characteristics, and pressure drops for each air coil.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: 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.

B. Product Data:

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.

1.4 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.

C. Minimum Working-Pressure/Temperature Ratings: 200 psig/300 deg F.

D. Select cooling coils for no moisture carryover at design conditions. Provide moisture eliminators on discharge face of cooling coil if necessary to eliminate moisture carryover.

2.2 HYDRONIC AIR COILS

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

1. Aerofin.
2. Modine Commercial and Industrial Solutions.
3. Trane.
4. USA Coil & Air.

B. Source Limitations: Obtain hydronic coils from single source from single manufacturer.

C. Description: Coils constructed of staggered tubes mechanically expanded into continuous collars that are die-formed into the coil fins; self-venting; counterflow design of air to fluid.

D. Tubes:

1. Material: Copper.
2. Nominal Diameter: Minimum 1/2 inch or 5/8 inch (16 mm) before expanding, selected to provide performance indicated.
3. Nominal Wall Thickness: As required by performance, minimum 0.035 inch thick.
4. Return Bends: 180-degree bends; material and nominal diameter to match tubes.
5. Fluid Velocity at Design Flow Rate:

    a. Maximum: 6 fps.
    b. Minimum: 3 fps.

6. Features: Cleanable.

E. Fins:

1. Type: Plate.
2. Materials:

    a. Aluminum: 0.0060 inch (0.15 mm) thick.
    b. Copper: 0.0060 inch (0.15 mm) thick.

3. Spacing: Maximum 12 fins per inch.
4. Collars: Full collars for accurate fin spacing and maximum tube contact while leaving no surface of tube exposed.
5. Configuration: Fin type as required by performance requirements.

F. Headers:

1. Material: Carbon steel Copper, removable for cleaning and inspection of tubes.
2. Tube-to-Header Connections: Tube-to-header holes to intrude inward, so landed surface area is 3 times the core tube thickness, to provide enhanced-header-to-tube joint integrity. Evenly extend tubes within the ID of the header no more than 0.12 inch (3 mm).
3. Header Top and Bottom Caps: End caps to be die-formed and installed on the ID of header, such that the landed surface area is 3 times the header wall thickness.
4. Drains: Include low point of header with a NPS 1/2 (DN 13) drain connection.
5. Vents: Include high point of header with a NPS 1/2 (DN 13) vent connection.
6. Supply and Return Connections: Copper Carbon steel pipe; threaded or flanged, same end of coil.
7. Protect opening of supply, return, vent, and drain connections with a threaded cap to prevent entry of dirt into coil.
8. Fluid Velocity at Design Flow Rate: Maximum of 6 fps (1.8 m/s).

G. Holes: Include number, size, and location of holes in casing and end tube sheets required for coil installation.

H. Hardware: Use hex-head bolts, nuts, and washers constructed of Type 304 or Type 316 stainless steel.

I. 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.

J. Casing: Galvanized Steel

2.3 MATERIALS

A. Aluminum: ASTM B209.

B. Copper Tube: ASTM B75/ASTM 75M annealed temper or ASTM B280 drawn temper.

C. Copper Sheet: ASTM B152.

D. 90/10 Cupronickel Alloy: ASTM B122/ASTM B122M.

E. Steel:

1. Pipe Connections: ASTM A53/A53M.

F. Corrosion-Resistant Coating: Where indicated on Drawings, coat coils with a corrosion-resistant coating capable of withstanding a 3000-hour salt-spray test in accordance with ASTM B117.

1. Standards:

a. ASTM B117 for salt spray.
b. ASTM D2794 for minimum impact resistance of 100 in. lb.
c. ASTM D3359 for cross-hatch adhesion of 5B.

2. Application: Spray.
3. Thickness: 1 mil.
4. Gloss: Minimum gloss of 60 on a 60-degree meter.

2.4 SOURCE QUALITY CONTROL

A. Hydronic Coils: Factory tested with air while coil is completely submerged underwater to design pressure indicated, but not less than 300-psig internal pressure.

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. Install stainless steel drain pan under each cooling coil.

1. Construct drain pans with connection for drain; insulated and complying with ASHRAE 62.1.
2. Construct drain pans to extend beyond coil length and width and to connect to condensate trap and drainage.
3. Extend drain pan upstream and downstream from coil face.
4. Extend drain pan under coil headers and exposed supply piping.

D. Install moisture eliminators for cooling coils. Extend drain pan under moisture eliminator.

E. Straighten bent fins on air coils.

F. 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 water piping with unions and shutoff valves to allow coils to be disconnected without draining piping.

END OF SECTION 238216.11

SECTION 238229 - RADIATORS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes flat-pipe steel radiators.

1.3 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. Indicate location and size of each field connection.
   4. Indicate location and arrangement of piping valves and specialties.
   5. Indicate location and arrangement of integral controls and other accessories.

C. Samples: For each exposed product and for each color and texture specified.

D. Color Samples for Initial Selection: For radiators with factory-applied color finishes.

E. Color Samples for Verification: For each type of exposed finish.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
   1. Structural members, including wall construction, to which radiators will be attached.

2. Method of attaching radiators to building structure.
3. Penetrations of fire-rated wall and floor assemblies.

B. Field quality-control reports.

PART 2 - PRODUCTS

2.1 FLAT-PIPE STEEL RADIATORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Myson North America, Inc.
2. Runtal North America, Inc.
3. Stearling North America Inc.

B. Heating Elements: Steel, welded and formed into flat, square, steel header with minimum thickness of 0.109 inch. Include threaded piping and air-vent connections.
1. Working Pressure: 128 psig; 0.078 inch.
2. Element Height: 18 inches .
3. Element Depth: 3 3/8 inches .

C. Mounting: Floor pedestals with maximum spacing of 36 inches.

D. Finish: Baked-enamel finish in manufacturer's standard color as selected by Architect.

E. Accessories:
1. Steel piping covers finished to match radiator finish.
2. Flexible Expansion Compensation Hoses: Minimum 400-psig working pressure, and operating temperatures from 33 to 211 deg F.
a. Length: 24 inches.
b. Minimum Diameter: Equal to connection size.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas to receive radiators 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 radiators.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install units level and plumb.

B. Install expansion compensation hoses.

C. Install piping covers.

3.3 CONNECTIONS

A. Piping installation requirements are specified in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Connect radiators and components to piping according to Section 232113 "Hydronic Piping" and Section 232116 Hydronic Piping Specialties."
   1. Install shutoff valves on inlet and outlet, and balancing valve on outlet.

C. Install control valves as required by Section 230923.11 "Control Valves."

D. Install piping adjacent to radiators to allow service and maintenance.

3.4 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.

B. Units will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

END OF SECTION 238229

This page intentionally left blank

SECTION 238236 - FINNED-TUBE RADIATION HEATERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes hydronic, finned-tube radiation heaters.

1.3 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.

1.4 INFORMATIONAL SUBMITTALS

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

1. Structural members, including wall construction, to which finned-tube radiation heaters will be attached.
2. Method of attaching finned-tube radiation heaters to building structure.
3. Penetrations of fire-rated wall and floor assemblies.

B. Field quality-control reports.

PART 2 - PRODUCTS

2.1 HOT-WATER 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: Filler sections, corners, relay sections, and splice plates all matching the enclosure and grille finishes.

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 BASEBOARD 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.

3.3 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.

3.4 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 238239.13 - CABINET UNIT HEATERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes cabinet unit heaters with centrifugal fans and hot-water coils.

1.3 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 location and size of each field connection.
4. Include details of anchorages and attachments to structure and to supported equipment.
5. Include equipment schedules to indicate rated capacities, operating characteristics, furnished specialties, and accessories.
6. Indicate location and arrangement of piping valves and specialties.
7. Indicate location and arrangement of integral controls.
8. Wiring Diagrams: Power, signal, and control wiring.

C. Samples: For each exposed product and for each color and texture specified.

D. Samples for Initial Selection: Finish colors for units with factory-applied color finishes.

E. Samples for Verification: Finish colors for each type of cabinet unit heater indicated with factory-applied color finishes.

1.4 INFORMATIONAL SUBMITTALS

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

1. Suspended ceiling components.
2. Structural members to which cabinet unit heaters will be attached.
3. Method of attaching hangers to building structure.
4. Size and location of initial access modules for acoustical tile.
5. Items penetrating finished ceiling, including the following:

a. Lighting fixtures.
b. Air outlets and inlets.
c. Speakers.
d. Sprinklers.
e. Access panels.
f. .

6. Perimeter moldings for exposed or partially exposed cabinets.

B. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For cabinet unit heaters to include in emergency, operation, and maintenance manuals.

1.6 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. Cabinet Unit-Heater Filters: Furnish one spare filter(s) for each filter installed.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Airtherm; a Mestek company.
2. QMark; Marley Engineered Products.
3. Trane.
4. Airedale

2.2 DESCRIPTION

A. Factory-assembled and -tested unit complying with AHRI 440.

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

C. Comply with UL 2021.

2.3 PERFORMANCE REQUIREMENTS

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

B. ASHRAE/IESNA 90.1 Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

2.4 CABINETS

A. Material: Steel with baked-enamel finish with manufacturer's standard paint, in color selected by Architect.

1. Vertical Unit, Exposed Front Panels: Minimum 0.0677-inch- thick galvanized sheet steel, removable panels with channel-formed edges secured with tamperproof cam fasteners.
2. Horizontal Unit, Exposed Bottom Panels: Minimum 0.0677-inch- thick galvanized sheet steel, removable panels secured with tamperproof cam fasteners and safety chain.
3. Recessed Flanges: Steel, finished to match cabinet.
4. Control Access Door: Key operated.
5. Base: Minimum 0.0528-inch- thick steel, finished to match cabinet, 4 inches high with leveling bolts.
6. Extended Piping Compartment: 8-inch- wide piping end pocket.
7. False Back: Minimum 0.0428-inch- thick steel, finished to match cabinet.

2.5 FILTERS

A. Minimum Efficiency Reporting Value and Average Arrestance: According to ASHRAE 52.2.

B. Minimum Efficiency Reporting Value: According to ASHRAE 52.2.

C. Material: Pleated cotton-polyester media, MERV 8.

2.6 COILS

A. Hot-Water Coil: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch and rated for a minimum working pressure of 200 psig and a maximum entering-water temperature of 220 deg F. Include manual air vent and drain.

B. Electric-Resistance Heating Coil: Nickel-chromium heating wire, free from expansion noise and hum, mounted in ceramic inserts in galvanized-steel housing; with fuses in terminal box for overcurrent protection and limit controls for high-temperature protection. Terminate elements in stainless-steel machine-staked terminals secured with stainless-steel hardware.

2.7 CONTROLS

A. Fan and Motor Board: Removable.

1. Fan: Forward curved, double width, centrifugal, directly connected to motor; thermoplastic or painted-steel wheels and aluminum, painted-steel, or galvanized-steel fan scrolls.
2. Motor: Permanently lubricated, multispeed; resiliently mounted on motor board. Comply with requirements in Section 230513 "Common Motor Requirements for HVAC Equipment."
3. Wiring Terminations: Connect motor to chassis wiring with plug connection.

B. Electrical Connection: Factory-wired motors and controls for a single field connection.

2.8 Filters:

1. Rating: Merv 8
2. Outdoor air filter:
    a. If there is an outdoor air duct connected to the unit that bypasses the filters in the unit. Provide a separate, field fabricated, duct mounted filter box for the outdoor air.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas to receive cabinet unit heaters for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for piping and electrical connections to verify actual locations before unit-heater installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install wall boxes in finished wall assembly; seal and weatherproof.

B. Install cabinet unit heaters to comply with NFPA 90A.

C. Suspend cabinet unit heaters from structure with elastomeric hangers.

D. Install wall-mounted thermostats and switch controls in electrical outlet boxes at heights to match lighting controls. Verify location of thermostats and other exposed control sensors with Drawings and room details before installation.

E. Install new filters in each fan-coil unit within two weeks of Substantial Completion.

3.3 CONNECTIONS

A. Install piping adjacent to machine to allow service and maintenance.

B. Connect piping to cabinet unit heater's factory, hot-water piping package. Install the piping package if shipped loose.

C. Connect supply and return ducts to cabinet unit heaters with flexible duct connectors.

D. Comply with safety requirements in UL 1995.

3.4 FIELD QUALITY CONTROL

A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.

2. Operate electric heating elements through each stage to verify proper operation and electrical connections.
3. Test and adjust controls and safety devices. Replace damaged and malfunctioning controls and equipment.

B. Units will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

3.5 ADJUSTING

A. Adjust initial temperature set points.

B. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain cabinet unit heaters.

END OF SECTION 238239.13

SECTION 238239.16 - PROPELLER UNIT HEATERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes propeller unit heaters with hot-watercoils.

1.3 DEFINITIONS

A. CWP: Cold working pressure.

B. PTFE: Polytetrafluoroethylene plastic.

C. TFE: Tetrafluoroethylene plastic.

1.4 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 location and size of each field connection.
4. Include details of anchorages and attachments to structure and to supported equipment.
5. Include equipment schedules to indicate rated capacities, operating characteristics, furnished specialties, and accessories.
6. Indicate location and arrangement of piping valves and specialties.

7. Indicate location and arrangement of integral controls.
8. Wiring Diagrams: Power, signal, and control wiring.

1.5 INFORMATIONAL SUBMITTALS

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

B. ed ceiling plans, and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Suspended ceiling components.
2. Structural members to which propeller unit heaters will be attached.
3. Method of attaching hangers to building structure.
4. Size and location of initial access modules for acoustical tile.
5. Items penetrating finished ceiling, including the following:

    a. Lighting fixtures.
    b. Air outlets and inlets.
    c. Speakers.
    d. Sprinklers.
    e. Access panels.

C. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For propeller unit heaters to include in emergency, operation, and maintenance manuals.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Airedale

2.2 DESCRIPTION

A. Assembly including casing, coil, fan, and motor in [**vertical**] [**and**] [**horizontal**] discharge configuration with adjustable discharge louvers.

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

C. Comply with UL 2021.

D. Comply with UL 823.

2.3 PERFORMANCE REQUIREMENTS

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

B. e requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

.

C. ASHRAE/IESNA 90.1 Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

2.4 HOUSINGS

A. Finish: Manufacturer's standardbaked enamel applied to factory-assembled and -tested propeller unit heaters before shipping.

B. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

C. Discharge Louver: Adjustable fin diffuser for horizontal units and conical diffuser for vertical units.

2.5 COILS

A. General Coil Requirements: Test and rate hot-water propeller unit-heater coils according to ASHRAE 33.

B. Hot-Water Coil: Copper tube, minimum 0.025-inch wall thickness, with mechanically bonded aluminum fins spaced no closer than 0.1 inch and rated for a minimum working pressure of 200 psig and a maximum entering-water temperature of 325 deg F with manual air vent. Test for leaks to 350 psig underwater.

C. Fan: Propeller type with aluminum wheel directly mounted on motor shaft in the fan venturi.

D. Motor: Permanently lubricated, multispeed.

2.6 CONTROLS

A. Control Devices:

1. Unit -mounted, fan-speed switch.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas to receive propeller unit heaters for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for piping and electrical connections to verify actual locations before unit-heater installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install propeller unit heaters to comply with NFPA 90A.

B. Install propeller unit heaters level and plumb.

C. Suspend propeller unit heaters from structure with all-thread hanger rods and spring hangers with vertical-limit stop.

D. Install wall-mounted thermostats and switch controls in electrical outlet boxes at heights to match lighting controls. Verify location of thermostats and other exposed control sensors with Drawings and room details before installation.

3.3 CONNECTIONS

A. Install piping adjacent to machine to allow service and maintenance.

B. Connect piping to propeller unit heater's factory, hot-water piping package. Install the piping package if shipped loose.

C. Comply with safety requirements in UL 1995.

D. Ground equipment.

3.4 FIELD QUALITY CONTROL

A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
2. Operate electric heating elements through each stage to verify proper operation and electrical connections.
3. Test and adjust controls and safety devices. Replace damaged and malfunctioning controls and equipment.

B. Units will be considered defective if they do not pass tests and inspections.

C. 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 propeller unit heaters.

END OF SECTION 238239.16

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 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.

1.3 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

1.4 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.

1.5 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.

1.6 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.

1.7 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 17
    4. Android V2.3
    5. Android V4.3
    6. Android V14

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.

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

2.14 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.

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. All training is to be video recorded.

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

This page intentionally left blank

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 45°F (adjustable), the control valve will fully open, and when it drops below 40°F (adjustable), mixed air dampers shall be in the full return air position.

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 cooling 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. 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.

1.4 HEATING PLANT

A. Main System Components:
1. Condensing boilers.
2. Boiler (primary) pumps, modulating with variable speed drives for speed control
3. Distribution (secondary) pumps, modulating with variable speed drives for speed control.

B. System Description
1. Heating hot water is provided to a primary loop by the condensing boilers and associated pumps which are in lead/lag/stand by configuration. Heating hot water is then provided to the building by the distribution pumps.

C. System Off
1. Condensing boilers are off
2. Boiler pumps are off.
3. Distribution pumps are off.

D. Heating Mode
1. The Heating plant enables when the outdoor air temperature is less than 65°F (adjustable)
2. Primary Loop:
    a. Boilers and boiler pumps stage/modulate to maintain heating hot water supply temperature (of the secondary loop) according to the boiler factory controls.
        1) Heating hot water supply temperature shall be reset linearly in 5 °F (adjustable) increments based on OA temperature within the following range:

a) 150°F (adjustable) when OAT is less than 35°F (adjustable)
b) 110°F (adjustable) when OAT is greater than 60°F (adjustable)

E. Secondary Loop:

1. The distribution pumps modulate to maintain the loop differential pressure setpoint as measured by the TAB agency.

2. Pump modulation/staging:
   a. The lead pump modulates to maintain differential pressure set point.
   b. If the pump speed is at its minimum per the manufacturers recommendations, and the differential pressure of the system is above set point, the minimum flow bypass will modulate to maintain set point.
   c. If the pump reaches 90% (adjustable) of it's maximum speed and the differential pressure remains below the setpoint, the lag pump starts and the pump speeds modulate to match while maintain differential pressure set point.
   d. If both pumps reach 40% (Adj.) of their maximum speed and the system differential pressure remains above the setpoint, the lag pump will turn off.

F. Hardwired Safeties (always enabled)

1. Boilers shall shutdown upon detection of any of the following:
   a. Low Water Level
   b. High Heating Water Supply Temperature.
   c. Emergency Boiler Shut-Down Activation

G. Boiler Emergency Shut-down

1. Provide manually reset momentary contact latching switch at each boiler room door. The switch shall be marked as "Emergency Boiler Shutdown".

2. Wire boiler primary control circuits through switch to de-energize the boilers and close the gas control valve when the switch is depressed.

3. Upon the detection of gas leakage in the mechanical room, The building automation system shuts down the boilers.

4. An affected boiler shall be shut down upon the following alarm conditions:
   a. Low water level alarm.
   b. Flame failure.
   c. High hot water supply temperature.
   d. Flow below minimum flow.

H. Alarms:

1. Common boiler alarms via packaged boiler controls.

2. Pump Alarms
    a. Pump variable frequency drive fault
    b. Pump failure: commanded ON, but the status is OFF.
    c. Pump running in hand: commanded OFF, but the status is ON.
    d. Pump runtime exceeded: status runtime exceeds a user definable limit.

1.5 GLYCOL HOT WATER SYSTEM

A. Main System Components:
    1. Heat exchanger hot water control valve.
    2. Distribution pumps, modulating with variable speed drives for speed control.

B. System Description
    1. Glycol hot water is generated by the heat exchanger and is then provided to the building by the distribution pumps.

C. System Off
    1. Heat exchanger control valve is closed.
    2. Distribution pumps are off.

D. Heating Mode
    1. The Heating plant enables when the outdoor air temperature is less than 65°F (adjustable).
    2. Heat exchanger control valves modulates to maintain glycol heating hot water supply temperature which shall be reset linearly in 5 °F (adjustable) increments based on OA temperature within the following range:
        1) 145°F (adjustable) when OAT is less than 35°F (adjustable)
        2) 105°F (adjustable) when OAT is greater than 60°F (adjustable)

E. Distribution pumps:
    1. The distribution pumps modulate to maintain the loop differential pressure setpoint as measured by the TAB agency.
    2. Pump modulation/staging:
        a. The lead pump modulates to maintain differential pressure set point.
        b. If the pump speed is at its minimum per the manufacturers recommendations, and the differential pressure of the system is above set point, the minimum flow bypass will modulate to maintain set point.

c. If the pump reaches 90% (adjustable) of it's maximum speed and the differential pressure remains below the setpoint, the lag pump starts and the pump speeds modulate to match while maintain differential pressure set point.

d. If both pumps reach 40% (Adj.) of their maximum speed and the system differential pressure remains above the setpoint, the lag pump will turn off.

F. Alarms:

1. Pump Alarms

a. Pump variable frequency drive fault

b. Pump failure: commanded ON, but the status is OFF.

c. Pump running in hand: commanded OFF, but the status is ON.

d. Pump runtime exceeded: status runtime exceeds a user definable limit.

1.6 **ROOF TOP UNITS**

A. System Components

1. Roof top unit:

a. Supply fan, constant volume with variable frequency drive or electrically commutated motors for automatic balancing and outdoor air damper, 2-position.

b. Exhaust fan, constant volume with electrically commutated motor for automatic balancing.

c. Mixed air dampers, modulating.

d. Heating hot water (glycol) coil control valve, modulating.

e. DX, modulating with hot gas reheat.

B. System Description

1. A roof top unit provides heating, cooling, ventilation, and exhaust.

C. System Off

1. Roof top unit:

a. Supply fan is off and outdoor air damper is closed.

b. Exhaust fan is off.

c. Mixed air damper is in the full return air position.

d. Heating hot water (glycol) coil control valve is closed.

e. DX is off.

D. Start-Up:

1. Roof top unit:

a. Supply fan is on, and outdoor air damper is open.

b. Exhaust fan is on.

c. Mixed air damper is in the full return air position.

d. Heating hot water (glycol) coil control valve is open in heating mode, otherwise it is closed.

e. DX is on in cooling mode, otherwise it is off.

E. Occupied Mode

1. Roof top unit:

a. Supply fan is on, and outdoor air damper is open.

b. Exhaust fan modulates to track the position of the mixed air damper.

1) Culinary exhaust fan modulates to track the position of the mixed air damper and decreases by 1890 cfm when F-F-206.6 is commanded on and 600 cfm when F-F-206.7 is commanded on.

c. Mixed air damper opens to provide minimum volumetric flow rate of outdoor air as scheduled (for gym, it modulates between normal and event mode cfms), unless space temperature rises above space cooling temperature setpoint and outdoor air temperature is less than space temperature, then 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 (default = 55°F) by modulating the mixed air damper to decrease the outdoor air without dropping below the minimum scheduled value.

d. Heating hot water (glycol) coil control valve modulates to maintain space temperature set point in heating mode, otherwise it is closed.

e. DX modulates to maintain space temperature and humidity set points in cooling mode, otherwise it is off.

F. Unoccupied Mode:

1. Roof top unit:

a. Supply fan cycles (with heating hot water (glycol) coil control valve or DX).

b. Exhaust fan is off and exhaust damper is closed.

c. Mixed air damper is in the full return air position.

d. Heating hot water (glycol) coil control valve cycles open (with fan) to maintain space temperature set point in heating mode, otherwise it is closed.

e. DX cycles on (with fan) to maintain space temperature cooling and humidity set points in cooling mode, otherwise it is off.

1.7 **ENERGY RECOVERY UNITS**

A. System Components

1. Energy recovery unit.
    a. Supply fan, constant volume with variable frequency drive for automatic balancing and outdoor air damper, 2-position.
    b. Exhaust fan, constant volume with variable frequency drive for automatic balancing and exhaust damper 2-position.
    c. Energy recovery wheel, constant speed.
    d. Heating hot water (glycol) coil control valve, modulating.
    e. DX, modulating with hot gas reheat.

B. System Description
1. An energy recover unit on the roof provides tempered ventilation, and exhaust.

C. System Off
1. Energy recovery unit:
    a. Supply fan is off and outdoor air damper is closed.
    b. Exhaust fan is off and exhaust damper is closed.
    c. Energy recovery wheel is off.
    d. Heating hot water (glycol) coil control valve is closed.
    e. DX is off.

D. Start-Up:
1. Energy recovery unit:
    a. Supply fan is on, and outdoor air damper is open.
    b. Exhaust fan is on, and exhaust damper is open.
    c. Energy recovery wheel is off.
    d. Heating hot water (glycol) coil control valve is fully open in heating mode, otherwise it is closed.
    e. DX is on in cooling mode, otherwise it is off.

E. Occupied Mode
1. Energy recovery unit:
    a. Supply fan is on, and outdoor air damper is open.
    b. Exhaust fan is on, and exhaust damper is open.
    c. Energy recovery wheel is on unless space temperature rises above space cooling temperature setpoint and outdoor air temperature is less than space temperature (economizer mode), then it slows to its minimum. Provide low-limit override to prevent discharge air temperature from dropping below low limit setpoint (default = 55°F) by modulating the speed of the wheel.

d. Heating hot water (glycol) coil control valve modulates to maintain discharge air temperature set point of 75°F (adjustable) in heating mode otherwise it is closed.

e. DX modulates to maintain discharge air temperature set point of 65°F (adjustable) and relative humidity set point of 50% in cooling mode, otherwise it is off.

F. Unoccupied Mode:

1. Energy recovery unit:

a. Supply fan is off and outdoor air damper is closed.

b. Exhaust fan is off and exhaust damper is closed.

c. Energy recovery wheel is off.

d. Heating hot water (glycol) coil control valve is closed.

e. DX is off.

1.8 ENERGY RECOVER UNITS WITH RECIRCULATION

A. System Components

1. Energy recovery unit.

a. Supply fan, constant volume with variable frequency drive for automatic balancing and outdoor air damper, 2-position.

b. Exhaust fan, constant volume with variable frequency drive for automatic balancing and exhaust damper 2-position.

c. Recirculation damper, modulating.

d. Energy recovery wheel, constant speed and bypass dampers.

e. Heating hot water (glycol) coil control valve, modulating.

f. DX, modulating with hot gas reheat.

2. Vehicle exhaust fan, constant volume with VFD for balancing. (Auto Tech Shop only).
3. General exhaust fan, constant volume with ECM for balancing. (Kitchen only).

B. System Description

1. An energy recover unit on the roof provides heating, cooling, ventilation, and exhaust.

C. System Off

1. Energy recovery unit:

a. Supply fan is off.

b. Exhaust fan is off.

c. Outdoor air damper is closed.

d. Exhaust damper is closed.

e. Recirculation damper is fully open.

f. Energy recovery wheel is off and bypass dampers are closed.
g. Heating hot water (glycol) coil control valve is closed.
h. DX is off.

2. Vehicle exhaust fan is off.
3. General exhaust fan is off.

D. Start-Up:
1. Energy recovery unit:
a. Supply fan is on.
b. Exhaust fan is off.
c. Outdoor air damper is closed.
d. Exhaust damper is closed.
e. Recirculation damper is open.
f. Energy recovery wheel is off and bypass dampers are closed.
g. Heating hot water (glycol) coil control valve is fully open in heating mode, otherwise it is closed.
h. DX is on for cooling mode, otherwise it is off.
2. Vehicle exhaust fan is off.
3. General exhaust fan is off.

E. Occupied Mode
1. Energy recovery unit:
a. Supply fan is on.
b. Exhaust fan modulates to track the position of the mixed air damper. Minimum position to match minimum outdoor air position.
1) Cafeteria minimum is 2900 cfm.
2) Auto Tech Shop minimum is as scheduled unless F-H-117 is commanded on, then it decreases by 1800 cfm.
c. Outdoor air damper is open to provide minimum volumetric flow rate of outdoor air as scheduled unless space temperature rises above space cooling temperature setpoint and outdoor air temperature is less than space temperature (economizer mode), then the return 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 (default = 55°F) by modulating the mixed air damper to decrease the outdoor air without dropping below the minimum scheduled value.
d. Exhaust damper is open.
e. Recirculation damper modulates to inversely track the outdoor air damper position.

f. Energy recovery wheel is on and bypass dampers are closed unless economizer mode is activated, then the wheel slows to its minimum speed and bypass dampers are open.

g. Heating hot water (glycol) coil control valve modulates to maintain space temperature set point in heating mode otherwise it is closed.

h. DX modulates to maintain space temperature and humidity set points in cooling mode.

i. Vehicle exhaust fan is off, unless commanded on.

j. General exhaust fan is on.

F. Unoccupied Mode:

1. Energy recovery unit:

a. Supply fan cycles (with heating hot water (glycol) coil control valve or DX).

b. Exhaust fan is off.

c. Outdoor air damper is closed.

d. Exhaust damper is closed.

e. Recirculation damper is fully open.

f. Energy recovery wheel is off and bypass dampers are closed.

g. Heating hot water (glycol) coil control valve cycles open (with fan) to maintain space temperature set point in heating mode, otherwise it is closed.

h. DX cycles on (with fan) to maintain space temperature cooling and humidity set points in cooling mode, otherwise it is off.

i. Vehicle exhaust fan is off.

j. General exhaust fan is off.

1.9 **ENERGY RECOVER VENTILATORS**

A. System Components

1. Energy recovery ventilator.

a. Supply fan, constant volume with variable frequency drive for automatic balancing and outdoor air damper, 2-position.

b. Exhaust fan, constant volume with variable frequency drive for automatic balancing and exhaust damper 2-position.

2. Heating hot water coil control valve(s), modulating.

B. System Description

1. A core style energy recover ventilator on the roof provides ventilation and exhaust. Ducted heating coils provide heating of ventilation air.

C. System Off

1. Energy recovery ventilator:
    a. Supply fan is off and outdoor air damper is closed.
    b. Exhaust fan is off and exhaust damper is closed.
2. Heating hot water coil control valve is closed.

D. Start-Up:
1. Energy recovery ventilator:
    a. Supply fan is on, and outdoor air damper is open.
    b. Exhaust fan is on, and exhaust damper is open.
2. Heating hot water coil control valve is open in heating mode, otherwise it is closed.

E. Occupied Mode
1. Energy recovery ventilator:
    a. Supply fan is on, and outdoor air damper is open.
    b. Exhaust fan is on, and exhaust damper is open.
2. Heating hot water coil control valve modulates to maintain discharge air temperature set point of 75°F (adjustable) in heating mode otherwise it is closed

F. Unoccupied Mode:
1. Energy recovery ventilator:
    a. Supply fan is off and outdoor air damper is closed.
    b. Exhaust fan is off and exhaust damper is closed.
2. Heating hot water coil control valve is fully open in heating mode, otherwise it is closed.

1.10 **VRF / DUCTLESS SPLIT UNITS**

A. System Description
1. The VRF (variable refrigerant flow) system, which is comprised of indoor split units, and roof mounted condensing units provide (optional) heating and cooling through the unit's factory provided, internal controls.
2. For the units serving the corridors:
    a. Outdoor air dampers are open during occupied mode, and closed during unoccupied mode.
    b. Ducted heating hot water control valves and DX modulate to maintain space temperature.

1.11 **EXHAUST / MAKE-UP AIR SYSTEMS.**

A. System Components:
1. Exhaust system(s) (welding capture, dust collector, kitchen hoods)

2. Make-up air unit:
    a. Supply fan, constant volume with variable frequency drive for automatic balancing and outdoor air damper, 2-position.
    b. Furnace gas valve, modulating.

B. System Description:
1. Exhaust systems provide exhaust for welding capture, dust collector, and kitchen hoods. Make-up air units provide tempered make-up air upon the activation of the exhaust systems.

C. System Off:
1. Exhaust systems are off
2. Make-up air unit:
    a. Supply fan is off, and damper is closed.
    b. Furnace gas valve is closed.

D. System On:
1. Exhaust systems are activated on.
2. Make-up air unit:
    a. Supply fan is on, and damper is open.
    b. Furnace gas valve modulates to maintain discharge temperature of 65°F (adjustable).

1.12 EXHAUST FANS

A. System Components:
1. Exhaust fans, constant speed with ECM or VFD for balancing.

B. System Description:
1. Exhaust fans provide exhaust during occupied mode.

C. Occupied Mode:
1. Exhaust fans are on.

D. Unoccupied Mode:
1. Exhaust fans are off.

1.13 CABINET UNIT HEATERS AND PROPELLER UNIT HEATERS

A. System Components:
1. Unit Heater:
    a. Supply fan, constant speed.
    b. Heating hot water coil control valve, modulating.

B. System Description:
   1. Cabinet heaters provide heating.

C. System Off
   1. Cabinet Unit Heater:
      a. Supply fan is off.
      b. Heating hot water coil control valve is closed.

D. Start-Up
   1. Cabinet Unit Heater:
      a. Supply fan is on in heating mode, otherwise it is off.
      b. Heating hot water coil control valve is open in heating mode, otherwise it is closed.

E. Occupied Mode
   1. Cabinet Unit Heater:
      a. Supply fan is on in heating mode, otherwise it is off.
      b. Heating hot water coil control valve modulates to maintain occupied space temperature setpoint in heating mode, otherwise it is closed.

F. Unoccupied Mode:
   1. Cabinet Unit Heater:
      a. Supply fan cycles.
      b. Heating hot water coil control valve is open in heating mode, otherwise it is closed.

1.14 FINNED TUBE/RADIANT PANEL

A. System Components
   1. Finned tube/radiant panel control valve, modulating.

B. System Description
   1. Finned tube/radiant panel provides heat.

C. System Off
   1. Finned tube/radiant panel control valve is closed.

D. Start-Up:
   1. Finned tube/radiant panel control valve is open in heating mode, otherwise it is closed.

E. Occupied Mode

1. Finned tube/radiant panel control valve modulates to maintain occupied space temperature set point in heating mode, otherwise it is closed.

F. Unoccupied Mode
1. Finned tube/radiant panel control valve modulates to maintain unoccupied space temperature set point in heating mode, otherwise it is closed.

END OF SECTION 230993

This page intentionally left blank