



**Henry county Public Schools**  
45 Drewry Mason School Rd  
Ridgeway, VA 24148

# **ELEVATOR ADDITION**

## **Drewry Mason Elementary School**

**Henry county Public Schools**

# **VOLUME 2**

## **Project Manual**



**RRMM**  
**ARCHITECTS**

**RRMM Architects**  
28 Church Ave.  
Roanoke, Virginia 24016

Invitation for bid # **BID# 25-081933-3131**

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SECTION 220000 - PLUMBING GENERAL REQUIREMENTS

PART 1: GENERAL

1.1 DESCRIPTION:

- A. This section of the specifications shall be applicable to all phases of plumbing work covered by specifications and drawings issued for this project.
- B. The "General Conditions of the Contract," "Supplementary General Conditions," and all other similar general requirements issued for this project shall apply to all plumbing work and are hereby made a part of this section.
- C. The Contractor and/or his representatives shall be fully acquainted with the design and operation of the systems and equipment described in these specifications and on the drawings.
- D. Work included under this section shall include complete systems as shown on the plans and as specified. Provide supervision, labor, material, equipment, machinery, plant, and other items necessary to complete the plumbing systems. It is the intention of these specifications and drawings to call for finished work, tested, and ready for operation.
- E. Definitions:
  - 1. "Owner" and "Contractor" shall mean the respective parties to the prime contract governing the project. Only one contractor is recognized as a party to this contract. Where the terms "Plumbing Contractor" or "Subcontractor" are used, it is for convenience only.
  - 2. "Architect/Engineer" shall mean the firm and authorized representatives of the firm engaged by the Owner for architectural and engineering services related to this project.
  - 3. "Plumbing" shall mean all work related to plumbing systems including sanitary and storm drainage, domestic water, gas, compressed air, fuel oil, and similar systems, including all related components, accessories, controls, and miscellaneous work required for a complete system.
  - 4. "Contract Documents" shall mean and include the agreement, the drawings and specifications and all modifications thereto authorized by the Owner in writing prior to final completion of the project.
    - a. The term "Agreement" shall mean the completed and signed contract form.
    - b. The term "Drawings" shall mean the drawings prepared by the Architect/Engineer for specific use in bidding and execution of the work.
    - c. The term "Specifications" shall include the legal and procedural documents, the general conditions, special conditions, and the technical specifications.
    - d. The term "Technical Specifications" shall mean that part of the specifications which describes, outlines, and stipulates the kind and quality of the materials to be furnished, the quality of workmanship required, and the methods to be used in the construction under the contract. For convenience, the plumbing portions of the technical specifications are arranged into one general section and several detailed

sections related to the various trades represented in the work. Such arrangement and references shall not operate to make the Architect/Engineer an arbiter in establishing the limits of any subcontract or trade.

5. "Work" of the Contractor shall mean labor or materials or both.
6. "As shown," "as indicated," "as detailed," or words of similar import shall mean reference to the drawings included in the contract documents, unless stated otherwise.
7. "As directed," "as required," "as permitted," "approved," or words of similar import shall mean that the direction, requirement, permission, approval, or acceptance of the Architect/Engineer is intended unless stated otherwise.
8. "As necessary" shall mean that which is necessary to achieve satisfactory completion of the work in order to provide the intended function and form of the project in compliance with the contract documents.
9. "Provide" shall mean "provide complete and in place," that is "furnish and install," ready for beneficial occupancy by the Owner. Except where stated otherwise, description of any work in the contract documents shall mean that the work shall be provided by the Contractor, even though the words "provide" or "furnish and install" do not accompany the description.
10. "Similar" shall be interpreted in a general sense and not as meaning identical, and all related details shall be worked out in respect to their location and their connection with other parts of the work.
11. Exposed: Piping and equipment exposed to view in finished rooms.
12. Option or Optional: Contractor's choice of an alternate material or method.
13. "Sprinkler" shall mean all work related to fire suppression systems including sprinkler, standpipe, fire pump, and similar work, including all related components, accessories, controls, and miscellaneous work required for a complete system.

## 1.2 INTENT OF CONTRACT DOCUMENTS:

- A. The contract documents are complementary, and what is called for in one place shall be as binding as if called for in all places. Where variances occur between drawings and specifications or within either document itself, include in the contract price the item or arrangement of better quality, greater quantity, or higher cost. Agreement shall take precedence over the specifications and drawings. Figured dimensions shall be used in preference to scaling the drawings. In case of conflict between large and small scale drawings, the large scale drawings shall govern.
- B. The plumbing drawings show the general arrangement of all piping, equipment, and appurtenances and shall be followed as closely as actual building construction and the work of other trades will permit. The plumbing work shall conform to the requirements shown on the plumbing drawings. Architectural and structural drawings shall take precedence over plumbing drawings. Because of the small scale of the plumbing drawings, it is not possible to indicate all offsets, fittings, and accessories which may be required. The Contractor shall investigate the structural and finish conditions affecting the work and shall arrange his work accordingly, providing such fittings, valves, boxes, offsets, transitions, and other accessories as may be required to meet such conditions.

**1.3 CODES AND STANDARDS:**

- A. All materials and workmanship shall comply with all applicable codes, state and federal laws, local ordinances, industry standards, utility company regulations, and all other criteria which normally apply to work of this nature.
- B. In case of difference between building codes, state laws, federal laws, local ordinances, industry standards, utility company regulations, other criteria and the contract documents, the more stringent regulations will apply. The Contractor shall promptly notify the Architect/Engineer in writing of any such difference.
- C. If the Contractor performs any work that does not comply with these contract documents or the requirements of the applicable building codes, state laws, local ordinances, industry standards, utility company regulations, and other applicable criteria, he shall bear all costs arising in correcting the deficiencies.
- D. The standards referred to, except as modified in the specifications, shall have full force and effect as though printed in these specifications. The manufacturer and trades involved shall be familiar with the application of these standards.
- E. Applicable codes and standards shall include, but are not necessarily restricted to, the most recently recognized issues of the following:
  - 1. Building Codes:
    - a. Virginia Uniform Statewide Building Code
    - b. International Plumbing Code and accumulative supplements.
  - 2. Industry Standards, Codes, and Specifications:
    - a. AASHO American Association of State Highway Officials
    - b. ABA Architectural Barriers Act
    - c. ADA Americans with Disabilities Act
    - d. AGA American Gas Association
    - e. ANSI American National Standards Institute
    - f. ASHRAE American Society of Heating, Refrigeration, and Air Conditioning Engineers
    - g. ASME American Society of Mechanical Engineers
    - h. ASPE American Society of Plumbing Engineers
    - i. ASSE American Society of Sanitary Engineering
    - j. ASTM American Society of Testing and Materials
    - k. AWS American Welding Society
    - l. CISPI Cast Iron Soil Pipe Institute
    - m. CSA Canadian Standards Association
    - n. AWWA American Water Works Association
    - o. FS Federal Specification

p.	MSS	Manufacturer's Standardization Society of the Valve and Fittings Industry, Inc.
q.	NBS	National Bureau of Standards
r.	NEC	National Electrical Code
s.	NSF	National Sanitation Foundation
t.	PDI	Plumbing & Drainage Institute
u.	UL	Underwriters' Laboratories, Inc.
v.	UFAS	Uniform Federal Accessibility Standards (2012)

**1.4 GOVERNMENTAL FEES, PERMITS, AND INSPECTIONS:**

- A. Under each applicable section of the detailed plumbing specifications, the Contractor shall obtain and pay for all required licenses, permits, charges for connections to outside services, fees and inspections. Upon completion of the work under each section of the detailed plumbing specifications, the Contractor shall furnish a certificate of final inspection to the Architect/Engineer from the governmental inspection department having jurisdiction.

**1.5 VISITING THE SITE:**

- A. Each Contractor shall be responsible for visiting the site before bidding the job to familiarize himself with all existing conditions to be met in the execution of the work under this contract. No additional compensation will be allowed for any changes which may be required to make because of site conditions.

**1.6 QUALITY ASSURANCE:**

**A. Product Criteria:**

1. All materials shall be new and shall bear the manufacturer's name, trade name, and the UL label in every case where a standard has been established for this particular material. The equipment to be furnished shall be essentially the standard product of a manufacturer regularly engaged in the production of the required type of equipment and shall be the manufacturer's latest approved design. All equipment shall bear a permanent and legible factory-applied nameplate to permit identification of manufacturer, model number and type of unit.
2. Equipment Service: Products shall be supported by a service organization which maintains an adequate inventory of repair parts and is located, in the opinion of the Architect/Engineer, reasonably close to the site.
3. Multiple Units: When two or more units of materials or equipment of the same type or class are required, these units shall be products of one manufacturer to provide for uniform appearance, operation, and maintenance.
4. Assembled Units: Manufacturers of equipment assemblies, which use components made by others, assume complete responsibility for the final assembled product.

- B. Manufacturers' directions shall be followed in the delivery, storage, protection, and installation of all equipment and materials. The Contractor shall promptly notify the Architect/Engineer in writing of any conflict between any requirements of the contract documents and the written instructions before proceeding with the work. If the Contractor performs any work that does not comply with the manufacturers' directions or such written instructions from the Architect/Engineer, he shall bear all costs arising in correcting the deficiencies.
- C. Factory Start-up by the manufacturer's Factory Certified Representative shall be provided where required for each water heater or other equipment specified to have factory start-up. Letters signed by the Representative stating that their equipment has been started, tested, and is operating safely shall be submitted to the Owner as part of the bound Operations and Maintenance Instructions manual specified in section 2.10 CATALOG DATA FOR OWNER of this specification.

**1.7 BIDDING INSTRUCTIONS:**

- A. Products are generally specified by a performance specification and/or by manufacturer's name and model number or trade name.
- B. When specified only by a performance specification, the Contractor may use any manufacturer who meets the performance specification and applicable codes. (The Contractor shall be subject to the requirements of 1.9 - SHOP DRAWINGS.)
- C. When several products/manufacturers are specified together, then the Contractor has the option of using any product/manufacturer listed. The Contractor shall be subject to the requirements of 1.9 - SHOP DRAWINGS. The Contractor's bid shall be compiled on the use of the listed products without exception. Substitutions will only be considered after the contract has been executed and shall be subject to the requirements of 1.8 - SUBSTITUTIONS.
- D. When several products/manufacturers are specified together and the system design is based on one of the listed products by specific model number(s) or catalog number(s), then the Contractor has the option of using the one specific product or any other product/manufacturer listed. In either case, the Contractor shall be subject to the requirements of 1.9 - SHOP DRAWINGS. However, when the other listed product/ manufacturer is used, the Contractor shall be responsible for determining that the product(s) will be compatible with building design, electrical design, plumbing design, and the product(s) will not necessitate design modifications by the Architect/Engineer. The Contractor's bid shall be compiled on the use of the listed products without exception. Substitutions will only be considered after the Contract has been executed and shall be subject to the requirements of 1.8 - SUBSTITUTIONS. If the products/manufacturer are listed to be "only," then substitutions will not be considered.
- E. When only one manufacturer's name is listed, this shall be the basis of the bid. The Contractor's bid shall be compiled on the use of the listed product. Substitutions will only be considered after the Contract has been executed and shall be subject to the requirements of 1.8 - SUBSTITUTIONS.

**1.8 SUBSTITUTIONS:**

- A. Substitutions will not be considered during the bid.
- B. After the Contract has been executed, the Architect/Engineer will consider a formal request for a review of substituted products in place of those specified, under the following conditions:
  - 1. Not later than 30 days from the Contract Date, the Contractor shall provide a list of products proposed as substitutions, including the name, manufacturer, and section of the specifications governing the product.
  - 2. The request shall be accompanied by accurate cost data on the proposed substitutions indicating whether or not a modification of the Contract Sum is to be considered.
- C. Substitutions are understood to mean that the installing Contractor:
  - 1. Has personally investigated the proposed substitute and has determined that it is equal or superior in all respects to the item specified;
  - 2. Will provide the same guarantee for the substitution that he would for the item or equipment specified;
  - 3. Certifies that the cost data is complete and includes all related costs under this Contract, and waives all claims for additional cost related to the installation of the accepted substitute;
  - 4. Has coordinated the installation of the substitute, providing design modifications and changes as required for the work to be complete in all respects;
  - 5. Has coordinated the installation of the substitute with the General Contractor pertaining to changes required for the work to be complete with all trades and all changes shall be provided without additional cost to the Owner.
- D. The acceptance by the Architect/Engineer of any or all of those substitute items listed by the Contractor for review shall not constitute an approval of the substitute but shall mean that the Contractor may then submit detailed shop drawings for review.
- E. When a request for substitution is granted, shop drawings will be reviewed by the Architect/Engineer. Shop drawings not complete with proper review information will not be reviewed and will be returned unchecked. If after two submittals, the substitute equipment is not approved, the specified equipment shall be provided.

**1.9 SHOP DRAWINGS:**

- A. Shop Drawings are required for all material and equipment that is specified by a manufacturer's name or as indicated in the technical specifications. Furnish the number of copies required by the General and Special Conditions of the Contract, preferably one digital (pdf) copy. Submittal data for related equipment shall be submitted at one time.



- B. Substitutions will not be considered if:
  - 1. They are indicated or implied on shop drawing submissions without information specified in 1.8 - SUBSTITUTIONS.
  - 2. They require a substantial revision of the Contract Documents in order to accommodate their use.
- C. Identify submittals with PROJECT NAME and NUMBER, CONTRACTOR'S NAME, SECTION NUMBER & NAME, and PARAGRAPH NUMBER of SPECIFICATION GOVERNING, MANUFACTURER, MODEL or STYLE, and CONTRACTOR's REVIEW STAMP. Submittals shall be detailed, dimensioned drawings showing construction, size and arrangement, service clearances, performance characteristics, and capacity. Submittals not properly identified or containing information of a general nature will not be reviewed and will be returned unchecked.
- D. Where submittals are provided that include multiple types or styles of the specified item and/or multiple options, THE EXACT ITEM AND OPTIONS BEING SUBMITTED SHALL BE CLEARLY MARKED ON THE SUBMITTAL SHEET.
- E. Submittals shall include manufacturers' standard warranty information for the products being submitted.
- F. Acceptance of shop drawings shall not be considered as a guarantee of measurements or building conditions. Acceptance shall not relieve the Contractor from the responsibility or necessity of furnishing material or performing work required by the drawings and specifications. Submittal data on any one item shall not be reviewed more than three (3) times. If not accepted after the third review, the Contractor shall provide the equipment upon which the design was based.
- G. Failure to submit shop drawings in ample time for checking shall not entitle an extension of contract time, and no claim for extension by reason of such default will be allowed.
- H. No material or equipment, for which submittals are required, may be delivered to or installed at the job site until submittals have been accepted.
- I. Unless a specific finish is indicated in the contract documents, wherever a choice of finish is available for the specified item, submit accurate color chips or charts to the Architect for review and selection.

## **PART 2: PRODUCTS**

### **2.1 DRIVE GUARDS:**

- A. For machinery and equipment, provide guards as shown in AMCA 410 for belts, chains, couplings, pulleys, sheaves, shafts, gears and other moving parts regardless of height above the floor. Drive guards may be excluded where motors and drives are inside factory fabricated unit casings.

- B. Materials: Sheet steel, cast iron, expanded metal or wire mesh rigidly secured so as to be removable without disassembling pipe, duct, or electrical connections to equipment.
- C. Access for Speed Measurement: One inch diameter hole at each shaft center.
- D. Lubrication: Guards shall not interfere with lubrication of equipment.

## 2.2 PAINTING:

- A. General - Paint plumbing equipment and material in Equipment Rooms and utility type areas and located outside of the building or on the roof. Painting of equipment and material in finished rooms or areas shall be accomplished as described in PAINTING Section of the Architectural Specifications. Painting in concealed spaces shall be limited to equipment and materials not otherwise protected from rusting such as hangers and supports. Paint shall be products of Sherwin-Williams, Pittsburgh, or Pratt-Lambert. All paints, finishes and coatings shall comply with Green Seal Standards GS-03, GS-11, and SCAQMD Rule #1113 VOC limits for paints and coatings.
- B. Workmanship - The work shall be accomplished by workmen skilled in the painting trade after testing is complete and systems are ready for operation. Surfaces to be painted shall be completely dry before applying paint. Surfaces shall not be painted when the temperature is below 50 Deg. F or above 120 Deg. F, or when they are exposed to hot sun. Materials shall be evenly spread and smoothly flowed on without runs or sags. Each coat shall be thoroughly dry before application of succeeding coat. The painters shall protect adjacent surfaces with drip covers during the process of painting. Upon completion, paint spots, if any, shall be removed from adjacent surfaces.
- C. Preparation of surface - Metal surfaces shall be cleaned with solvent before applying materials. Rust and scale shall be removed by wire brushing or sanding. Galvanized surfaces shall be pretreated with a phosphoric acid cleaning solution and primed with Sherwin-Williams "Galvanized Iron Primer."
- D. Painting - After preparation as described above, each item shall be painted as follows, except color of paint for equipment and material located outside of the building or on the roof shall be as selected by the Architect.
  - 1. Painting is not required of equipment, equipment supports, and hangers with a factory-finish coat. Patch painting is required of any damaged areas to match factory-finish coat. Painting is required where equipment or equipment supports do not have factory-finish paint. Equipment and associated hangers and supports shall be primed with one coat of alkyd, zinc potassium chromate metal primer, except insulated surfaces shall be primed with one coat Sherwin-Williams "Wall Primer and Sealer." Finish with two coats of Sherwin-Williams "Metalastic II-Steel Gray" Enamel. Exterior of belt guards and other protective guards shall be finished with two coats of machinery enamel in OSHA yellow color. Interior of items covered by belt guards and other protective guards shall be

finished with two coats of machinery enamel in OSHA orange color. Nameplates on equipment shall not be painted.

2. Exposed pipes, conduits, and associated hangers exposed in equipment rooms and other unfinished areas such as storage areas shall have two finish coats of paint of the same color as adjacent walls or ceilings. Bare copper pipe shall not be painted. Canvas or paper jacket insulation of pipes exposed in unfinished areas shall be primed with Sherwin-Williams "Wall Primer and Sealer" before final two coats of paint. Hangers and supports in concealed areas not protected by factory-finish paint shall have one coat of Sherwin-Williams "Kromik Metal Primer."
3. All exposed gas piping and fittings, interior and exterior, shall be painted, coated or wrapped as described in Section 22 60 00 and this section as applicable.

E. Identification of pipes and equipment:

1. Equipment - Each piece of equipment shall be identified by stenciled marking that will read the same as the identification shown on plumbing drawings. Stencil letters shall be 2 inches high upper case painted with Sherwin-Williams "Metalastic II" white enamel.
2. Pipes and conduit - Color bands shall be painted on each pipe or conduit where exposed or accessible. Bands shall be 1-1/2 inches wide and shall be placed every 15 feet maximum along the pipe or conduit. Color bands shall be Sherwin-Williams "Kem Lustral" enamel as shown in the following color code schedule and chart. Provide color code chart, framed with glass front, sized appropriately for number of colors used. Post in mechanical room where directed by Engineer.
3. Color code schedule

**COLOR BANDING CODE**

Number	Color	Catalog Number
1.	Orange	No. F65 E 36
2.	Blue	No. F65 L 3
3.	Brown	No. F65 N 11
4.	Red	No. F65 R 1
5.	Black	No. F65 B 1
6.	Yellow	No. F65 Y 48
7.	Green	No. F65 G 40

4. Pipe shall be identified with flow arrows as described below
  - a. Arrows shall be stencil type.
  - b. Arrows shall be readable from floor.
  - c. Arrows shall be installed every 15'-0" maximum.
  - d. Arrows shall be painted on pipes.

- F. Identification of Valves: Properly mark service and control valves. Valve markers shall be metal tags with designations stamped thereon or laminated engraved plastic chained with jack chains (not beaded chains) to their respective valves. Identification symbols or designations shall be the same as shown on the Contract Documents.

- G. Equipment locations above acoustic tile ceilings: Provide colored brass push-pins complete with a minimum 1/2" shank and 5/8" diameter head. Pin head color shall be blue or color as selected by Architect or Owner. Locate push-pins directly below all scheduled plumbing equipment.

**2.3 MOTORS, CONTROL, ELECTRICAL WIRING AND POWER REQUIREMENTS:**

- A. Provide motors in accordance with NEMA Standards and suitably designed to match the starting and running characteristics of the driven equipment. Unless indicated otherwise, motors less than 1/2 horsepower shall be wound for 120 volt, single phase, 60 hertz. Motors 1/2 horsepower and above, unless indicated otherwise, shall be wound for three phase, 60 hertz, 200 volt, 208 volt, 230 volt, or 460 volt as required by the system voltage. Select motors coordinated with the utilization voltage and phase. Motors for equipment with VFD shall be matched to the VFD.
- B. All starters and safety switches, except for those specified to be furnished with the plumbing equipment, shall be furnished as part of the Electrical Work - Division 26.
- C. Starters and safety switches furnished with the plumbing equipment shall comply with the specifications of Division 26. Starters furnished as an integral part of the plumbing equipment shall be complete with properly sized overload heaters. Integral 3-phase motor starters and VFD's shall be provided with phase loss relay as specified in Division 26.
- D. Domestic water temperature control wiring, equipment control wiring, and interlock wiring necessary for the proper sequence of operation of plumbing equipment shall be furnished as part of the Plumbing Work, [Section 22 33 00 - DOMESTIC WATER HEATERS] [and [Section 22 11 23 - PLUMBING PUMPS]. Control wiring is any wiring, regardless of voltage, related to plumbing equipment that is not the equipment power circuit from the circuit breaker in the panelboard to the motor starter or safety disconnect switch and to the motor or equipment junction box. Where control devices (On-Off switch, Aquastat, etc.) that are intended to interrupt the motor or equipment power circuit are provided by the Plumbing Contractor and are mounted other than on or directly adjacent to the controlled equipment, the Plumbing Contractor shall provide wiring through these devices regardless of voltage or phases. All wiring shall conform to applicable sections of Divisions 26, 27, and 28 of the specifications. All low voltage control wiring in inaccessible areas or in exposed areas shall be in metal conduit and shall comply with the specifications of Divisions 26, 27, and 28. All low voltage control wiring in unexposed, accessible areas shall be wire in conduit or U.L. approved plenum rated cable supported from the structure with ties spaced 3'-0" on center. All 120 volt wiring shall be wire in conduit and shall comply with the specifications of Divisions 26, 27, and 28 of the specifications.
- E. All equipment that has electrical connections shall have wiring terminals/connectors rated for not less than 75 deg. C. If terminals/connectors are provided that are rated for less than 75 deg. C., the mechanical contractor shall incur all costs associated with upsizing wire and conduit as required by the National Electrical Code.

- F. Voltage requirements for equipment that has electrical connections shall comply with the following voltage ranges as listed in ANSI C8.4.1, Voltage Tolerance Standard:
- 480 Volt Equipment: Utilization Voltage Range = 504 Volts to 440 Volts.
  - 277 Volt Equipment: Utilization Voltage Range = 291 Volts to 254 Volts.
  - 208 Volt Equipment: Utilization Voltage Range = 281 Volts to 191 Volts.
  - 120 Volt Equipment: Utilization Voltage Range = 126 Volts to 110 Volts.
- G. Equipment that has voltage requirements which fall outside of the above values shall be provided with special power conditioning equipment as required to maintain the necessary voltage ranges to the equipment. Such conditioning equipment shall be provided by the equipment manufacturer as part of the equipment package at no additional cost to the owner.

**2.4 FIRE-STOPPING:**

- A. Pipe penetrations of rated walls, floors, and floor-ceiling assemblies shall be constructed in accordance with Underwriter's Laboratories, Inc., Fire Resistance Directory, Volume II, Hourly Ratings for Through Firestop Penetrations. The Contractor shall provide U.L. firestop penetrations according to the particular wall, floor, or floor-ceiling assembly rating, construction type, pipe material, pipe size, insulation requirements, sleeve requirements, and the contractor's choice of firestop products as listed by U.L. Refer to the architectural drawings for the wall, floor, or floor-ceiling assembly construction types and ratings.

**2.5 PIPE AND EQUIPMENT SUPPORTS AND RESTRAINTS:**

- A. Under each applicable section of the detailed plumbing specifications, the Contractor shall furnish and install all accessories, connections, bases, guards, supports, and incidental items necessary to fully complete the work, ready for use, occupancy, and operation by the Owner.
- B. Type Numbers Specified: MSS SP-58; for selection and application, MSS SP-69. Refer to Division 05, METALS, for miscellaneous metal support materials and prime coat painting.
- C. For Attachment to Concrete Construction:
1. Concrete Insert: MSS SP-69, Type 18
  2. Self-Drilling Expansion Shields and Machine Bolt Expansion Anchors: Fed. Spec. FF-S-325, permitted in concrete not less than four inches thick. Applied load shall not exceed one-fourth the proof test load listed in Fed. Spec. FF-S-235.
  3. Power-Driven Fasteners: Permitted in existing concrete or masonry not less than four inches thick when approved by the Architect/ Engineer for each job condition. Use fasteners capable of supporting a 1000 pound test load, with the actual load not exceeding 50 pounds.
- D. For Attachment to Steel Construction; MSS SP-69:
1. Welded Attachment: Type 22.

2. Beam Clamps: Types 20, 21, 28 or 29. Type 23 C-clamp may be used on steel beams only for individual copper tubing up to 7/8-inch outside diameter. Beam clamps on steel joists shall be concentric loading type. Beam clamps that are attached to only one side of a joist are NOT acceptable.
- E. Attachment to Metal Pan or Deck: As required for materials specified in Division 05 - METALS.
- F. For Attachment to Wood Construction: Wood screws or lag bolts.
- G. Hanger Rods: Hot-rolled steel, ASTM A 36 or A 575 for allowable load listed in MSS SP-58. For piping, provide adjustment means for controlling level or slope. Types 13 or 15 turnbuckles shall provide 1-1/2 inches minimum of adjustment and incorporate locknuts. All-thread rods are acceptable.
- H. Multiple (Trapeze) Hangers: Galvanized, cold formed, lipped steel channel horizontal member, not less than 1-1/2 inches by 1-1/2 inches, No. 12 gage, designed to accept special spring held, hardened steel nuts. Not permitted for condensate piping, fire and sprinkler piping or chemical waste drain piping.
  1. Allowable Hanger Load: Manufacturers rating less 200 pounds.
  2. Guide individual pipes on the horizontal member of every other trapeze hanger with 1/4-inch U-bolt fabricated from steel rod. Provide Type 40 insulation shield, secured by two 2-inch galvanized steel bands, for insulated piping at each hanger.
- I. Pipe Hangers and Supports: Use hangers sized to encircle insulation on insulated piping. Refer to Section 22 07 00 - PLUMBING INSULATION, for insulation thickness. To protect insulation, provide Type 39 saddles for roller type supports. Provide Type 40 insulation shields at all other types of supports and hangers including those for pre-insulated piping.
  1. General Types (MSS SP-69):
    - a. Standard Clevis Hanger: Type 1; provide locknut
    - b. Riser Clamps: Type 8 or 42
    - c. Wall Brackets: Types 31, 32, or 33
    - d. Saddle Support: Type 36, 37, or 38
    - e. Roller Support: Type 41, 43, or 46
    - f. Turnbuckle: Types 13 or 15
    - g. U-Bolt Clamp: Type 24
    - h. For Uninsulated Copper Tube: Material compatible for use with copper to prevent electrolysis
    - i. Supports for Plastic or Glass Piping: As recommended by the pipe manufacturer
  2. Plumbing Piping:
    - a. Sprinkler System: NFPA or Factory Mutual approved types.
    - b. Horizontal Piping: Types 1, 5, 7, 9, and 10
    - c. Chrome Plated Piping: Chrome plated supports

- d. Hangers and Supports in Pipe Chase: Prefabricated system ABS self-extinguishing material, not subject to electrolytic action, to hold piping, prevent vibration, and compensate for all static and operational conditions
  - e. Blocking, Stays and Bracing: Angle iron or preformed metal channel shapes, 18 gage minimum
- J. Support hubless cast iron pipe and fittings per CISPI 301-12. Brace hubless cast iron pipe and fittings 5 inches and larger using Holdrite 117 Series No-Hub Pipe and Fitting Restraints or approved equal.
- K. Concrete Equipment Bases: Unless otherwise noted on the drawings or in the specifications, concrete pads and bases not less than 4 inches high and which project not less than 3 inches beyond the equipment on all sides shall be provided for pumps, compressors, water heaters, tank supports, and other similar floor-mounted equipment which normally requires foundations. Concrete shall conform to requirements in the concrete section of these specifications. The trade responsible for the supported equipment shall establish sizes and locations of the various concrete bases required and shall provide all necessary anchor bolts, together with templates for holding these bolts in position. Anchor bolts shall be placed in steel pipe sleeves to allow for adjustment, with a suitable plate at bottom end of sleeve to hold the bolt. When indicated in the drawings or detailed specifications, other floor-mounted items of equipment shall have a similar concrete base. Special vibration isolation foundations that are required are specified in the detailed specifications.

**2.6 PIPE SLEEVES:**

- A. Locate sleeves during normal course of work. Provide sleeves for piping and conduit passing through concrete floor slabs and concrete, masonry, tile, and gypsum wall construction. Sleeves shall not be provided for piping and conduit running embedded in concrete or slab on grade, except that copper piping shall require sleeves through slabs on grade. Sleeves through structural members shall be only as directed by Architect. In interior wall, provide 1/4 inch space all around between sleeve and conduit, piping, or insulation of piping.
- B. Sleeves placed in exterior walls below grade shall be O.Z. Gedney Type 'FSK', Thunderline 'LINK SEAL', Polywater PGKD Series or equal sleeve assemblies sized for the pipe or conduit encountered, except for cast iron piping. Sleeve assembly shall provide watertight seal and electrical insulation to reduce cathodic reaction. When a sleeve passes through a wall below a concrete slab on grade, the sealing assembly shall be on the outside of the wall. When a sleeve passes through a wall into a crawl space or the building interior, the sealing assembly shall be in the crawl space or interior of the building. Provide sleeve assembly for copper piping through slab on grade, with sealing assembly located on interior side of floor slab. Where cast iron pipes pass through an exterior wall below grade, provide an iron-pipe sleeve two (2) pipe sizes greater than pipe passing through. Caulk between pipe and sleeve with a rubber-based compound.
- C. Where sleeves are located through fire-rated walls and floor/ceiling assemblies, provide sleeves and protect the penetration in accordance with Underwriter's Laboratories, Inc., Fire Resistance Directory, Volume II, Ratings for Through Firestop Penetrations.

- D. Sleeves in mechanical rooms with floor drains or hose bibbs shall extend 4 inches above floor. Provide flanges or flashing rings with sleeves in floors with waterproof membrane and clamp or flash into the membrane. Provide sleeves flush with floor in other rooms.
- E. Sleeves shall be constructed of 20 gage galvanized sheet steel with lock seam joints for all sleeves set in concrete floor slabs terminating flush with the floor. All other sleeves shall be constructed of galvanized steel pipe unless otherwise indicated.
- F. Fasten sleeves securely in floors or walls so that they will not become displaced when concrete is poured or when other construction is built around them. Take precautions to prevent concrete, plaster, or other materials from being forced into the space between pipe and sleeve during construction.
- G. All penetrations through exterior walls shall be sealed. Caulk above grade penetrations with a rubber-based compound.

**2.7 WALL, FLOOR AND CEILING PLATES (ESCUTCHEONS):**

- A. Material and Type: Chrome plated brass or chrome plated steel, one piece or split type with concealed hinge, with setscrew for fastening to pipe, or sleeve. Use plates that fit tight around pipes, cover openings around pipes, and cover the entire pipe sleeve projection on all pipes including sanitary rough-ins. Escutcheons for sprinkler heads shall be threaded.
- B. Thickness: Not less than 3/32-inch for floor plates. For wall and ceiling plates, not less than 0.025 for up to 3-inch pipe, 0.035 for larger pipe.
- C. Locations: Provide at all locations where pipe penetrates floors, walls and ceilings in exposed locations, except mechanical rooms.

**2.8 ACCESS PANELS:**

- A. Under each applicable section of the detailed plumbing specifications, the Contractor shall provide access panels in all locations where required for access to concealed valves, traps, air cushions, controls, and any other equipment or materials requiring inspection or maintenance. Access panels shall be of adequate size and properly located so that concealed items will be readily accessible for servicing or for removing and replacing if necessary, except as indicated or specified otherwise. Access panels are not required in ceilings formed of removable acoustical panels.
- B. Access panels that are not fire-rated shall be Milcor or equal. Provide modular-sized access panels in inaccessible acoustic tile ceilings sized according to the tile size. Provide Milcor metal access panels with cam lock, continuous hinge and mounting trim to match finish encountered. Provide natural anodized aluminum finish for panels in kitchens and toilets. Provide prime finished steel for panels in other areas. Paint panels in finished areas to match finish surface.



- C. Where indicated and where access panels are installed in walls of shafts that are not sealed at each floor, access panels shall be Milcor or equal "Fire-Rated" and shall bear the Underwriters' Laboratories, Inc. Class B, 1-1/2 hour label. Openings shall be framed in accordance with the access panel manufacturer's recommendations. Frames shall be not lighter than 16-gage steel. Panels shall be not lighter than 20-gage steel and shall be insulated sandwich type. Panels shall have a continuous hinge, self-lubricating lock, a direct action-knurled knob, and an interior latch release mechanism.

**2.9 CHARTS, DIAGRAMS, AND SCHEMES:**

- A. Charts, diagrams, and schemes listed below shall be provided under each applicable section of the detailed plumbing specifications by the Contractor, framed under glass, and installed where shown on the drawings or directed in the field. All charts, diagrams, and schemes shall be complete, neat, clear, legible, and permanent.
- B. Valve identification chart with typewritten schedule of all valves giving their tag number, description, location in building via room number, system served, and normal operation position.
- C. Piping schemes where required by the detailed specifications.

**2.10 CATALOG DATA FOR OWNER:**

- A. Furnish one (1) bound copy or one (1) digital file (pdf format) of all Catalog Data on each manufactured item of equipment used in the mechanical work, complete with index listing the products alphabetically by name, together with the names and addresses of manufacturers, sales, and service representatives. Furnish two (2) bound copies or one (1) digital file (pdf format) of all Operating and Maintenance Instructions of each item of equipment. A single comprehensive file or digital file of all Catalog Data and Operating and Maintenance Instructions shall be submitted to the Engineer for review prior to transmittal to the Owner. Single sections or multiple files will not be reviewed.

**2.11 RECORD OF AS-BUILTS AND CONDITIONS:**

- A. Provide a complete set of prints and electronic version of plumbing plans marked to indicate as-built conditions which are different from those shown on the original construction documents. Site as-built conditions which are different from the construction documents shall be dimensioned from building or identifiable marker. Accurate locations of all concealed utility lines, both interior and exterior shall be recorded. These drawings shall be delivered to the Architect/Engineer before being turned over to the Owner.

**PART 3: EXECUTION**

**3.1 INSTALLATION:**

**A. Coordination of Work:**

1. The Contractor shall compare the plumbing drawings and specifications with the drawings and specifications of other trades, and shall report any discrepancies between them to the Architect/Engineer, and shall obtain from him written instructions for changes necessary in the plumbing work. The plumbing work shall be installed in cooperation with other trades installing interrelated work. Before installation, the Contractor shall make proper provision to avoid interferences in a manner approved by the Architect/Engineer. All changes required in the work of the Contractor caused by his neglect to do so shall be made by him at his own expense.
2. Anchor bolts, sleeves, inserts, and supports that may be required for the work shall be fully coordinated and compatible with the related equipment or materials. Locations shall be determined by the trade installing the related equipment or materials.
3. Slots, chases, openings, and recesses through floors, walls, ceilings, roofs, and partitions shall be located by the trades requiring them.
4. Locations of pipes, equipment, fixtures, etc., shall be adjusted to accommodate the work to interferences anticipated and encountered. The installing Contractors shall coordinate their work to the building structure and to other trades as directed by the General Contractor. No additional compensation or extension of completion time will be granted for extra work caused by a lack of coordination. The installing Contractor shall provide dimensions and locations of all openings, shafts, and similar items to the General Contractor for his coordination and execution. Work shall be installed as required so as not to interfere with or delay the building construction. Pipes, etc., shall be concealed above ceilings, in walls, or in floors as applicable in all areas of the building except in equipment rooms, unfinished storage rooms, or other areas specifically noted to the contrary.
  - a. Right-of-Way: Lines which pitch shall have right-of-way over those which do not pitch. For example, plumbing drains shall normally have right-of-way. Lines whose elevations cannot be changed shall have the right-of-way over lines whose elevations can be changed.
  - b. Offsets, transitions, and changes in direction of pipes shall be made as required to maintain proper head room and pitch of sloping lines whether or not indicated on the drawings. The Contractor shall furnish and install all traps, drains, sanitary vents, etc., as required to affect these offsets, transitions, and changes in direction.
5. Exact locations of items shall be coordinated with each other, the building structure, and architectural features thereof so as to be aligned with or centered on other items as applicable. Locations indicated on the drawings are approximate. Trades shall coordinate their work with door swings, block coursing, tile arrangement, required clearances and other similar features before establishing the location of any components. Before any related work has begun, the Architect/Engineer may direct reasonable minor changes in equipment locations with no increase in contract price to the Owner. Before roughing in conduit or pipe, verify the location of equipment to be connected.

6. Installation and Arrangement: The Contractor shall install all plumbing work to permit removal of all parts requiring periodic replacement or maintenance. The Contractor shall arrange pipes and equipment to permit ready access to valves, cocks, traps, motors, control components, and to clear the openings of swinging and overhead doors and of access panels.
7. Drawings by Contractor: When directed by the Architect/Engineer, the Contractor shall submit for review by Architect/Engineer drawings clearly showing certain portions of the plumbing work and its relation to the work of other trades before beginning shop fabrication or erection in the field.
8. Dimensions: The Contractor shall ensure that items to be furnished fit the space available. He shall make necessary field measurements to ascertain space requirements, including those for connections, and shall furnish and install such sizes and shapes of equipment that the final installation shall suit the true intent and meaning of the drawings and specifications. If he concludes that there is insufficient space for installation or specified materials, he shall immediately notify the Architect/Engineer of the conflict and shall stop affected work until he receives instructions as to how to proceed from the Architect/Engineer.
9. Damage to Work: The Contractor is responsible for damage caused by his work or workmen. Repairing of damaged work shall be done by the Contractor as directed by the Engineer at no additional cost.
10. Connections to Existing Facilities, Piping Systems, Etc: All connections to existing facilities, piping systems, etc., shall be made as required or deemed necessary to ensure the maintenance of continued operation of the above and provide the very minimum of interruption. This Contractor shall make such temporary connections as may be required to facilitate this work and to protect the existing building from damage. Any work which will in any way affect the continued operation of any existing facility shall be coordinated with the proper authorities as well as the Architect-Engineer before any service is interrupted.
11. The Contractor shall be responsible for any interruptions to existing services and shall repair any damages to existing systems caused by his operations.

**B. Protection and Cleaning:**

1. Equipment and materials shall be carefully handled, properly stored, and adequately protected to prevent damage before and during installation, in accordance with the manufacturer's recommendations. Damaged or defective items, in the opinion of the Architect/Engineer, shall be replaced.
2. All items subject to moisture damage (such as controls and electrical equipment) shall be stored in dry, heated spaces.
3. Protect all finished parts of equipment, such as shafts and bearings where accessible, from rust prior to operation by means of protective grease coating and wrapping. Close pipe openings with caps or plugs during installation. Tightly cover and protect fixtures and equipment against dirt, water, chemical or mechanical injury. Clean plumbing equipment to remove dust, oil, dirt, plaster, mortar, trash, or paint. Piping and conduit shall be blown out or flushed of all foreign matter before wires are pulled in or before connections are made to equipment or systems.

- C. Protection of Electrical and I.T. Equipment: Plumbing and sprinkler piping and any other piping containing liquids shall NOT be installed directly over electrical panelboards, switchboards, I.T. equipment or motor control centers, unless the pipe is a minimum of 6 feet above the electrical equipment or above a structural ceiling (concrete cap or similar). If compliance with this requirement is not possible, notify the engineer immediately. If the piping is directly above and at least 6 feet above the electrical equipment, provide a galvanized steel drain pan installed directly under the piping. Drain pan shall have minimum 2 inch high sides with a drain pipe connection at the lowest point and shall be full width of the electrical equipment being protected. Extend drain pipe to exterior or to nearest floor drain.
- D. Concrete and Grout: Use concrete and shrink compensating grout 3000 psi minimum.
- E. Work in Existing Building:
  - 1. Cut required openings through existing masonry and reinforced concrete using diamond core drills. Use of pneumatic hammer type drills, impact type electric drills, and hand or manual hammer type drills will be permitted only with approval of the Architect/Engineer. Locate openings that will least effect structural slabs, columns, ribs or beams. Refer to the Architect/Engineer for determination of proper design for openings through structural sections and opening layouts approval, prior to cutting or drilling into structure. After Architect/Engineer's approval, carefully cut opening through construction not larger than is absolutely necessary for the required installation.
  - 2. Remove existing work as necessary to install new work. Except as otherwise shown or specified, do not cut, alter or remove any structural work or any ducts, plumbing, steam, gas or electric work without approval of Architect/Engineer. Existing work (walls, ceilings, partitions, floors, mechanical, and electrical work) disturbed or removed as a result of performing required new work shall be patched, repaired, reinstalled, replaced with new work, and refinished and left in as good condition as existed before commencing work. Existing work to be altered or extended that is found to be defective in any way shall be reported to the Architect/Engineer before it is disturbed. Materials and workmanship used in restoring work shall conform in type and quality to that of original existing construction, except as otherwise shown or specified.
  - 3. Continuity of service shall be maintained to all existing systems, except for designated short intervals during which connections are to be made. Interruptions shall be coordinated with the Owner as to the time and duration.
  - 4. Upon completion of contract, deliver work complete and undamaged. Damage that is caused by Contractor or Contractor's workmen to existing structures, grounds, or utilities or to work done by others shall be repaired by Contractor and left in as good condition as existed prior to damaging.
    - a. At Contractor's own expense, Contractor shall immediately restore to service and repair any damage caused by Contractor's workmen to existing piping and conduits, wires, cable, etc., of utility services or of fire protection system and communications systems (except telephone) which are not scheduled for discontinuance or abandonment.
    - b. Restoration work required by damage to telephone systems shall be done by telephone company at Contractor's expense.

**3.2 GENERAL PIPING INSTALLATION:**

- A. Under each applicable section of the detailed plumbing specifications, the Contractor shall furnish and install as shown on the drawings or as necessary to complete the working system in accordance with the intent of the drawings and specifications, a complete system of piping, valves, supports, anchors, sleeves, and all other appurtenances. The piping drawings are diagrammatic and indicate the general location and connections. The piping may have to be offset, lowered, or raised as required or as directed at the site. This does not relieve the Contractor of responsibility for the proper erection of systems of piping in every respect suitable for the work intended as described in the specifications and as approved by the Architect/Engineer. Wherever two dissimilar metals join in any piping system, install a dielectric fitting at their intersection.
- B. Erection: Piping shall be properly supported and adequate provisions shall be made for expansion, contraction, slope, and anchorage without damage to joints or hangers. All piping shall be cut accurately for fabrication to measurements established at the construction site. Pipe shall be worked into place without springing and/or forcing, properly clearing all windows, doors, and other openings and equipment. Cutting or other weakening of the building structure to facilitate piping installation will not be permitted without written approval. Pipe extending through the roof shall be properly flashed. All changes in direction shall be made with fittings. Wherever pipe hanger bears directly on the pipe being supported, the hanger shall be of the same material as the pipe.
- C. Arrangement: All piping shall be arranged so as not to interfere with removal of other equipment or devices nor to block access to doors, windows, manholes, or other access openings. Piping shall be arranged so as to facilitate removal of tube bundles. Flanges or unions, as applicable for the type of piping specified, shall be provided in the piping at connections to all items of equipment. Piping shall be placed and installed so that there will be no interference with the installation of the equipment, ducts, etc. All piping shall be installed to ensure noiseless circulation. All piping shall be erected and pitched to ensure proper drainage. Piping shall be installed so as to avoid liquid or air pockets throughout the work. Pipe in finished areas shall be concealed. Install piping generally parallel to walls and column centerlines, unless shown otherwise on the drawings. Space piping, including insulation, to provide one inch minimum clearance between adjacent piping or other surface. Pipe shall be installed to permit free expansion and contraction without damage to joints or hangers. Exposed piping shall be installed in practical alignment with the building. All valves and specialties shall be placed to permit easy operation and access, and all valves shall be regulated, packed, and glands adjusted at the completion of the work before final acceptance. Water pipes shall not be installed in attic spaces, crawl spaces, exterior walls or similar areas which are subject to freezing, unless indicated to be heat traced.
- D. Installation of Underground Pipe: Each pipe shall be laid true to line and grade and in such manner as to form a close concentric joint with adjoining pipe and to prevent sudden offsets to flow line. As work progresses, the interior of the pipe shall be cleared of dirt and superfluous materials of every description. Where cleaning after laying is difficult because of small pipe size, a suitable swag or drag shall be kept in the pipe and pulled forward past each joint immediately after jointing has been completed. Trenches shall be kept free from water until

pipe jointing material has set. Pipe shall not be laid when the condition of the trench or weather is unsuitable for such work. At all times when work is not in progress, all open ends of pipe and fittings shall be securely closed so that no water, earth, or other substance will enter the pipe or fittings.

### **3.3 PIPE AND EQUIPMENT SUPPORTS:**

- A. Supports: The Contractor shall support plumb, rigid, and true to line all work and equipment furnished under each section of these specifications. The Contractor shall study thoroughly all general, structural, and plumbing drawings, shop drawings, and catalog data to determine how equipment, fixtures, piping, ductwork, etc., are to be supported, mounted, or suspended, and shall provide extra steel bolts, inserts, pipe stands, brackets and accessories for proper support, whether or not shown on the drawings. When directed, the Contractor shall submit drawings showing supports for review by the Architect/Engineer.
- B. Where hanger spacing does not correspond with joist or rib spacing, use structural steel channels secured directly to joist and rib structure that will correspond to the required hanger spacing, and then suspend the equipment and piping from the channels. Drill or burn holes in structural steel only with the prior approval of the Architect/Engineer.
- C. Use of chain, wire or strap hangers; wood for blocking stays or bracing; or hangers suspended from piping above will not be permitted. If products are rusty, replace or thoroughly clean and coat with prime paint.
- D. Use hanger rods that are straight and vertical. Turnbuckles for vertical adjustments may be omitted where limited space prevents use. Provide a minimum of 2-inch clearance between pipe or pipe covering and adjacent work. Pipe hanger rods shall be attached to the top chord only on steel joists and beams by joist or beam clamps, without welding. Where clamps cannot be attached to the top chord of joists or beams, trapeze hangers shall be provided.
- E. Horizontal Pipe Support Spacing:
  - 1. Cast Iron: Five feet on centers maximum spacing. At least one hanger on each full length of pipe, close to hub where possible and at least one within 24 inches of each fitting, and wherever else required to prevent tendency toward deflection due to load. Provide a hanger at upper angle at each drop. Locate hangers adjacent to hubs on multiple fittings not more than four feet on centers.
  - 2. Plastic and Glass Pipe: Support in accordance with manufacturer's recommendations.
  - 3. For support spacing of all other horizontal piping, refer to MSS SP-69 and provide additional supports at valves, strainers, inline pumps and other heavy components. Provide a support within one foot of each elbow.
- F. Vertical Pipe Supports--Cast Iron Stacks: Base of stacks shall be supported on concrete, brick in cement mortar, or metal brackets permanently attached to building structure. Support stacks on each building floor structure, but not to exceed 15 feet spacing.

- G. Connections: All piping connecting to pumps and other equipment shall be installed without strain at the piping connection. The Contractor shall be required as directed to remove the bolts in flanged connections or to disconnect piping to demonstrate that piping has been so connected.

**3.4 MOTOR AND DRIVE ALIGNMENT:**

- A. Belt Drive: Set driving and driven shafts parallel and align so that the corresponding grooves are in the same plane.
- B. Direct-Connect Drive: Securely mount motor in accurate alignment so that shafts are free from both angular and parallel misalignment when both motor and driven machine are operating at normal temperatures.

**3.5 EXCAVATION AND TRENCHING:**

- A. Under each applicable section of the detailed plumbing specifications, the Contractor shall perform all excavation of every description and of whatever substances encountered, to the depths indicated on the drawings or as otherwise specified. No extras will be allowed for rock unless indicated otherwise. During excavation, material suitable for backfilling shall be piled in an orderly manner a sufficient distance from the banks of the trench to avoid overloading and to prevent slides or cave-ins. All excavated materials not required or suitable for backfill shall be removed and wasted as indicated on the drawings or as directed by the Architect/Engineer. Such grading shall be done as may be necessary to prevent surface water from flowing into trenches or other excavations, and any water accumulating therein shall be removed by pumping or by other approved method. Such sheeting and shoring shall be done as may be necessary for the protection of the work and for the safety of personnel. Unless otherwise indicated, excavation shall be by open cut except that short sections of a trench may be tunneled if, in the opinion of the Architect/Engineer, the pipe can be safely and properly installed and backfill can be properly tamped in such tunnel sections.
- B. Trench Excavations (Includes under building and 5 feet outside of building): Trenches shall be of necessary width for the proper laying of the pipe or duct, and the banks shall be as nearly vertical as practicable. The bottom of the trenches shall be accurately graded to provide uniform bearing and support for each section of the pipe on undisturbed soil at every point along its entire length. Except where rock is encountered, care shall be taken not to excavate below the depths indicated. Where rock excavations are required, the rock shall be excavated to a minimum over depth of 4 inches below the trench depths indicated on the drawings or specified. Over-depths in the rock excavation and authorized over depths shall be backfilled with loose, granular, moist earth, thoroughly tamped. When corrosive material or unstable soil or material that is incapable of supporting the pipe is encountered in the bottom of the trench, the Contractor shall promptly notify the Architect/Engineer. Such unsuitable soil or material shall be removed to a depth as directed by Architect/Engineer and the trench backfilled to the proper grade with coarse sand, fine gravel, or other suitable backfill material, as directed by the Architect/Engineer.

- C. Sanitary Sewers, Storm Sewers, and Water Mains: The width of the trench at and below the top of the pipe shall be such that the clear space between the barrel of the pipe and the trench shall be between 6 and 12 inches on either side of the pipe. The width of the trench above that level may be as wide as necessary for sheeting and bracing and the proper performance of the work. The bottom of the trench shall be rounded so that at least the bottom quadrant of the pipe shall rest firmly on undisturbed soil for as much of the full length of the barrel as proper jointing operations will permit. This part of the excavation shall be done manually only a few feet in advance of the pipe laying by men skilled in this type of work.
- D. Protection of Existing Utilities: Existing utility lines to be retained that are shown on the drawings or the locations of which are made known to the Contractor prior to excavation, as well as all utility lines uncovered during excavation operations, shall be protected from damage during excavation and backfilling, and if damaged, shall be repaired by the Contractor, at his expense.

### **3.6 BACKFILLING OF TRENCHES:**

- A. Trenches shall not be backfilled until all required pressure and other tests and inspections have been performed and until the utilities systems as installed conform to the requirements of the drawings and specifications. Trenches for piping shall be carefully backfilled with materials consisting of earth, loam, sandy clay, sand and gravel, soft shale, or other approved materials saved from the excavation or borrowed as required. The backfill materials shall be granular in nature and shall not contain coal, dust, cinders, ashes, roots, sod, rubbish, corrosive materials, large clods of earth, or stones over 2-inch maximum dimension. The Architect/Engineer may reject any on-site or borrowed materials which he considers unsuitable for the intended use of the fill.
- B. Controlled compacted backfill shall be used under slabs-on-grade, building structure, concrete paving, asphaltic concrete paving, driveway, parking areas, and other areas so specified or indicated on the drawings. All backfill required to raise the surface to the desired subgrade shall be continuously controlled and placed in maximum of 8-inch loosely placed lifts and compacted to 100 percent maximum dry density beneath the building and 95 percent under all paved drives and parking areas in accordance with ASTM D 698 (Standard Proctor). The soils engineer shall check each lift and submit reports to the Architect/Engineer in accordance with Division 31 - Earthwork.
- C. Normal Backfill: Where controlled compacted backfill is not required, such as grassed areas, the trenches shall be carefully backfilled with material in eight-inch layers and thoroughly and carefully rammed until cover is not less than one foot. The remainder of the backfill material shall then be carefully placed in the trench in one-foot layers and tamped. The surface shall be graded to a reasonable uniformity and the mounding over trenches left in a uniform and neat condition as approved by the Architect/Engineer.



- D. Test for Displacement of Sewers: Storm and sanitary sewer mains shall be checked by the Contractor to determine whether any displacement of the pipe has occurred after the trench has been backfilled to two feet or more above the pipe. A light shall be flashed between manhole locations and through each straight section of pipe. If the illuminated interior of the pipeline shows poor alignment, displaced pipe, or any other defects, in the opinion of the Architect/Engineer, such defects shall be remedied by the Contractor at his expense.
- E. Plants, turf, and surfacing that are to remain in the area of the excavation shall be carefully removed and placed where they will not be damaged. After the excavations are filled, the plants, turf, and surfacing shall be replaced as directed. Provide repairs for sidewalks, driveways, and other cement and asphalt surfaces which are damaged during excavating to match the adjacent work in material and finish.

**3.7 CUTTING AND PATCHING:**

- A. The Contractor shall be responsible for all required digging, cutting, etc., incident to the work, and shall thereafter make all required repairs necessary to restore the cut structure or material to the condition existing prior to the cutting. In no case shall the Contractor cut into any major structural element, beam, or column without the written approval of the Architect/Engineer. All cutting, patching, repairing, or replacing of work required because of fault, error, tardiness, or damage by any trade shall be performed with no increase in the contract price to the Owner.
- B. Patch and repair roof in accordance with requirements of existing roof warranties and manufacturer's standard approved details.

**3.8 LUBRICATION:**

- A. Under each applicable section of the detailed plumbing specifications, the Contractor shall provide all oil and grease required for the operation of all equipment until acceptance by the Owner. The type and application of all lubricants shall conform to the recommendations of the manufacturer of the equipment involved. The Contractor shall be held responsible for all damage to bearings while the equipment is being operated by him up to the date of acceptance of the project. This Contractor shall be required to protect all bearings during installation and shall thoroughly grease or otherwise protect steel shafts and other bare ferrous parts to prevent corrosion. All equipment shall be provided with covers as necessary for proper protection against damage or deterioration during construction.

**3.9 OPERATING AND PERFORMANCE TESTS:**

- A. Prior to the final inspection, perform required tests as specified under each applicable section of the detailed plumbing specifications, and submit the test reports and records to the Architect/Engineer.

- B. Should evidence of malfunction in any tested system, or piece of equipment or component part thereof, occur during or as a result of tests, make proper corrections, repairs or replacements, and repeat tests at no additional cost to the Owner.

**3.10 QUIET OPERATION AND VIBRATION:**

- A. Systems shall operate under conditions of load without unusual or excessive noise or vibration. Unusual or excessive noise or vibration shall be corrected.

**3.11 INSTRUCTIONS TO OWNER'S PERSONNEL:**

- A. Under each applicable section of the detailed plumbing specifications, the Contractor shall instruct the representative of the Owner in the proper operation and maintenance of all elements of the plumbing systems. A competent representative of the Contractor shall spend not less than two days in such formal instruction and shall spend such additional time as directed by the Architect/Engineer to fully prepare the Owner to operate and maintain the plumbing systems. The Contractor shall provide letter of instruction upon completion to the Architect/Engineer stating the date of instruction and the names of those in attendance.

**3.12 GUARANTEE:**

- A. All plumbing equipment, materials, and labor required by the contract documents for this project shall be guaranteed to be free of defective materials or workmanship for a period of one year after final acceptance of the project. Defects in equipment, materials, or workmanship occurring during this period shall be corrected with new equipment and materials or additional labor at no cost to the Owner.

**3.13 SITE VISIT REPORT:**

- A. Answer in writing each item of discrepancy noted on all site visit reports.

**3.14 DEMOLITION:**

- A. Contractor shall visit the site before bidding to determine the extent and location of demolition to be performed.
- B. Contractor to remove all pipes, equipment, etc. not required, reused or needed for reconnecting to the new systems. All items not required for the new system shall be removed.
- C. The Owner shall select and retain such existing items indicated or required to be removed as he desires. Items selected by the Owner to be retained shall be removed and relocated to an Owner designated location by the Contractor.

- D. All equipment, piping, conduit, etc. to remain and be reused shall be protected from damage. Any damage to existing material shall be repaired to original condition.
- E. Coordinate all demolition activities with the phasing of construction. Demolition shall not affect operations of the building.

**3.15 PHASING OF WORK:**

- A. The plumbing contractor is required to fully understand the phasing of work and to coordinate his work according to phasing plan drawings and related sections of the specifications.
- B. Sections of the existing building will continue to be occupied during renovation. The contractor shall be responsible for retaining existing plumbing systems to serve the occupied sections of the building. Otherwise, the contractor shall provide interim plumbing systems for the occupied sections of the building.
- C. The contractor is cautioned to fully understand the need to operate plumbing systems during construction.
- D. Provide temporary plumbing to protect the owner's property from freeze damage and from high humidity. For new construction, provide plumbing for proper drying and application of finishes.
- E. Portions of the renovated building will be reoccupied as sections of renovation become complete. The contractor shall be responsible for providing plumbing for the reoccupied sections of building.

END OF SECTION 220000

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SECTION 221123 - PLUMBING PUMPS

PART 1: GENERAL

1.1 CONDITIONS:

- A. The applicable provisions of SECTION 220000, PLUMBING GENERAL REQUIREMENTS, are hereby made a part of this section, and the Contractor is cautioned to read Section 220000 carefully as items of work applicable to this section are included in Section 220000.

1.2 DESCRIPTION OF WORK:

- A. Sump pump

1.3 RELATED WORK:

- A. SECTION 220000 - PLUMBING GENERAL REQUIREMENTS.
- B. SECTION 220900 – INSTRUMENTATION AND CONTROL FOR PLUMBING.

1.4 SUBMITTALS:

- A. In accordance with SECTION 220000 - PLUMBING GENERAL REQUIREMENTS, furnish the following:
  - 1. Manufacturer's Literature and Data:
    - a. Sump pump

PART 2: PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS:

- A. Manufacturers (Subject to compliance with requirements):
  - 1. Goulds
  - 2. Taco
  - 3. Armstrong
  - 4. Bell & Gossett
  - 5. Willo
  - 6. Zoeller (Pedestal & Submersible)
  - 7. Pentair Myers (Pedestal & Submersible)
  - 8. Grundfos

- 9. Federal (Pedestal)
- 10. Paco
- 11. Liberty Pumps

**2.2 SUMP PUMP (ELEVATOR SHAFT):**

- A. Sump pump shall be Stancor "Oil-Minder", Ebara "Oil Smart", Xylem B&G Model ELKT2EC0511 or equal, elevator type pump system, Model O/M SE-50 ELV, capable of pumping water while restricting pumping of oil. The system shall function automatically and shall provide for an alarm in the event of: (1) the presence of oil in the sump, (2) high liquid level, or (3) high amps or a locked rotor condition. The pump shall be submersible type, UL 778, capable of pumping 50 GPM at 22 feet TDH, with thermal and overload protection. The motor shall be rated at 1/2 HP, 1 phase, 115 volt, 3600 RPM and capable of operating continuously or intermittently. The motor housing shall be constructed of #304 stainless steel, and mechanical seals shall be housed in a separate oil-filled compartment. The control shall be UL 508 approved and housed in a gasketed NEMA 4X enclosure with stainless steel hinged hardware. The control shall include dual relays with variable sensitivity settings, magnetic contactor with separate over-current relay, self-cleaning stainless steel sensor probe, high decibel warning horn with illuminated red light and alarm silencing switch, LED lights indicating power and pump run functions, dual floats, clearly marked terminal board and remote monitoring contact. Unit shall include control cables (length as required), and a cable and plug from the control unit (length as required). Mount control panel 5'-0" above finished floor to bottom of panel. Provide factory wired NEMA 4X junction box in Elevator pit with 8-pin twist-lock receptacle and 25 ft. of heavy duty 8-pin mating cable. Provide cable lengths as required in 25 ft. lengths with 8-pin quick connects on ea20ch end to connect the junction box to the control panel. Provide factory hard wiring of pump, oil probe and floats into junction box. Entire system shall be factory tested and approved by a nationally recognized testing laboratory.

**PART 3: EXECUTION**

**3.1 INSTALLATION:**

- A. Coordinate installation of elevator sump pump equipment and piping with elevator equipment.

**3.2 TESTS:**

- A. Make tests under actual or simulated operating conditions and prove full compliance with design and specified requirements. Tests of the various items of equipment shall be performed simultaneously with the system of which each item is an integral part.
- B. When any defects are detected, correct defects and repeat tests.

END OF SECTION 221123

**SECTION 221300 - DRAINAGE SYSTEMS**

**PART 1: GENERAL**

**1.1 CONDITIONS:**

- A. The applicable provisions of Section 220000, PLUMBING GENERAL REQUIREMENTS, are hereby made a part of this section and the Contractor is cautioned to read Section 220000 carefully as items of work applicable to this section are included in Section 220000.

**1.2 DESCRIPTION OF WORK:**

- A. The work includes providing a complete plumbing system including, but not necessarily restricted to, the following:
  - 1. Pumped waste sewer system to a point five feet away from exterior building walls.
  - 2. Installation and connections to miscellaneous equipment furnished by Owner.
  - 3. Connections to fixtures and equipment provided under other sections of these specification.
  - 4. Miscellaneous work as described herein, as shown on drawings, and as required for a complete system.

**1.3 RELATED WORK:**

- A. Supports: Division 05, METAL FABRICATIONS.
- B. Section 220000, PLUMBING GENERAL REQUIREMENTS.

**1.4 SUBMITTALS:**

- A. Manufacturer's shop drawings shall indicate that piping and equipment meet specified codes. In accordance with Section 220000, PLUMBING GENERAL REQUIREMENTS, furnish the following Manufacturer's Literature and Data:
  - 1. Piping
  - 2. Valves
  - 3. Cleanouts
  - 4. Access Panels
  - 5. Pipe supports
  - 6. IGCC Submittals: Submit product documentation indicating VOC content in g/L for all insulation material, field-applied interior adhesives, sealants and mastics.
- B. Acceptable Manufacturers: Josam, Mifab, Smith, Wade, Watts, Zurn

**PART 2: PRODUCTS**

**2.1 PIPE AND EQUIPMENT SUPPORTS, PIPE SLEEVES, AND WALL CEILING PLATES:**

- A. Provide in accordance with specifications in Section 220000, PLUMBING GENERAL REQUIREMENTS.

**2.2 SOIL, WASTE AND RAIN CONDUCTOR PIPING:**

- A. Cast Iron Soil Pipe and Fittings: Used for pipe buried in or in contact with earth and for extension of pipe to a distance of approximately five feet outside of building walls. May be used for piping above ground, where space within partitions involved can accommodate greatest diameter of cast iron soil pipe without any dimension deviation from the requirements of contract drawings. Pipe shall be bell and spigot, modified hub, or plain end (no-hub) as required by selected jointing method. Pipe and fittings shall be listed by NSF International, IAPMO, ICC or other third party organization that is accredited as an ANSI-Guide 65 organization as listed on [www.ansi.org](http://www.ansi.org).
  - 1. Soil and Waste Vent Piping Material (Pipe and Fittings): ASTM A74, ASTM A888 or CISPI 301, service weight.
  - 2. Rain Conductor Piping Material (Pipe & Fittings): ASTM A888.
  - 3. Joints: Provide any one of the following types to suit pipe furnished.
    - a. Lead and oakum and caulked by hand.
    - b. Mechanical: Compression-type (ASTM C564) molded neoprene gasket. Gaskets shall suit class of pipe being jointed. Dual-service gaskets will not be accepted.
    - c. Mechanical: Mechanical joint coupling (ASTM C564) (CSA CAN/CSA-B602) shall be heavy duty and shall consist of a stainless steel coupling and neoprene gasket with center stop. Do not install below grade.
    - d. Adapters: Where service weight pipe is connected to extra heavy pipe and extra heavy fittings of chair carriers, provide adapters or similar system to make tight, leakproof joints.
  - 4. Coating: Provide a heavy coat of asphalt or bitumastic paint on pipe buried in earth or installed in cinders or concrete construction.
  - 5. Cast Iron Soil Pipe Markings: All cast iron soil pipe shall be clearly marked with the manufacturer's name, country of origin, eight-digit date code, pipe diameter and length, relevant ASTM standard and registered trademark of the third party certifier.
  - 6. Material Test Reports: Supplier of cast iron soil pipe shall be able to supply material test reports in accordance with the relevant ASTM standard and shall include testing and analysis on radioactivity, dimensional characteristics, tensile strength and chemical/metallurgical content. Suppliers shall also supply MSDS sheets on all coatings.



- B. Steel Pipe and Fittings: May be used for rain conductor above ground, sanitary forced main above and below ground.
  - 1. Pipe Galvanized: ASTM A 53, schedule 40.
  - 2. Fittings: Rain Conductor: Cast iron ASME B16.12, threaded, galvanized.
  - 3. Joints: Threads shall conform to ASME B1.20.1. Pipe-joint compound or tape shall be applied on the male threads only.
- C. Plastic Pipe: May be used for piping above ground and below ground, sanitary forced main above and below ground. Foam core piping is NOT acceptable. All plastic pipe, fittings and components shall be third party certified as conforming to NSF 14. PVC shall not be used in return air plenums.
  - 1. Pipe: PVC Schedule 40 DWV, ASTM D 2665.
  - 2. Soil, Waste, & Vent Fittings: PVC ASTM D3311 fittings for solvent joints.
  - 3. Rain Conductor Fittings: ASTM D2665 fittings for solvent joints.
  - 4. Joints: ASTM F656 purple primer, solvent ASTM D2564 (Not Purple in color) complying with SCAQMD Rule #1168, joints made in accordance with ASTM D2855.

## 2.3 CLEANOUTS:

- A. Same size as pipe served up to 4 inches. Cleanouts shall be easily accessible. Provide a minimum of 18-inch clearance for 6 inch and smaller pipes, 36 inches for 8 inch and larger pipes, for rodding. Cleanouts shall be provided at the base of each vertical rain conductor at all points in sanitary drainage systems where direction change is more than 45 degrees, where required by code, and where indicated on the drawings. All cleanout plugs shall be bronze, set in graphite grease.
- B. In horizontal runs above grade: Cleanouts shall be iron body ferrule with bronze screw plug in fitting or tapped cast iron ferrule with bronze plug.

## 2.4 WATERPROOFING:

- A. Provide at points where pipes pass through membrane waterproofed floors or walls in contact with earth. Waterproofing shall consist of 6-pound sheet lead mopped-in between piles of waterproofing membrane. Flange out lead at opening for pipe and caulk into a cast iron pipe hub set just below line of membrane waterproofing to form watertight joint through floors.

**PART 3: EXECUTION**

**3.1 INSTALLATION:**

**A. General:**

1. Suspended horizontal piping shall be supported by adjustable wrought steel clevis hangers. Chain, strap, wire or other make-shift devices will not be permitted as hangers or supports. Risers and stacks shall be securely supported and braced in an approved manner. Hangers for plastic piping shall be 4 feet apart. Hangers shall be located at all changes in direction and at each joint for suspended pumped waste or storm branches and mains.
2. Install branch piping for waste from the respective piping systems and connect to all fixtures, outlets, casework, cabinets and equipment, including those furnished by the Owner or specified in other sections of these specifications. Approximate locations for roughing-in are shown on the contract drawings. No piping or roughing-in shall be started until data showing exact locations for equipment and connections required are provided by the Architect. This data shall then be used for roughing-in equipment. Individual traps and other connection components not furnished with the equipment, but required for a complete installation, shall be provided under this section of these specifications.
3. Install trim and fittings provided with pump but not installed at point of fabrication.
4. Pipe shall be round and straight. Cutting shall be done with proper tools. Pipe, including plastic, shall be reamed to full size after cutting.
5. All pipe runs shall be laid out and scheduled to avoid interferences with other work.
6. Exterior storm sewer and exterior sanitary sewer piping shall have a minimum of 36-inch cover unless indicated otherwise on drawings. Exterior underground PVC piping shall be buried in accordance with ASTM D2321 and the pipe manufacturer's recommendations.
7. Plastic pipe shall not be located in return air ceiling plenums, and shall not be located in above ceiling or attic spaces constructed of combustible material.
8. Plastic pipe shall not penetrate a fire assembly or smokestop. Transitions from metal pipe to plastic pipe must be a minimum of 36 inches away from fire assembly or smokestop penetrations.
9. Screwed joints for steel pipe shall be made with tapered threads, properly cut and all burrs removed. Pipe ends shall be reamed to full size of bore and all filings removed. Joints shall be made tight with an approved joint cement suitable for the service encountered and applied to the male threads only. A maximum of 3 threads shall show after joint is made up.
10. Caulked joints for cast iron sewer pipe shall be made by packing each joint two thirds full with pure tarred rope oakum, and filling remaining 1/3 full of molten lead. Minimum lead depth shall be 2-1/2 inches.
11. Compression gasket joints for cast iron sewer pipe shall be made with neoprene compression gaskets conforming to ASTM C-564 and suitable for use with hub and spigot pipe and fittings. Gaskets shall be installed in strict accordance with manufacturer's recommendations.

12. No-hub joints for cast iron pipes shall be made with neoprene gaskets (ASTM C564) and stainless steel clamps conforming to ASTM C564 AND ASTM C1277. Joints shall be made in accordance with manufacturer's recommendations.
13. Mechanical joints elastomeric sealing sleeve for cast iron pipe shall be in accordance with ASTM C564.
14. Solvent cement for PVC piping shall be handled in accordance with ASTM F402.
15. Drains from urinals shall be cast iron or PVC, with brass or Schedule 80 PVC nipple connecting to urinal. Copper or galvanized steel will not be acceptable.
16. Floor drains shall be installed with top of rim 1 inch below finished floor with floor with floor sloped at 1/8 inch per foot down towards floor drain unless noted otherwise, coordinate with architectural drawings.

**B. Piping shall conform to the following:**

**1. Pumped Waste:**

- a. Slope pumped waste and vent piping as follows:

<u>Pipe Size</u>	<u>Minimum Pitch Down</u>
Pumped Waste--2-1/2 inch & smaller	1/4 inch to the foot

- b. Changes in direction of piping shall be made with fittings. Changes in direction of drainage piping shall be made by the appropriate use of long-sweep 1/4 bends, 1/6, 1/8, or 1/16 bends, 45 degree wyes, 1/2 wyes, or a combination of these fittings, except that changes in direction of flow from the horizontal to the vertical may be made with short-sweep 1/4 bends.

**3.2 PROTECTION OF ELECTRICAL EQUIPMENT:**

- A. Refer to Specification Section 220000, Paragraph 3.01.C.1 for requirements for piping above electrical equipment.

**3.3 PROTECTION OF PLASTIC PIPE:**

- A. All plastic piping shall be installed with sufficient distance and insulation relative to recessed light fixtures in accordance with Plastics Pipe Institute (PPI) Technical Note 56 "Installation of Plastic Pressure Piping Materials Near IC-Rated and Non-IC-Rated Recessed Lighting Fixtures".

**3.4 TESTS:**

- A. General: Contractor shall provide all instruments, materials, and labor required. Tests shall be made in the presence of the Owner or Authority having jurisdiction or as otherwise directed by the Architect, who shall be given five (5) days notice by this Contractor of his readiness to perform such tests. Any leaks that develop during the tests shall be repaired by

remaking the joint or replacing pipe and fittings. Temporary caulking will not be permitted. No piping shall be concealed until it has been tested, with results acceptable to the Architect. Except for plastic piping, air testing will be acceptable for other piping materials where permitted by the Virginia Construction Code. Test systems either in its entirety or in sections.

- B. Pumped Waste Systems: Conduct tests before trenches are backfilled or fixtures are connected. Conduct water test or air test, as directed in accordance with the Virginia Construction Code and this specification.
  - 1. Water Test: If entire system is tested, tightly close all openings in pipes except highest opening, and fill system with water to point of overflow. If system is tested in sections, tightly plug each opening except highest opening of section under test, fill each section with water and test with at least 10-foot head of water. In testing successive sections, test at least upper 10 feet of next preceding section so that each joint or pipe except uppermost 10-foot head of water. Keep water in system, or in portion under test, for at least 15 minutes before inspection starts. System shall then be tight at all joints.
  - 2. Final Test: When required by the Building Inspector, conduct as directed in accordance with Virginia Construction Code and this specification. Either one of the following tests may be used:
    - a. Smoke Test: After fixtures are permanently connected and traps are filled with water, fill entire drainage and vent systems with smoke. When smoke appears at stack openings on the roof, the stack openings shall be closed and a pressure equivalent to a 1-inch water column shall be held for a test period of not less than 15 minutes. Chemical smoke prohibited.
    - b. Peppermint Test: Introduce two ounces of peppermint into each line or stack.
    - c. Air Test: Air test shall be made by forcing air into the system until obtaining a uniform gauge pressure of 5 psi or sufficient to balance a 10 inch column of mercury. This pressure shall be held for a test period of not less than 15 minutes. Testing procedures in excess of 5 psi can result in a dangerous situation and shall not be allowed. Plastic piping shall not be tested using air.

### 3.5 CLEANING:

- A. After tests have been successfully completed, thoroughly flush the interior drainage system.
- B. Remove trash, plaster, dust, paint spots and all foreign matter from inside and outside of all fixtures and equipment.
- C. The Contractor shall check each length of pipe before it is put in place to make certain there is not foreign material (stones, sand, etc.) in the systems. Provide temporary bypass around equipment if or as required. All plumbing pipes shall be thoroughly flushed with water to remove construction debris before final connections are made to equipment and fixtures.

3.6 REPORTS:

- A. Reports of cleaning and testing: Contractor shall verify *in writing before completion of the job* that all specified cleaning procedures and tests have been performed, with results as specified or as required by codes.

END OF SECTION 221300

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SECTION 230000 - HEATING, VENTILATING AND AIR-CONDITIONING (HVAC)

PART 1: GENERAL

1.1 DESCRIPTION:

- A. This section of the specifications shall be applicable to all phases of mechanical work covered by specifications and drawings issued for this project.
- B. The "General Conditions of the Contract", "Supplementary General Conditions", and all other similar general requirements issued for this project shall apply to all mechanical work and are hereby made a part of this section.
- C. The Contractor and/or his representatives shall be fully acquainted with the design and operation of the systems and equipment described in these specifications and on the drawings.
- D. Work included under this section shall include complete systems as shown on the plans and as specified. Provide supervision, labor, material, equipment, machinery, plant, and other items necessary to complete the mechanical systems. It is the intention of these specifications and drawings to call for finished work, tested, and ready for operation.
- E. Definitions:
  - 1. "Owner" and "Contractor" shall mean the respective parties to the prime contract governing the project. Only one contractor is recognized as a party to this contract. Where the terms "Mechanical Contractor" or "Subcontractor" are used, it is for convenience only.
  - 2. "Architect/Engineer" shall mean the firm and authorized representatives of the firm engaged by the Owner for architectural and engineering services related to this project.
  - 3. "Mechanical" shall mean all work related to air conditioning, heating, ventilation, plumbing, sprinkler systems, noise and vibration control, and similar work, including all related components, accessories, controls, and miscellaneous work required for a complete system.
  - 4. "Contract Documents" shall mean and include the agreement, the drawings and specifications and all modifications thereto authorized by the Owner in writing prior to final completion of the project.
    - a. The term "Agreement" shall mean the completed and signed contract form.
    - b. The term "Drawings" shall mean the drawings prepared by the Architect/Engineer for specific use in bidding and execution of the work.
    - c. The term "Specifications" shall include the legal and procedural documents, the general conditions, special conditions, and the technical specifications.
    - d. The term "Technical Specifications" shall mean that part of the specifications which describes, outlines, and stipulates the kind and quality of the materials to be furnished, the quality of workmanship required, and the methods to be used in the construction under the contract. For convenience, the mechanical portions of the technical specifications are arranged into one general section and several detailed

sections related to the various trades represented in the work. Such arrangement and references shall not operate to make the Architect/Engineer an arbiter in establishing the limits of any subcontract or trade.

5. "Work" of the Contractor shall mean labor or materials or both.
6. "As shown", "as indicated", "as detailed", or words of similar import shall mean reference to the drawings included in the contract documents, unless stated otherwise.
7. "As directed", "as required", "as permitted", "approved", or words of similar import shall mean that the direction, requirement, permission, approval, or acceptance of the Architect/Engineer is intended unless stated otherwise.
8. "As necessary" shall mean that which is necessary to achieve satisfactory completion of the work in order to provide the intended function and form of the project in compliance with the contract documents.
9. "Provide" shall mean "provide complete and in place", that is "furnish and install", ready for beneficial occupancy by the Owner. Except where stated otherwise, description of any work in the contract documents shall mean that the work shall be provided by the Contractor, even though the words "provide" or "furnish and install" do not accompany the description.
10. "Similar" shall be interpreted in a general sense and not as meaning identical, and all related details shall be worked out in respect to their location and their connection with other parts of the work.
11. Exposed: Piping, ductwork, and equipment exposed to view in finished rooms.
12. Option or Optional: Contractor's choice of an alternate material or method.

## 1.2 INTENT OF CONTRACT DOCUMENTS:

- A. The contract documents are complementary, and what is called for in one place shall be as binding as if called for in all places. Where variances occur between drawings and specifications or within either document itself, include in the contract price the item or arrangement of better quality, greater quantity, or higher cost. Agreement shall take precedence over the specifications and drawings. Figured dimensions shall be used in preference to scaling the drawings. In case of conflict between large and small scale drawings, the large scale drawings shall govern.
- B. The mechanical drawings show the general arrangement of all piping, equipment, and appurtenances and shall be followed as closely as actual building construction and the work of other trades will permit. The mechanical work shall conform to the requirements shown on all of the drawings. Architectural and structural drawings shall take precedence over mechanical drawings. Because of the small scale of the mechanical drawings, it is not possible to indicate all offsets, fittings, and accessories which may be required. The Contractor shall investigate the structural and finish conditions affecting the work and shall arrange his work accordingly, providing such fittings, valves, boxes, offsets, transitions, and other accessories as may be required to meet such conditions.



**1.3 CODES AND STANDARDS:**

- A. All materials and workmanship shall comply with all applicable codes, state and federal laws, local ordinances, industry standards, utility company regulations, and all other criteria which normally apply to work of this nature.
- B. In case of difference between building codes, state laws, federal laws, local ordinances, industry standards, utility company regulations, other criteria and the contract documents, the more stringent regulations will apply. The Contractor shall promptly notify the Architect/Engineer in writing of any such difference.
- C. If the Contractor performs any work that does not comply with these contract documents or the requirements of the applicable building codes, state laws, local ordinances, industry standards, utility company regulations, and other applicable criteria, he shall bear all costs arising in correcting the deficiencies.
- D. The standards referred to, except as modified in the specifications, shall have full force and effect as though printed in these specifications. The manufacturer and trades involved shall be familiar with the application of these standards.
- E. Applicable codes and standards shall include, but are not necessarily restricted to, the most recently recognized issues of the following:
  - 1. Building Codes:
    - a. Virginia Uniform Statewide Building Code
    - b. International Mechanical Code and accumulative supplements.
  - 2. Industry Standards, Codes, and Specifications:
    - a. AASHO - American Association of State Highway Officials
    - b. ADA - Americans with Disabilities Act
    - c. AGA - American Gas Association
    - d. ARI - Air Conditioning and Refrigeration Institute
    - e. AMCA- Air Moving and Conditioning Association
    - f. ANSI - American National Standards Institute
    - g. ASHRAE - American Society of Heating, Refrigeration, and Air Conditioning Engineers
    - h. ASME - American Society of Mechanical Engineers
    - i. ASSE - American Society of Sanitary Engineering
    - j. ASTM - American Society of Testing and Materials
    - k. AWS - American Welding Society
    - l. CISPI - Cast Iron Soil Pipe Institute
    - m. CSA - Canadian Standards Association
    - n. AWWA- American Water Works Association
    - o. FIA - Factory Insurance Association
    - p. FM - Factory Mutual
    - q. FS - Federal Specification

r.	IBR	-	Institute of Boiler and Radiator Manufacturers
s.	IRI	-	Industrial Risk Insurers
t.	ISO	-	Insurance Services Office
u.	MSS	-	Manufacturer's Standardization Society of the Valve and Fittings Industry, Inc.
v.	NBS	-	National Bureau of Standards
w.	NEC	-	National Electrical Code
x.	NFPA	-	National Fire Protection Association
y.	NSF	-	National Sanitation Foundation
z.	PDI	-	Plumbing & Drainage Institute
aa.	UL	-	Underwriters' Laboratories, Inc.
bb.	SMACNA	-	Sheet Metal and Air Conditioning Contractors' National Association
cc.	UFAC	-	Uniform Federal Accessibility Standards
dd.	SCAQMD	-	South Coast Air Quality Management District
ee.	GS	-	Green Seal Standard

**1.4 GOVERNMENTAL FEES, PERMITS, AND INSPECTIONS:**

- A. Under each applicable section of the detailed mechanical specifications, the Contractor shall obtain and pay for all required licenses, permits, charges for connections to outside services, fees and inspections. Upon completion of the work under each section of the detailed mechanical specifications, the Contractor shall furnish a certificate of final inspection to the Architect/Engineer from the governmental inspection department having jurisdiction.

**1.5 VISITING THE SITE:**

- A. Each Contractor shall be responsible for visiting the site before bidding the job to familiarize himself with all existing conditions to be met in the execution of the work under this contract. No additional compensation will be allowed for any changes which may be required to make because of site conditions.

**1.6 QUALITY ASSURANCE:**

- A. Product Criteria:
1. All materials shall be new and shall bear the manufacturer's name, trade name, and the UL label in every case where a standard has been established for this particular material. The equipment to be furnished shall be essentially the standard product of a manufacturer regularly engaged in the production of the required type of equipment, and shall be the manufacturer's latest approved design. All equipment shall bear a permanent and legible factory-applied nameplate to permit identification of manufacturer, model number and type of unit.

2. Equipment Service: Products shall be supported by a service organization which maintains an adequate inventory of repair parts and is located, in the opinion of the Architect/Engineer, reasonably close to the site.
  3. Multiple Units: When two or more units of materials or equipment of the same type or class are required, these units shall be products of one manufacturer to provide for uniform appearance, operation, and maintenance.
  4. Assembled Units: Manufacturers of equipment assemblies, which use components made by others, assume complete responsibility for the final assembled product.
- B. Manufacturers' directions shall be followed in the delivery, storage, protection, and installation of all equipment and materials. The Contractor shall promptly notify the Architect/Engineer in writing of any conflict between any requirements of the contract documents and the written instructions before proceeding with the work. If the Contractor performs any work that does not comply with the manufacturers' directions or such written instructions from the Architect/Engineer, he shall bear all costs arising in correcting the deficiencies.
- C. Factory Start-up by the manufacturer's Factory Certified Representative shall be provided for each Boiler, Chiller, Cooling Tower, Air Handling Unit (Packaged, Split, Central Station, Heat Pump, or ERV) and Variable Refrigerant System. Letters signed by the Representative stating that their equipment has been started, tested, and is operating safely shall be submitted to the Owner as part of the bound Operations and Maintenance Instructions manual specified in section 2.10 CATALOG DATA FOR OWNER of this specification.

**1.7 BIDDING INSTRUCTIONS:**

- A. Products are generally specified by a performance specification and/or by manufacturer's name and model number or trade name.
- B. When specified only by a performance specification, the Contractor may use any manufacturer who meets the performance specification and applicable codes. (The Contractor shall be subject to the requirements of 1.9 - SHOP DRAWINGS.)
- C. When several products/manufacturers are specified together, then the Contractor has the option of using any product/manufacturer listed. The Contractor shall be subject to the requirements of 1.9 - SHOP DRAWINGS. The Contractor's bid shall be compiled on the use of the listed products without exception. Substitutions will only be considered after the contract has been executed and shall be subject to the requirements of 1.8 - SUBSTITUTIONS.
- D. When several products/manufacturers are specified together and the system design is based on one of the listed products by specific model number(s) or catalog number(s), then the Contractor has the option of using the one specific product or any other product/manufacturer listed. In either case, the Contractor shall be subject to the requirements of 1.09 - SHOP DRAWINGS. However, when the other listed product/manufacturer is used, the Contractor shall be responsible for determining that the product(s) will be compatible with building design, electrical design, mechanical design, and the product(s) will not necessitate design modifications by the Architect/Engineer. The Contractors bid shall be compiled on the use of the listed products without exception. Substitutions will only be considered after the Contract

has been executed and shall be subject to the requirements of 1.8 - SUBSTITUTIONS. If the products/manufacture are listed to be "only", then substitutions will not be considered.

- E. When only one manufacture's name is listed, this shall be the basis of the bid. The Contractor's bid shall be compiled on the use of the listed product. Substitutions will only be considered after the Contract has been executed and shall be subject to the requirements of 1.8 - SUBSTITUTIONS.

**1.8 SUBSTITUTIONS:**

- A. Substitutions will not be considered during the bid.
- B. After the Contract has been executed, the Architect/Engineer will consider a formal request for a review of substituted products in place of those specified, under the following conditions:
  - 1. Not later than 30 days from the Contract Date, the Contractor shall provide a list of products proposed as substitutions, including the name, manufacturer, and section of the specifications governing the product.
  - 2. The request shall be accompanied by accurate cost data on the proposed substitutions indicating whether or not a modification of the Contract Sum is to be considered.
- C. Substitutions are understood to mean that the installing Contractor:
  - 1. Has personally investigated the proposed substitute and has determined that it is equal or superior in all respects to the item specified;
  - 2. Will provide the same guarantee for the substitution that he would for the item or equipment specified;
  - 3. Certifies that the cost data is complete and includes all related costs under this Contract, and waives all claims for additional cost related to the installation of the accepted substitute;
  - 4. Has coordinated the installation of the substitute, providing design modifications and changes as required for the work to be complete in all respects;
  - 5. Has coordinated the installation of the substitute with the General Contractor pertaining to changes required for the work to be complete with all trades and all changes shall be provided without additional cost to the Owner.
- D. The acceptance by the Architect/Engineer of any or all of those substitute items listed by the Contractor for review shall not constitute an approval of the substitute but shall mean that the Contractor may then submit detailed shop drawings for review. When a request for substitution is granted, shop drawings will be reviewed by the Architect/Engineer. Shop drawings not complete with proper review information will not be reviewed and will be returned unchecked. If after two submittals, the substitute equipment is not approved, the specified equipment shall be provided.

**1.9 SHOP DRAWINGS:**

- A. Shop Drawings are required for all material and equipment that is specified by a manufacturer's name or as indicated in the technical specifications. Submittal data for related equipment shall be submitted at one time *and shall be submitted as a digital file (pdf)*.
- B. Substitutions will not be considered if:
  - 1. They are indicated or implied on shop drawing submissions without information specified in 1.8 - SUBSTITUTIONS.
  - 2. They require a substantial revision of the Contract Documents in order to accommodate their use.
- C. Identify submittals with PROJECT NAME and NUMBER, CONTRACTOR'S NAME, SECTION NUMBER & NAME, and PARAGRAPH NUMBER of SPECIFICATION GOVERNING, MANUFACTURER, MODEL or STYLE, and CONTRACTOR's REVIEW STAMP. Submittals shall be detailed, dimensioned drawings showing construction, size and arrangement, service clearances, performance characteristics, and capacity. Submittals not properly identified or containing information of a general nature will not be reviewed and will be returned unchecked.
- D. Acceptance of shop drawings shall not be considered as a guarantee of measurements or building conditions. Acceptance shall not relieve the Contractor from the responsibility or necessity of furnishing material or performing work required by the drawings and specifications. Submittal data on any one item shall not be reviewed more than three (3) times. If not accepted after the third review, the Contractor shall provide the equipment upon which the design was based.
- E. Failure to submit shop drawings in ample time for checking shall not entitle an extension of contract time, and no claim for extension by reason of such default will be allowed.
- F. No material or equipment, for which submittals are required, may be delivered to or installed at the job site until submittals have been accepted.
- G. Unless a specific finish is indicated in the contract documents, wherever a choice of finish is available for the specified item, submit accurate color chips or charts to the Architect for review and selection.

**1.10 OPERATING AND MAINTENANCE MANUALS:**

- A. Operating and Maintenance Manuals shall be submitted as separate comprehensive digital files (pdf) containing all materials related to each specific Division and named to reflect that particular Division. O&M Manuals shall not be accepted if materials for more than one division is combined into one file. O&M Manuals shall not be accepted if materials for a particular division are submitted separately.

**PART 2: PRODUCTS**

**2.1 DRIVE GUARDS:**

- A. For machinery and equipment, provide guards as shown in AMCA 410 for belts, chains, couplings, pulleys, sheaves, shafts, gears and other moving parts regardless of height above the floor. Drive guards may be excluded where motors and drives are inside factory fabricated unit casings.
- B. Materials: Sheet steel, cast iron, expanded metal or wire mesh rigidly secured so as to be removable without disassembling pipe, duct, or electrical connections to equipment.
- C. Access for Speed Measurement: One-inch diameter hole at each shaft center.
- D. Lubrication: Guards shall not interfere with lubrication of equipment.

**2.2 PAINTING:**

- A. General - Paint mechanical and electrical equipment and material in Equipment Rooms and utility type areas and located outside of the building or on the roof. Painting of equipment and material in finished rooms or areas shall be accomplished as described in PAINTING Section of the Architectural Specifications. Painting in concealed spaces shall be limited to equipment and materials not otherwise protected from rusting such as hangers and supports. Paint shall be products of Sherwin-Williams, Pittsburgh, or Pratt-Lambert. All paints, finishes and coatings shall comply with Green Seal Standard GS-11, GS-03, and SCAQMD Rule #1113 VOC limits for paints and coatings
- B. Workmanship - The work shall be accomplished by workmen skilled in the painting trade after testing is complete and systems are ready for operation. Surfaces to be painted shall be completely dry before applying paint. Surfaces shall not be painted when the temperature is below 50 Deg. F or above 120 Deg. F, or when they are exposed to hot sun. Materials shall be evenly spread and smoothly flowed on without runs or sags. Each coat shall be thoroughly dry before application of succeeding coat. The painters shall protect adjacent surfaces with drip covers during the process of painting. Upon completion, paint spots, if any, shall be removed from adjacent surfaces.
- C. Preparation of surface - Metal surfaces shall be cleaned with solvent before applying materials. Rust and scale shall be removed by wire brushing or sanding. Galvanized surfaces shall be pretreated with a phosphoric acid cleaning solution and primed with Sherwin-Williams "Galvanized Iron Primer".
- D. Painting - After preparation as described above, each item shall be painted as follows, except color of paint for equipment and material located outside of the building or on the roof shall be as selected by the Architect.

1. Painting is not required of equipment, equipment supports, and hangers with a factory-finish coat. Patch painting is required of any damaged areas to match factory-finish coat. Painting is required where equipment or equipment supports do not have factory-finish paint. Painting shall be as follows:
    - a. Uninsulated boiler surfaces and other similar hot surfaces shall be painted with two coats of silicone alkyd aluminum paint with a dry temperature resistance of 1000 Deg. F.
    - b. Other equipment and associated hangers and supports shall be primed with one coat of alkyd, zinc potassium chromate metal primer, except insulated surfaces shall be primed with one coat Sherwin-Williams "Wall Primer and Sealer." Finish with two coats of Sherwin-Williams Steel Gray Enamel. Exterior of belt guards and other protective guards shall be finished with two coats of machinery enamel in OSHA yellow color. Interior of items covered by belt guards and other protective guards shall be finished with two coats of machinery enamel in OSHA orange color. Nameplates on equipment shall not be painted.
  2. Ducts, pipes, and conduits - Interior duct behind grilles, registers, and diffusers shall have 1 finish coat of Sherwin-Williams Black Enamel. Exposed duct, pipes, conduits, and associated hangers exposed in equipment rooms and other unfinished areas such as storage areas shall have two finish coats of paint of the same color as adjacent walls or ceilings. Bare copper pipe shall not be painted. Canvas or paper jacket insulation of pipes or duct exposed in unfinished areas shall be primed and sealed before final two coats of paint. Hangers and supports in concealed areas not protected by factory-finish paint shall have one coat of metal primer.
- E. Identification of pipes and equipment
1. Equipment - Each piece of equipment shall be identified by stenciled marking that will read the same as the identification shown on mechanical or electrical drawings. Stencil letters shall be 2 inches high upper case painted with white enamel.
  2. Pipes shall be identified using pre-printed markers sized appropriately for the pipes being identified (shop drawings required). Markers shall be Seton "Setmark" type or equal. Pipe identification shall meet the most current edition of ANSI Specification A13.1. Markers shall be located close to valves or flanges and adjacent to changes in direction, branches and where pipes pass through walls or floors, and at intervals of 15 feet on straight runs. Provide a Color Code Chart, framed with glass front, indicating piping service and color code schedule. Post in Mechanical Room where directed by Engineer.
- F. Identification of Valves: Properly mark service and control valves. Valve markers shall be metal tags with designations stamped thereon or laminated engraved plastic chained to their respective valves. Identification symbols or designations shall be the same as shown on the Contract Documents.

- G. Equipment locations above acoustic tile ceilings: Provide colored brass push-pins complete with a minimum 1/2" shank and 5/8" diameter head. Pin head color shall be blue or color as selected by Architect or Owner. Locate push-pins directly below all scheduled mechanical equipment.

**2.3 MOTORS, CONTROL, AND ELECTRICAL WIRING:**

- A. Provide motors in accordance with NEMA Standards and suitably designed to match the starting and running characteristics of the driven equipment. Unless indicated otherwise, motors less than 1/2 horsepower shall be wound for 120 volt, single phase, 60 hertz. Motors 1/2 horsepower and above, unless indicated otherwise, shall be wound for three phase, 60 hertz, 200 volt, 230 volt, or 460 volt as required by the system voltage. Select motors coordinated with the utilization voltage and phase. Motors for equipment with VFD shall be matched to the VFD.
- B. All starters and safety switches, except for those specified to be furnished with the mechanical equipment, shall be furnished as part of the Electrical Work - Division 26.
- C. Starters and safety switches furnished with the mechanical equipment shall comply with the specifications of Sections 26 28 16 and 26 29 13.13. Starters furnished as an integral part of the mechanical equipment shall be complete with properly sized overload heaters. Integral 3-phase motor starters and VFD's shall be provided with phase loss protection.
- D. Temperature control wiring shall be furnished as part of the Mechanical Work, Section 23 09 00 - INSTRUMENTATION AND CONTROL FOR HVAC. Temperature control wiring is any wiring, regardless of voltage, related to mechanical equipment that is not the equipment power circuit from the circuit breaker in the panelboard to the motor starter or safety disconnect switch and to the motor or equipment junction box. Temperature control wiring shall include, regardless of voltage, power for control panels, power for actuators, signal for input and outputs, interlocks, and line voltage as herein specified to provide the proper operation and sequence of control for all heating, ventilating, and air conditioning equipment. All wiring shall conform to applicable sections of Division 26, 27 and 28 of the specifications.
  - 1. Power for control panels shall be provided by Controls Contractor and shall be obtained from nearest receptacle or unswitched 120 volt lighting circuit. Control Contractor shall coordinate with Electrical Contractor when connecting to these circuits. Circuit directories in panelboards shall indicate where control panels are connected. When control panels require voltage other than 120 VAC, Control Contractor shall provide transformer to reduce voltage. All wiring shall conform to applicable sections of Division 26, 27 and 28 of the specifications.
  - 2. Power for damper actuators and valves which are an integral part of mechanical equipment shall be provided by the Controls Contractor and shall be obtained from the power source to the equipment or the nearest receptacle circuit. Where power requirement for the actuator or valve is different from that supplied to the equipment, the Controls Contractor shall provide a transformer or tap the nearest receptacle circuit or unswitched 120 volt lighting circuit. Dampers located at fans shall be considered an



integral part of the mechanical equipment and shall be factory wired to the equipment power source.

3. Where equipment is controlled by a line voltage control device (thermostat, On-Off switch, Speed Switch, etc.) the Controls Contractor shall wire from the control device to the equipment, unless specifically indicated otherwise on the drawings.
4. Where control devices that are intended to interrupt the motor or equipment power circuit are provided by the Control System Contractor and are mounted other than on or directly adjacent to the controlled equipment, the Control System Contractor shall provide wiring through these devices regardless of voltage or phases.
5. All low voltage control wiring in inaccessible areas or in exposed areas shall be in metal conduit and shall comply with the specifications of Divisions 26, 27 and 28. All low voltage control wiring in unexposed, accessible areas shall be wire in conduit or U.L. approved plenum rated cable supported from the structure with ties spaced 4'-0" on center. Cable shall not be supported on ceiling, lights, or pipes. All low voltage control wiring penetrating walls or floors shall be in conduits. All 120 volt wiring shall be wire in conduit and shall comply with the specifications of Division 26, 27 and 28. All wall-mounted thermostats, sensors, and switches shall be mounted in recessed metal rough-in box.
6. The Controls Contractor shall coordinate with the Electrical Contractor all 120 volt power source, connections required for the controls system. The Controls Contractor shall verify that wiring of motors and controls provides the correct sequence of operation.
7. All equipment that has electrical connections shall have wiring terminals/connectors rated for not less than 75 deg. C. If terminals/connectors are provided and are rated for less than 75 deg. C., the mechanical contractor shall incur all costs associated with upsizing wire and conduit as required by the National Electrical Code.

#### 2.4 FIRE-STOPPING:

- A. Pipe penetrations of rated walls, floors, and floor-ceiling assemblies shall be constructed in accordance with Underwriter's Laboratories, Inc., Fire Resistance Directory, Volume II, Hourly Ratings for Through Firestop Penetrations. The Contractor shall provide U.L. firestop penetrations according to the particular wall, floor, or floor-ceiling assembly rating, construction type, pipe material, pipe size, insulation requirements, sleeve requirements, and the contractor's choice of firestop products as listed by U.L. Refer to the architectural drawings for the wall, floor, or floor-ceiling assembly construction types and ratings.

#### 2.5 PIPE AND EQUIPMENT SUPPORTS AND RESTRAINTS:

- A. Under each applicable section of the detailed mechanical specifications, the Contractor shall furnish and install all accessories, connections, bases, guards, supports, and incidental items necessary to fully complete the work, ready for use, occupancy, and operation by the Owner.
- B. Type Numbers Specified: MSS SP-58; for selection and application, MSS SP-69. Refer to Section METAL FABRICATIONS, for miscellaneous metal support materials and prime coat painting.

- C. For Attachment to Concrete Construction
  - 1. Concrete Insert: MSS SP-69, Type 18
  - 2. Self-Drilling Expansion Shields and Machine Bolt Expansion Anchors: Fed. Spec. FF-S-325, permitted in concrete not less than four inches thick. Applied load shall not exceed one-fourth the proof test load listed in Fed. Spec. FF-S-235.
  - 3. Power-Driven Fasteners: Permitted in existing concrete or masonry not less than four inches thick when approved by the Architect/ Engineer for each job condition. Use fasteners capable of supporting a 1000 pound test load, with the actual load not exceeding 50 pounds.
- D. For Attachment to Steel Construction; MSS SP-69:
  - 1. Welded Attachment: Type 22.
  - 2. Beam Clamps: Types 20, 21, 28 or 29. Type 23 C-clamp may be used on steel beams only for individual copper tubing up to 7/8-inch outside diameter. Beam clamps on steel joists shall be concentric loading type. Beam clamps that are attached to only one side of a joist are NOT acceptable.
- E. Attachment to Metal Pan or Deck: As required for materials specified in Section METAL DECKING.
- F. For Attachment to Wood Construction: Wood screws or lag bolts.
- G. Hanger Rods: Hot-rolled steel, ASTM A 36 or A 575 for allowable load listed in MSS SP-58. For piping, provide adjustment means for controlling level or slope. Types 13 or 15 turnbuckles shall provide 1-1/2 inches minimum of adjustment and incorporate locknuts. All-thread rods are acceptable.
- H. Multiple (Trapeze) Hangers: Galvanized, cold formed, lipped steel channel horizontal member, not less than 1-1/2 inches by 1-1/2 inches, No. 12 gage, designed to accept special spring held, hardened steel nuts. Not permitted for steam supply and condensate piping, fire and sprinkler piping, or chemical waste drain piping.
  - 1. Allowable Hanger Load: Manufacturers rating less 200 pounds.
  - 2. Guide individual pipes on the horizontal member of every other trapeze hanger with 1/4-inch U-bolt fabricated from steel rod. Provide Type 40 insulation shield, secured by two 2-inch galvanized steel bands, for insulated piping at each hanger.
- I. Pipe Hangers and Supports: Use hangers sized to encircle insulation on insulated piping. Refer to Section 23 07 00, HVAC INSULATION, for insulation thickness. To protect insulation, provide Type 39 saddles for roller type supports. Provide Type 40 insulation shields at all other types of supports and hangers including those for pre-insulated piping.

1. General Types (MSS SP-69):
  - a. Standard Clevis Hanger: Type 1; provide locknut.
  - b. Riser Clamps: Type 8 or 42.
  - c. Wall Brackets: Types 31, 32, or 33.
  - d. Roller Supports: Type 41, 43 and 46.
  - e. Saddle Support: Type 36, 37, or 38.
  - f. Turnbuckle: Types 13 or 15.
  - g. U-Bolt Clamp: Type 24.
  - h. For Uninsulated Copper Tube: Material compatible for use with copper to prevent electrolysis.
  - i. Supports for Plastic or Glass Piping: As recommended by the pipe manufacturer.
2. HVAC Piping:
  - a. Low, Medium and High Pressure Steam:
    - (1) Provide eye rod or Type 17 eye nut near the upper attachment.
    - (2) Piping 3 Inches and Larger: Type 43 roller hanger. For roller hangers requiring seismic bracing, provide a Type 1 clevis hanger with Type 41 roller attached by flat side bars.
  - b. Spring Supports (Expansion and Contraction of Vertical Piping):
    - (1) Movement up to 3/4-Inch: Type 51 or 52 variable spring unit with integral turnbuckle and load indicator.
    - (2) Movement more than 3/4-Inch: Type 54 or 55 constant support unit with integral adjusting nut, turnbuckle, and travel position indicator.
3. Plumbing Piping:
  - a. Sprinkler System: NFPA or Factory Mutual approved types.
  - b. Horizontal Piping: Types 1, 5, 7, 9, and 10.
  - c. Chrome Plated Piping: Chrome plated supports.
  - d. Hangers and Supports in Pipe Chase: Prefabricated system ABS self-extinguishing material, not subject to electrolytic action, to hold piping, prevent vibration, and compensate for all static and operational conditions.
  - e. Blocking, Stays and Bracing: Angle iron or preformed metal channel shapes, 18 gage minimum.
- J. Support hubless cast iron pipe and fittings per CISPI 301-12. Brace hubless cast iron pipe and fittings 5 inches and larger using Holdrite 117 Series No-Hub Pipe and Fitting Restraints or approved equal.
- K. Concrete Equipment Bases: Unless otherwise noted on the drawings or in the specifications, concrete pads and bases not less than 4 inches high and which project not less than 3 inches beyond the equipment on all sides shall be provided for air handling units, fans, pumps, compressors, boilers, tank supports, and other similar floor-mounted equipment which normally

requires foundations. Concrete shall conform to requirements in the concrete section of these specifications. The trade responsible for the supported equipment shall establish sizes and locations of the various concrete bases required and shall provide all necessary anchor bolts, together with templates for holding these bolts in position. Anchor bolts shall be placed in steel pipe sleeves to allow for adjustment, with a suitable plate at bottom end of sleeve to hold the bolt. When indicated in the drawings or detailed specifications, other floor-mounted items of equipment shall have a similar concrete base. Special vibration isolation foundations that are required are specified in the detailed specifications.

**2.6 PIPE SLEEVES:**

- A. Locate sleeves during normal course of work. Provide sleeves for piping and conduit passing through concrete floor slabs and concrete, masonry, tile, and gypsum wall construction. Sleeves shall not be provided for piping and conduit running embedded in concrete or slab on grade, except that copper piping shall require sleeves through slabs on grade. Sleeves through structural members shall be only as directed by Architect. In interior wall, provide 1/4 inch space all around between sleeve and conduit, piping, or insulation of piping.
- B. Sleeves placed in exterior walls below grade shall be O.Z. Gedney Type 'FSK' or equal, Thunderline 'LINK SEAL', or equal sleeve assemblies sized for the pipe or conduit encountered, except for cast iron piping. Sleeve assembly shall provide watertight seal and electrical insulation to reduce cathodic reaction. When a sleeve passes through a wall below a concrete slab on grade, the sealing assembly shall be on the outside of the wall. When a sleeve passes through a wall into a crawl space or the building interior, the sealing assembly shall be in the crawl space or interior of the building. Provide sleeve assembly for copper piping through slab on grade, with sealing assembly located on interior side of floor slab. Where cast iron pipes pass through an exterior wall below grade, provide an iron-pipe sleeve two (2) pipe sizes greater than pipe passing through. Caulk between pipe and sleeve with a rubber-based compound.
- C. Where sleeves are located through fire-rated walls and floor/ceiling assemblies, provide sleeves and protect the penetration in accordance with Underwriter's Laboratories, Inc., Fire Resistance Directory, Volume II, Ratings for Through Firestop Penetrations.
- D. Sleeves in mechanical rooms with floor drains or hose bibbs shall extend 4 inches above floor. Provide flanges or flashing rings with sleeves in floors with waterproof membrane and clamp or flash into the membrane. Provide sleeves flush with floor in other rooms.
- E. Sleeves shall be constructed of 20 gage galvanized sheet steel with lock seam joints for all sleeves set in concrete floor slabs terminating flush with the floor. All other sleeves shall be constructed of galvanized steel pipe unless otherwise indicated.
- F. Fasten sleeves securely in floors or walls so that they will not become displaced when concrete is poured or when other construction is built around them. Take precautions to prevent concrete, plaster, or other materials from being forced into the space between pipe and sleeve during construction.

**2.7 WALL, FLOOR AND CEILING PLATES (ESCUTCHEONS):**

- A. Material and Type: Chrome plated brass or chrome plated steel, one piece or split type with concealed hinge, with setscrew for fastening to pipe, or sleeve. Use plates that fit tight around pipes, cover openings around pipes, and cover the entire pipe sleeve projection.
- B. Thickness: Not less than 3/32-inch for floor plates. For wall and ceiling plates, not less than 0.025 for up to 3-inch pipe, 0.035 for larger pipe.
- C. Locations: Use where pipe penetrates floors, walls and ceilings in exposed locations, except mechanical rooms.

**2.8 ACCESS PANELS:**

- A. Under each applicable section of the detailed mechanical specifications, the Contractor shall provide access panels in all locations where required for access to concealed valves, traps, air cushions, controls, dampers, damper operators, junction boxes, and any other equipment or materials requiring inspection or maintenance. Access panels shall be of adequate size and properly located so that concealed items will be readily accessible for servicing or for removing and replacing if necessary, except as indicated or specified otherwise. Access panels are not required in ceilings formed of removable acoustical panels.
- B. Access panels that are not fire-rated shall be Milcor or equal. Provide modular-sized access panels in inaccessible acoustic tile ceilings sized according to the tile size. Provide Milcor metal access panels with cam lock and mounting trim to match finish encountered. Provide natural anodized aluminum finish for panels in kitchens and toilets. Provide prime finished steel for panels in other areas. Paint panels in finished areas to match finish surface.
- C. Where indicated and where access panels are installed in walls of shafts that are not sealed at each floor, access panels shall be Milcor or equal "Fire-Rated" and shall bear the Underwriters' Laboratories, Inc. Class B, 1-1/2 hour label. Openings shall be framed in accordance with the access panel manufacturer's recommendations. Frames shall be not lighter than 16-gage steel. Panels shall be not lighter than 20-gage steel and shall be insulated sandwich type. Panels shall have a continuous hinge, self-lubricating lock, a direct action-knurled knob, and an interior latch release mechanism.

**2.9 CHARTS, DIAGRAMS, AND SCHEMES:**

- A. Charts, diagrams, and schemes listed below shall be provided under each applicable section of the detailed mechanical specifications by the Contractor, framed under glass, and installed where shown on the drawings or directed in the field. All charts, diagrams, and schemes shall be complete, neat, clear, legible, and permanent.
- B. Electric sequence control diagrams of all mechanical system components.

- C. Automatic temperature control diagrams identified as to name, sequence of operation, location, function, temperature setting, spring range, and manufacturer's part number.
- D. Valve identification chart with typewritten schedule of all valves giving their tag number, description, system served, and normal operation position.
- E. Piping schemes where required by the detailed specifications.

**2.10 CATALOG DATA FOR OWNER:**

- A. Furnish one (1) bound copy or one (1) digital file (pdf format) of all Catalog Data on each manufactured item of equipment used in the mechanical work, complete with index listing the products alphabetically by name, together with the names and addresses of manufacturers, sales, and service representatives. Furnish two (2) bound copies or one (1) digital file (pdf format) of all Operating and Maintenance Instructions of each item of equipment. A single comprehensive file or digital file of all Catalog Data and Operating and Maintenance Instructions shall be submitted to the Engineer for review prior to transmittal to the Owner. Single sections or multiple files will not be reviewed.

**2.11 RECORD OF AS-BUILTS AND CONDITIONS:**

- A. Provide a complete set of prints of mechanical plans marked to indicate as-built conditions which are different from those shown on the original construction documents. Site as-built conditions which are different from the construction documents shall be dimensioned from building or identifiable marker. Accurate locations of all concealed utility lines, both interior and exterior shall be recorded. These drawings shall be delivered to the Architect/Engineer before being turned over to the Owner.

**PART 3: EXECUTION**

**3.1 INSTALLATION:**

- A. Coordination of Work:
  - 1. The Contractor shall compare the mechanical drawings and specifications with the drawings and specifications of other trades, and shall report any discrepancies between them to the Architect/Engineer, and shall obtain from him written instructions for changes necessary in the mechanical work. The mechanical work shall be installed in cooperation with other trades installing interrelated work. Before installation, the Contractor shall make proper provision to avoid interferences in a manner approved by the Architect/Engineer. All changes required in the work of the Contractor caused by his neglect to do so shall be made by him at his own expense.
  - 2. Anchor bolts, sleeves, inserts, and supports that may be required for the work shall be fully coordinated and compatible with the related equipment or materials. Locations shall be determined by the trade installing the related equipment or materials.

3. Slots, chases, openings, and recesses through floors, walls, ceilings, roofs, and partitions shall be located by the trades requiring them.
4. Locations of pipes, ducts, equipment, fixtures, etc., shall be adjusted to accommodate the work to interferences anticipated and encountered. The installing Contractors shall coordinate their work to the building structure and to other trades as directed by the General Contractor. No additional compensation or extension of completion time will be granted for extra work caused by a lack of coordination. The installing Contractor shall provide dimensions and locations of all openings, shafts, and similar items to the General Contractor for his coordination and execution. Work shall be installed as required so as not to interfere with or delay the building construction. Pipes, ducts, etc., shall be concealed above ceilings, in walls, or in floors as applicable in all areas of the building except in equipment rooms, unfinished storage rooms, or other areas specifically noted to the contrary.
  - a. Right-of-Way: Lines which pitch shall have right-of-way over those which do not pitch. For example, plumbing drains shall normally have right-of-way. Lines whose elevations cannot be changed shall have the right-of-way over lines whose elevations can be changed.
  - b. Offsets, transitions, and changes in direction of pipes and ducts shall be made as required to maintain proper head room and pitch of sloping lines whether or not indicated on the drawings. The Contractor shall furnish and install all traps, drains, air vents, sanitary vents, etc., as required to affect these offsets, transitions, and changes in direction.
5. Exact locations of items such as diffusers, grilles, thermostats, hose bibbs, wall hydrants, and other similar items in finished areas of the building and on the exterior of the building shall be coordinated with each other, the building structure, and architectural features thereof so as to be aligned with or centered on other items as applicable. Locations indicated on the drawings are approximate. Trades shall coordinate their work with door swings, block coursing, tile arrangement, and other similar features before establishing the location of any components. Before any related work has begun, the Architect/Engineer may direct reasonable minor changes in equipment locations with no increase in contract price to the Owner. Thermostats shall be mounted so that the top of the thermostat is 48" above the floor and aligned with the top of the light switch plates and 8" from the light switch if shown on the drawings adjacent to a light switch. Room thermostat locations shall be coordinated with door swings, light switches and other wall mounted items. Corridor thermostats shall be mounted 60" above finished floor. Before roughing in conduit or pipe, verify the location of equipment to be connected.
6. Installation and Arrangement: The Contractor shall install all mechanical work to permit removal of coils, heat exchanger bundles, boiler tubes, fan shafts and wheels, filters, belt guards, sheaves and drives, and all other parts requiring periodic replacement or maintenance. The Contractor shall arrange pipes, ducts, and equipment to permit ready access to valves, cocks, traps, motors, control components, and to clear the openings of swinging and overhead doors and of access panels.
7. Ductwork: The Contractor shall change the cross-sectional dimensions of ductwork when required to meet job conditions but shall maintain at least the same equivalent cross-sectional area. The Contractor shall secure the approval of the Architect/Engineer

prior to fabrication of ductwork requiring substantial changes. Ductwork shall not be fabricated until coordination with available space.

8. Drawings by Contractor: When directed by the Architect/Engineer, the Contractor shall submit for review by Architect/Engineer drawings clearly showing certain portions of the mechanical work and its relation to the work of other trades before beginning shop fabrication or erection in the field.
9. Dimensions: The Contractor shall ensure that items to be furnished fit the space available. He shall make necessary field measurements to ascertain space requirements, including those for connections, and shall furnish and install such sizes and shapes of equipment that the final installation shall suite the true intent and meaning of the drawings and specifications. If he concludes that there is insufficient space for installation or specified materials, he shall immediately notify the Architect/Engineer of the conflict and shall stop affected work until he receives instructions as to how to proceed from the Architect/Engineer.
10. Damage to Work: The Contractor is responsible for damage caused by his work or workmen. Repairing of damaged work shall be done by the Contractor as directed by the Engineer at no additional cost.
11. The Contractor shall be responsible for any interruptions to existing services and shall repair any damages to existing systems caused by his operations.

**B. Protection and Cleaning:**

1. Equipment and materials shall be carefully handled, properly stored, and adequately protected to prevent damage before and during installation, in accordance with the manufacturer's recommendations. Damaged or defective items, in the opinion of the Architect/Engineer, shall be replaced.
2. All items subject to moisture damage (such as controls and electrical equipment) shall be stored in dry, heated spaces.
3. Protect all finished parts of equipment, such as shafts and bearings where accessible, from rust prior to operation by means of protective grease coating and wrapping. Close pipe openings with caps or plugs during installation. Tightly cover and protect fixtures and equipment against dirt, water, chemical or mechanical injury. Clean mechanical equipment to remove dust, oil, dirt, plaster, mortar, trash, or paint. Piping, conduit, and ductwork shall be blown out or flushed of all foreign matter before wires are pulled in or before connections are made to equipment or systems. (Clean each boiler in accordance with manufacturer's instructions before connecting to the system.) Provide temporary filters for air units that are operated during construction. After all construction dirt has been removed from the building, install new filters in air units.

**C. Concrete and Grout: Use concrete and shrink compensating grout 3000 psi minimum.**

- D. Install gages, thermometers, valves and other devices with due regard for ease in reading or operating and maintaining said devices. Locate and position thermometers and gages to be easily read by operator standing on floor or walkway provided. Servicing shall not require dismantling adjacent equipment or pipe work.**



E. Work in Existing Buildings:

1. Cut required openings through existing masonry and reinforced concrete using diamond core drills. Use of pneumatic hammer type drills, impact type electric drills, and hand or manual hammer type drills will be permitted only with approval of the Architect/Engineer. Locate openings that will least effect structural slabs, columns, ribs or beams. Refer to the Architect/Engineer for determination of proper design for openings through structural sections and opening layouts approval, prior to cutting or drilling into structure. After Architect/Engineer's approval, carefully cut opening through construction not larger than is absolutely necessary for the required installation.
2. Remove existing work as necessary to install new work. Except as otherwise shown or specified, do not cut, alter or remove any structural work or any ducts, plumbing, steam, gas or electric work without approval of Architect/Engineer. Existing work (walls, ceilings, partitions, floors, mechanical, and electrical work) disturbed or removed as a result of performing required new work shall be patched, repaired, reinstalled, replaced with new work, and refinished and left in as good condition as existed before commencing work. Existing work to be altered or extended that is found to be defective in any way shall be reported to the Architect/Engineer before it is disturbed. Materials and workmanship used in restoring work shall conform in type and quality to that of original existing construction, except as otherwise shown or specified.
3. Continuity of service shall be maintained to all existing systems, except for designated short intervals during which connections are to be made. Interruptions shall be coordinated with the Owner as to the time and duration.
4. Upon completion of contract, deliver work complete and undamaged. Damage that is caused by Contractor or Contractor's workmen to existing structures, grounds, or utilities or to work done by others shall be repaired by Contractor and left in as good condition as existed prior to damaging.
  - a. At Contractor's own expense, Contractor shall immediately restore to service and repair any damage caused by Contractor's workmen to existing piping and conduits, wires, cable, etc., of utility services or of fire protection system and communications systems (except telephone) which are not scheduled for discontinuance or abandonment.
  - b. Restoration work required by damage to telephone systems shall be done by telephone company at Contractor's expense.

3.2 PIPING:

- A. Under each applicable section of the detailed mechanical specifications, the Contractor shall furnish and install as shown on the drawings or as necessary to complete the working system in accordance with the intent of the drawings and specifications, a complete system of piping, valves, supports, anchors, sleeves, and all other appurtenances. The piping drawings are diagrammatic and indicate the general location and connections. The piping may have to be offset, lowered, or raised as required or as directed at the site. This does not relieve the Contractor of responsibility for the proper erection of systems of piping in every respect suitable for the work intended as described in the specifications and as approved by the

Architect/Engineer. Wherever two dissimilar metals join in any piping system, install a dielectric fitting at their intersection.

- B. Installation: Piping shall be properly supported and adequate provisions shall be made for expansion, contraction, slope, and anchorage without damage to joints or hangers. All piping shall be cut accurately for fabrication to measurements established at the construction site. Pipe shall be worked into place without springing and/or forcing, properly clearing all windows, doors, and other openings and equipment. Cutting or other weakening of the building structure to facilitate piping installation will not be permitted without written approval. Pipe extending through the roof shall be properly flashed. All changes in direction shall be made with fittings. Wherever pipe hanger bears directly on the pipe being supported, the hanger shall be of the same material as the pipe.
- C. Arrangement: All piping shall be arranged so as not to interfere with removal of other equipment or devices nor to block access to doors, windows, manholes, or other access openings. Piping shall be arranged so as to facilitate removal of tube bundles. Flanges or unions, as applicable for the type of piping specified, shall be provided in the piping at connections to all items of equipment. Piping shall be placed and installed so that there will be no interference with the installation of the equipment, ducts, etc. All piping shall be installed to ensure noiseless circulation. All piping shall be erected and pitched to ensure proper drainage. Piping shall be installed so as to avoid liquid or air pockets throughout the work. Pipe in finished areas shall be concealed. Exposed piping shall be installed in practical alignment with the building. All valves and specialties shall be placed to permit easy operation and access, and all valves shall be regulated, packed, and glands adjusted at the completion of the work before final acceptance. Water pipes shall not be installed in attic spaces, crawl spaces or similar areas which are subject to freezing, unless indicated to be heat traced.
- D. Underground Piping: Each pipe shall be laid true to line and grade and in such manner as to form a close concentric joint with adjoining pipe and to prevent sudden offsets to flow line. As work progresses, the interior of the pipe shall be cleared of dirt and superfluous materials of every description. Where cleaning after laying is difficult because of small pipe size, a suitable swag or drag shall be kept in the pipe and pulled forward past each joint immediately after jointing has been completed. Trenches shall be kept free from water until pipe jointing material has set. Pipe shall not be laid when the condition of the trench or weather is unsuitable for such work. At all times when work is not in progress, all open ends of pipe and fittings shall be securely closed so that no water, earth, or other substance will enter the pipe or fittings.

### 3.3 PIPE AND EQUIPMENT SUPPORTS:

- A. Supports: The Contractor shall support plumb, rigid, and true to line all work and equipment furnished under each section of these specifications. The Contractor shall study thoroughly all general, structural, and mechanical drawings, shop drawings, and catalog data to determine how equipment, fixtures, piping, ductwork, etc., are to be supported, mounted, or suspended, and shall provide extra steel bolts, inserts, pipe stands, brackets and accessories for proper support, whether or not shown on the drawings. When directed, the Contractor shall submit drawings showing supports for review by the Architect/Engineer.

- B. Where hanger spacing does not correspond with joist or rib spacing, use structural steel channels secured directly to joist and rib structure that will correspond to the required hanger spacing, and then suspend the equipment and piping from the channels. Drill or burn holes in structural steel only with the prior approval of the Architect/Engineer.
- C. Use of chain, wire or strap hangers; wood for blocking stays or bracing; or hangers suspended from piping above will not be permitted. If products are rusty, replace or thoroughly clean and coat with prime paint.
- D. Use hanger rods that are straight and vertical. Turnbuckles for vertical adjustments may be omitted where limited space prevents use. Provide a minimum of 2-inch clearance between pipe or pipe covering and adjacent work.
- E. Horizontal Pipe Support Spacing:
  - 1. Cast Iron: Five feet on centers maximum spacing. At least one hanger on each full length of pipe, close to hub where possible and at least one within 24 inches of each fitting, and wherever else required to prevent tendency toward deflection due to load. Provide a hanger at upper angle at each drop. Locate hangers adjacent to hubs on multiple fittings not more than four feet on centers.
  - 2. For support spacing of all other horizontal piping, refer to MSS SP-69 and provide additional supports at valves, strainers, inline pumps and other heavy components. Provide a support within one foot of each elbow.
  - 3. Black Steel Gas Piping: 8 feet on centers maximum spacing for on-roof horizontal supports. Provide a support within one (1) foot of each elbow.
- F. Vertical Pipe Supports – HVAC and Gas:
  - 1. Vertical runs less than 15 feet long may be supported by the hangers on the connecting horizontal runs.
  - 2. Up to 6-Inch Pipe, 60 Feet Long or Not Over 12-Inch Pipe Up to 30 Feet Long: Riser clamps bolted to pipe below couplings or welded to pipe and resting securely on the building structure.
  - 3. Vertical pipe larger than the foregoing, support on base elbows or tees, or substantial pipe legs extending to the building structure.
- G. Connections: All piping connecting to equipment shall be installed without strain at the piping connection. The Contractor shall be required as directed to remove the bolts in flanged connections or to disconnect piping to demonstrate that piping has been so connected.
- H. Gas Piping Supports: Shall have electro-galvanized steel top with (aluminum roller) (polymeric) supports, the roller axle, fittings and other hardware shall be galvanized steel or polymeric material. Support base shall be secured to roof with adhesive roofing mastic. Roofing membrane shall be compatible with mastic. Consult manufacturer of existing roofing system if isolation pads are required between roof membrane and support base. Consult manufacturer of existing or new roofing system to verify appropriate adhesive to bond base to roofing surface. Do not use wood as support materials. (Support base shall be secured to roof with zinc-coated bolts to structure.)

- I. Gas Piping Anchors: Shall be bolted or field welded to piping. Anchors shall be attached with zinc-coated or galvanized bolts or field welded to angle iron attached to building structure and HVAC equipment curb.

**3.4 MOTOR AND DRIVE ALIGNMENT:**

- A. Belt Drive: Set driving and driven shafts parallel and align so that the corresponding grooves are in the same plane.
- B. Direct-Connect Drive: Securely mount motor in accurate alignment so that shafts are free from both angular and parallel misalignment when both motor and driven machine are operating at normal temperatures.

**3.5 CUTTING AND PATCHING:**

- A. The Contractor shall be responsible for all required digging, cutting, etc., incident to the work, and shall thereafter make all required repairs necessary to restore the cut structure or material to the condition existing prior to the cutting. In no case shall the Contractor cut into any major structural element, beam, or column without the written approval of the Architect/Engineer. All cutting, patching, repairing, or replacing of work required because of fault, error, tardiness, or damage by any trade shall be performed with no increase in the contract price to the Owner.
- B. Patch and repair roof in accordance with requirements of existing roof warranties and manufacturer's standard approved details.

**3.6 LUBRICATION:**

- A. Under each applicable section of the detailed mechanical specifications, the Contractor shall provide all oil and grease required for the operation of all equipment until acceptance by the Owner. The type and application of all lubricants shall conform to the recommendations of the manufacturer of the equipment involved. The Contractor shall be held responsible for all damage to bearings while the equipment is being operated by him up to the date of acceptance of the project. This Contractor shall be required to protect all bearings during installation and shall thoroughly grease or otherwise protect steel shafts and other bare ferrous parts to prevent corrosion. All equipment shall be provided with covers as necessary for proper protection against damage or deterioration during construction.

**3.7 OPERATING AND PERFORMANCE TESTS:**

- A. Prior to the final inspection, perform required tests as specified in Section 23 05 93, TESTING, ADJUSTING AND BALANCING FOR HVAC, and submit the test reports and records to the Architect/Engineer.

- B. Should evidence of malfunction in any tested system, or piece of equipment or component part thereof, occur during or as a result of tests, make proper corrections, repairs or replacements, and repeat tests at no additional cost to the Owner.
- C. When completion of certain work or system occurs at a time when final control settings and adjustments cannot be properly made to make performance tests, then make performance tests for heating systems and for cooling systems respectively during first actual seasonal use of respective systems following completion of the work.

**3.8 QUIET OPERATION AND VIBRATION:**

- A. Systems shall operate under conditions of load without unusual or excessive noise or vibration. Unusual or excessive noise or vibration shall be corrected.

**3.9 INSTRUCTIONS TO OWNER'S PERSONNEL:**

- A. Under each applicable section of the detailed mechanical specifications, the Contractor shall instruct the representative of the Owner in the proper operation and maintenance of all elements of the mechanical systems. A competent representative of the Contractor shall spend not less than two days in such formal instruction and shall spend such additional time as directed by the Architect/Engineer to fully prepare the Owner to operate and maintain the mechanical systems. The Contractor shall provide letter of instruction upon completion to the Architect/Engineer stating the date of instruction and the names of those in attendance.

**3.10 GUARANTEE:**

- A. All mechanical equipment, materials, and labor required by the contract documents for this project shall be guaranteed to be free of defective materials or workmanship for a period of one year after final acceptance of the project. Defects in equipment, materials, or workmanship occurring during this period shall be corrected with new equipment and materials or additional labor at no cost to the Owner.

**3.11 SITE VISIT REPORT**

- A. Answer in writing each item of discrepancy noted on all site visit reports.

**3.12 DEMOLITION:**

- A. Contractor shall visit the site before bidding to determine the extent and location of demolition to be performed.
- B. Contractor to remove all pipes, ducts, equipment, controls, etc. not required, reused or needed for reconnecting to the new systems. All items not required for the new system shall be removed.

- C. The Owner shall select and retain such existing items indicated or required to be removed as he desires. Items selected by the Owner to be retained shall be removed and relocated to an Owner designated location by the Contractor.
- D. All equipment, piping, ductwork, conduit, etc. to remain and be reused shall be protected from damage. Any damage to existing material shall be repaired to original condition.
- E. Coordinate all demolition activities with the phasing of construction. Demolition shall not affect operation of the building.

**3.13 PHASING OF WORK:**

- A. The mechanical contractor is required to fully understand the phasing of work and to coordinate his work according to phasing plan drawings and related sections of the specifications.
- B. Sections of the existing building will continue to be occupied during renovation. The contractor shall be responsible for retaining existing HVAC systems to serve the occupied sections of the building. Otherwise, the contractor shall provide interim HVAC systems for the occupied sections of the building.
- C. The contractor is cautioned to fully understand the need to operate HVAC systems during construction and to block off ductwork serving areas under construction. Protect return ductwork with temporary filters at air inlet grilles, etc.
- D. Provide temporary HVAC to protect the owner's property from freeze damage and from high humidity. For new construction, provide HVAC for proper drying and application of finishes.
- E. Portions of the renovated building will be reoccupied as sections of renovation become complete. The contractor shall be responsible for providing HVAC for the reoccupied sections of building.

**END OF SECTION**

SECTION 230593 - TESTING, ADJUSTING AND BALANCING FOR HVAC

PART 1: GENERAL

1.1 CONDITIONS:

- A. The applicable provisions of Section 230000, HEATING, VENTILATING AND AIR-CONDITIONING (HVAC) are hereby made a part of this section, and the Contractor is cautioned to read Section 230000 carefully as items of work applicable to this section are included in Section 230000.

1.2 DESCRIPTION OF WORK:

- A. Testing, adjusting, and balancing (TAB) of heating, ventilating and air conditioning (HVAC) systems.
- B. The Contractor shall provide all labor, materials, instruments, equipment and service and shall perform all operations required for testing, adjusting, and balancing of systems and related work to obtain the performance of the systems as shown on the drawings and in the specifications.
- C. Definitions:
  - 1. Basic TAB terms used in this section: "Testing, Adjusting and Balancing" of ASHRAE Handbook, latest edition.
  - 2. TAB: Testing, adjusting and balancing. The process of checking and adjusting HVAC systems to meet design objectives.
  - 3. AABA: Associated Air Balance Council.
  - 4. NEBB: National Environmental Balancing Bureau.
  - 5. Hydronic Systems: Includes heating water and chilled water (HVAC).
  - 6. Air Systems: Includes all supply air, return air, exhaust air and outside air systems.

1.3 RELATED WORK:

- A. Section 23 00 00, HEATING, VENTILATING AND AIR-CONDITIONING (HVAC).
- B. Section 23 09 00, INSTRUMENTATION AND CONTROLS FOR HVAC.
- C. Section 23 20 00, HVAC PIPING AND PUMPS.
- D. Section 23 21 33, VARIABLE SPEED DRIVES.
- E. Section 23 30 00, HVAC AIR DISTRIBUTION.
- F. Section 23 34 00, HVAC FANS.

- G. Section 23 50 00, CENTRAL HEATING EQUIPMENT.
- H. Section 23 70 00, CENTRAL HVAC EQUIPMENT.
- I. Section 23 81 00, DECENTRALIZED UNITARY HVAC EQUIPMENT.
- J. Section 23 82 00, CONVECTION HEATING AND COOLING UNITS.

**1.4 QUALITY ASSURANCE:**

- A. TAB Agency Qualifications: The Contractor shall provide the services of a firm certified by the Associated Air Balancing Council, or the National Environment Balancing Bureau to adjust and balance all heating, ventilating, air conditioning, and exhaust systems. All personnel involved in the execution of the work shall be experienced in the balancing of mechanical systems. The firm shall not be the installer of the systems to be tested and shall be otherwise independent of the project.
- B. Performance Criteria: Work shall be performed in accordance with the approved TAB Agenda.
- C. Test Equipment Criteria: The basic instrumentation requirements and accuracy/calibration required by AABC (Section Two) or Section II of the NEBB Procedural Standards for Testing, Adjusting and Balancing of Environmental Systems.
- D. Guarantee: The AABC or NEBB certified firm shall guarantee that all testing, adjusting and balancing work shall be performed in accordance with NEBB standards and procedures and shall provide evidence of their certification for the Architect/Engineer.

**1.5 THE TAB AGENDA:**

- A. Definition: The proposed TAB procedures and proposed forms, diagrams, and reports for documenting the TAB work.
- B. Preparation: By the TAB Agency for review and approval by the Architect/ Engineer.
- C. The agenda shall include one complete set of the AABC or NEBB publications or, in the case of other TAB organizations, comparable publications to establish an approved systematic and uniform set of procedures.
- D. The Agenda shall also include the following detailed narrative procedures, system diagrams and forms for test results.
  - 1. Specific standard procedures required and proposed for each system. Additional procedures for variable flow systems shall be developed by the TAB Agency and included for review and approval.



2. Specified test forms for recording each TAB procedure and for recording sound and vibration measurements. Additional test forms for any variable flow systems shall be developed by TAB agency and submitted for review and approval.
3. System diagrams for each air and water system. Diagrams may be single line. In addition to the information recorded for standard AABC or NEBB procedures, report the following information:
  - a. Air Handling Units: Show design and actual CFM (outside air, return air, supply air). Measure and record each mode (minimum OA and 100% OA) where economizer cycle is specified.
  - b. Duct Distribution Systems: Record residual pressures at inlets of volume controlled terminals at ends of system. Show actual pressures at all static pressure control points utilized for constant or variable flow systems.
  - c. Variable Flow Systems (Water): Include in test forms provisions for measuring and reporting GPM (primary, secondary), system pressures, motor loads, other pertinent data, at full unthrottled capacity and at design (100 percent) flows. Modulate systems by varying the supply temperature of the medium or other approved means.
  - d. Water Systems: Record system fill pressures and expansion tank (level, pressure, temperature) conditions. Record shut-off heads for all pumps and compare with pumps curves to determine if correct pump impellers have been installed.

1.6 SUBMITTALS:

- A. In accordance with Section 23 00 00, HEATING, VENTILATING AND AIR-CONDITIONING (HVAC) General Requirements, furnish the following:
  1. TAB Agency qualifications, submit name and qualifications of job supervisor.
  2. Upon approval of TAB Agency, submit TAB AGENDA for approval.
  3. After completion of tests, the Contractor shall submit three copies of complete test reports for approval. Applicable NEBB or AABC reporting forms shall be used. Where test results differ from specified design conditions, indicating a contract deficiency, include explanatory comments in report. The Contractor shall submit final reports prior to requesting the final inspection for the project.
  4. Approved copy of report shall be bound in Operations and Maintenance Manuals; see Section 23 00 00, HEATING, VENTILATING AND AIR-CONDITIONING (HVAC) General Requirements.

PART 2: PRODUCTS

2.1 GENERAL

- A. The TAB agency shall be responsible for all items or materials necessary for connection of its instrumentation to the ductwork, piping or equipment. Test ports in ducts and plenums shall be installed by the Mechanical Contractor as directed by the TAB agency during the construction

of the systems. Test ports shall be identified. Do not proceed with testing, adjusting, and balancing work until systems are complete and operational.

### **PART 3: EXECUTION**

#### **3.1 GENERAL:**

- A. The General Contractor shall furnish a complete set of HVAC drawings and specifications to the TAB agency. The agency shall review plans and specifications prior to systems installation and submit a written report indicating deficiencies in the system that would preclude the proper adjusting, balancing, and testing of the system. The HVAC system shall be complete and fully operational with clean air filters and clean pipe strainers prior to system balancing. The TAB agency shall review the installed system for proper installation of testing, adjusting, and balancing equipment and submit a written report indicating system conditions. The Mechanical Contractor shall provide support through factory representatives, equipment mechanics, and control technicians to work with the balancing organization to adjust equipment and controls to obtain design performance.
- B. Coordinate TAB procedures with any phased construction requirements for the project so that usable increments of finished work may be accepted for beneficial occupancy. Systems serving partially occupied phases of the project may require balancing for each phase prior to final balancing.
- C. Allow sufficient time in construction schedule for TAB prior to final inspection for the project.
- D. Accomplish TAB in accordance with the Agenda approved by the Architect/Engineer. Put all HVAC systems into full operation and continue operation of the systems during each working day of TAB.
- E. Notify Architect/Engineer 48 hours prior to TAB work.
- F. The TAB agency shall be responsible for adjusting sheaves to acquire required air quantities. If the sheaves require replacement, the sheaves and belts will be replaced by the installer of the equipment.
- G. One week before the final site visit, the balancing organization shall provide the Architect/Engineer with three (3) typed copies of balance reports, in format recommended by NEBB. The report shall contain the following:
  - 1. Project name, location, contractors names, balancing organizations' name, and date.
  - 2. Balancing organizations' certification and individual certified qualifications of persons responsible for supervising and performing the actual work.
  - 3. Brief description of balancing instruments used for this project and their latest calibration performance.
  - 4. Weather conditions at the beginning and end of each day to include; outside dry bulb and wet bulb temperatures, general weather description and cloud cover.

5. System data for each unit:

- a. Installation data as applicable; mark, location, manufacturer, model, size, arrangement, motor HP, voltage, phase, and full load amps.
- b. Design quantities and balance readings taken during the balancing operation indicating the quantity measured on the first reading, and the final, balanced, measured quantity for air and hydronic balance.

3.2 AIR BALANCE:

- A. Place all interactive systems in operation with all filters installed and automatic control systems completed and operating. Artificially load air filters by partial blanking or other means to produce air pressure drop midway between the clean and dirty condition. Set/reset room thermostats as necessary to check heating and cooling function, and flow rates for factory set air terminal units and adjust units if not correct.
- B. Balance systems to design ratings. Adjust fan speeds to provide design flows, including system diversities, at actual system pressures. V-belt drives, including fixed pitch requirements, are specified in Section 23 00 00, HEATING, VENTILATING AND AIR-CONDITIONING (HVAC) General Requirements. Coordinate VAV balancing, including supply and return fan volume controls, with Section 23 09 00, Instrumentation and Controls for HVAC. Set supply fan static pressure control as low as practicable and still maintain required pressure at the remote terminal units. The drive motor of each fan shall not be loaded over the corrected full load amperage rating of the motor involved.
- C. Make pitot tube traverses of all trunk lines and major branches when required to determine proper proportioning of air flows. Air flow measuring devices, where installed, may be utilized for this purpose.
- D. Record pressure drop readings across all major systems.
- E. Make flow measurements at each terminal device and each supply, return, or exhaust diffuser. Adjust each air outlet unit within plus or minus 10 percent of design requirements. Adjust grilles and diffusers to minimize drafts in all areas.
- F. Adjust outside air and return air quantities for all systems to within plus or minus 10 percent.
- G. Adjust exhaust systems to CFM requirements. After balance is completed, change variable shims to fixed shims.
- H. Test function of automatic dampers and operation of air terminal units.
- I. Any adjustments necessary to achieve the specified results shall be provided by the Contractor who furnished and installed such equipment under his contractual obligations. Such adjustments may encompass, but are not necessarily restricted to, the changing of pulleys and belts.

- J. Report the air balance readings for the following as further specified in 3.01.G:
1. Air handling equipment - Outdoor air quantity, return air quantity, supply air quantity, fan speed (rpm), static pressure at fan suction and discharge (inches wg.), and actual motor amp and voltage reading.
  2. Exhaust fans - Air quantity, fan speed (rpm) and static pressure, actual motor amps and voltage reading.
  3. Each air distribution outlet and inlet identified by location and size, air velocity (fpm) and computed air quantity (cfm).
  4. Water coils - Air flow (cfm), entering and leaving air temperatures (DB and WB), load (BTU or MBH).
  5. Temperature in each room in building and thermostat setting.

**3.3 HYDRONIC BALANCE:**

- A. Perform final hydronic balance after all systems have been flushed, cleaned, and filled.
- B. Hydronic balance includes performance readings on all pumps, coils, heat exchangers, and flow measuring devices. Adjust pump flows to actual system heads by adjustment of balancing valves. Flow measuring devices take precedence over pump head readings. Record discrepancies for evaluation. The drive motors shall not be loaded over the corrected full load amperage rating of the motor involved.
- C. Report pressure drop readings across all major system components both for flow determination and deviations between actual and design values.
- D. Record on flow diagrams the flows obtained in each of the various circuits and modes of operation. Designate the manual rebalancing effort that is necessary for optimum operations. Measure flows in primary and secondary pumping systems when operating independently and jointly. Measure and record flows and power consumption of variable flow systems at maximum flow conditions and in increments of 10 percent reductions to a minimum system condition.
- E. Report the hydronic balance readings for the following as further specified in 3.01.G:
1. Water coils - Water flow (gpm), entering and leaving water temperatures.
  2. Refrigerant coils - Air flow (cfm), entering and leaving air temperatures (DB and WB), load (BTU and MBH).
  3. Converters - Water flow (gpm), steam valve position, steam pressure, entering and leaving water temperature, load (MBH).
  4. Boilers - Water supply temperature, return water temperature, boiler stack temperature and CO2 reading.
  5. Reset Station - Supply and return water temperatures.
  6. Chiller - Water supply and return temperatures and refrigerant condensing temperature.
  7. Pumps - Water flow (gpm), suction and discharge pressures, operating head, and full load amps.

3.4 TEMPERATURE CONTROL TEST:

- A. After the heating, ventilating and air conditioning systems have been adjusted and balanced completely, a six hour test shall be run on both the heating and cooling cycles, including the economizer cycle, to determine whether the systems are responding to the temperature controls. Thermostat settings, thermostat temperature readings, and an independent temperature measurement at the thermostat shall be recorded at each thermostat. If the tests on both the heating and cooling cycles can not be made together because of the time of the year, the test not made shall be performed later when conditions are acceptable. A supplement to the final report shall be filed when later tests are made.
- B. Test Verification - The TAB agency shall attest by letter that all equipment has been wired and tested to see that the indicated sequence of motor control is established, that all safety controls function properly, that all motor protective devices are sized correctly, and that the systems are operating at the points set on the controls.
- C. Control Setting - During the performance tests, control settings may require adjustment and if so, shall be adjusted to produce the best balanced system operation. The final setting of each operating and safety control shall be recorded. This shall include but not be limited to thermostats, limit controls, damper position switches, smokestats, firestats, freezestats, aquastats, and other similar items.
- D. Marking of settings - Upon completion of system balancing the settings of adjustment devices including valves and dampers shall be permanently marked. Do not mark room mounted thermostats.

END OF SECTION 230593

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SECTION 230700 - HVAC INSULATION

PART 1: GENERAL

1.1 CONDITIONS:

- A. The applicable provisions of Section 230000, HEATING, VENTILATING AND AIR-CONDITIONING (HVAC) General Requirements, are hereby made a part of this section, and the Contractor is cautioned to read Section 230000 carefully as items of work applicable to this section are included in Section 230000.

1.2 DESCRIPTION OF WORK:

- A. The work to be performed under this section of the specifications comprises the furnishing of all labor and materials and the completion of all work of this section as shown on the drawings and/or herein specified.
- B. Insulation materials and accessories shall be installed in a workmanlike manner by skilled and experienced workers who are regularly engaged in commercial insulation work.
- C. In general, the work included under this section consists of, but is not limited to, the following:
  - 1. Field applied insulation for thermal efficiency and condensation control for HVAC and plumbing piping, ductwork and equipment.

1.3 RELATED WORK:

- A. Section 230000, HEATING, VENTILATING AND AIR-CONDITIONING (HVAC).
- B. Section 232000, HVAC PIPING AND PUMPS.
- C. Section 233000, HVAC AIR DISTRIBUTION.
- D. Section 233400, HVAC FANS.
- E. Section 235000, CENTRAL HEATING EQUIPMENT.
- F. Section 237000, CENTRAL HVAC EQUIPMENT.
- G. Section 238100, DECENTRALIZED UNITARY HVAC EQUIPMENT.
- H. Section 238200, CONVECTION HEATING AND COOLING UNITS.

1.4 SUBMITTALS:

- A. In accordance with Section 230000, HEATING, VENTILATING AND AIR-CONDITIONING (HVAC) General Requirements, furnish the following:
  - 1. Manufacturer's Literature and Dimension Cuts:
    - a. Insulation Materials: Each type used. State surface burning characteristics and thermal properties.
    - b. Insulation Facings and Jackets: Each type used. State vapor barrier properties. State that white finish will be furnished for exposed pipe, ductwork, casings, and equipment.
    - c. Insulation Accessory Materials: Each type used.
    - d. Manufacturer's installation and fitting fabrication instructions for elastomeric unicellular insulation.
    - e. Make reference to applicable specification paragraph numbers for coordination.

1.5 DEFINITIONS:

- A. Air Conditioned Space: Space directly supplied with cooled air.
- B. Cold: Equipment, ductwork or piping handling media at design temperature of 60 Deg. F. or below.
- C. Hot: Ductwork handling air at design temperature above 60 Deg. F.; equipment or piping handling media above 105 Deg. F.
- D. PCF: Density, pounds per cubic foot.
- E. VOC's: Volatile Organic Compounds
- F. Runout: Branch pipe connection up to one inch nominal size and not over 12 feet in length to a floor mounted or ceiling mounted terminal unit.
- G. Thermal Conductance: Heat flow rate through materials.
  - 1. Flat Surface: BTU per hour per square foot.
  - 2. Pipe or Cylinder: BTU per hour per linear foot.
- H. Thermal Conductivity (k):  $(\text{BTU} \cdot \text{in thickness})/(\text{hr} \cdot \text{ft}^2 \cdot ^\circ\text{F temperature difference})$ .
- I. Outside: Open to view beyond the exterior side of walls, above the roof and unexcavated or crawl spaces, above or beneath pier floors, in tunnels or exposed on all sides in trenches connected or not connected to an exterior portion of a building.
- J. Finished Spaces: Spaces used for habitation or occupancy where rough surfaces are plastered, paneled, or otherwise treated to provide a pleasing appearance.



- K. Unfinished Spaces: Spaces used for storage or work areas where appearance is not a factor, unexcavated spaces, crawl spaces, etc.
- L. Concealed Spaces: Spaces between a ceiling and floor construction above or between double walls or furred-in areas, pipe and duct shafts, etc.
- M. Exposed: Open to view inside the building. For example, pipe run through a room, and not covered by other construction, is exposed.

## **PART 2: PRODUCTS**

### **2.1 GENERAL:**

- A. Building characteristics of insulation materials shall comply with NFPA 90A, pertinent parts of which are noted as follows:
  - 1. Duct coverings, duct linings, vapor barrier facings, tapes, and core materials in panels used in duct systems shall have a flame spread rating not over 25 without evidence of continued progressive combustion and a smoke developed rating not higher than 50. If coverings and linings are to be applied with adhesives, they shall be tested as applied with such adhesives, or the adhesives used shall have a flame spread rating not over 25 and a smoke developed rating no higher than 50 when in the final dry state.
  - 2. Duct coverings and linings shall not flame, glow, smolder, or smoke when tested in accordance with ASTM C 411 at the temperature to which it is exposed in service. In no case shall the test temperature be below 250 Deg. F.
  - 3. Pipe insulation and coverings shall meet the requirements of 2-3.3.1 and 2-3.3.2 when installed in ducts, plenums, or concealed spaces used as part of the air distribution system.
  - 4. In addition to NFPA, the insulation material shall not transform into a molten flaming liquid during combustion as characterized by some polyethylenes.
- B. Test Methods: ASTM E 84, UL 723, or NFPA 255.
- C. Insulation shall be Johns Manville, Owens Corning, Pittsburg Corning, or Armacell. Trade names are used herein, unless indicated otherwise, to establish a standard of quality.
- D. Specified k factors are at 75 Deg. F. mean temperature unless stated otherwise. Where optional insulation material is used, select thickness to provide thermal conductance no greater than that for the specified material. For pipe, use insulation manufacturer's published heat flow tables. For a flat surface, thermal conductance equal thermal conductivity (k) divided by the thickness of the insulation. For runout insulation and condensation control insulation, no thickness adjustment need be made.
- E. All materials shall be compatible and suitable for service temperature and shall not contribute to corrosion or otherwise attack surfaces to which applied in either the wet or dry state.

- F. Underwriters' Laboratories, Inc. label or listing, or satisfactory certified test report from an approved testing laboratory will be required to show that surface burning characteristics for materials to be used do not exceed specified ratings.
- G. All sealants and adhesives must comply with all applicable South Coast Air Quality Management District (SCAQMD) VOC limits including but not limited to Rule #1168. All mastics and coatings must comply with all applicable Green Seal GS-11 VOC limits.

## 2.2 FACINGS AND JACKETS:

- A. Fed. Spec. HH-B-100 for Vapor Barrier Types I and II:
  - 1. Puncture Test Method: ASTM D 781.
  - 2. Type I, Low Vapor Transmission (0.02 Perm Rating), Beach Puncture 50 Units: For insulating facing on exposed ductwork, casings, and equipment, and for all pipe insulation jackets. Facings and jackets shall be white all service type (ASJ) suitable for painting without priming.
  - 3. Type II, Medium Vapor Transmission, Beach Puncture 25 Units: Foil-Scrim-Kraft (FSK) type for concealed ductwork and equipment.
  - 4. Factory composite materials may be used provided they have been tested and certified by the manufacturer to meet Beach puncture units specified above.
  - 5. Fire and smoke treatment of jackets and facings shall be permanent. The use of water soluble treatments is not acceptable.
  - 6. Pipe insulation jackets shall have 1-1/2 inch minimum lap at longitudinal joints and not less than 3-inch butt strips at end joints. Facing on board, blanket and block insulation shall have 2-inch laps or 3-inch minimum butt strips. Butt strip material shall be the same as the jacket or facing. Laps and butt strips may be self-sealing type with factory applied pressure sensitive adhesive.

## 2.3 MINERAL FIBER INSULATION:

- A. Owens-Corning Faced Duct Wrap Fiberglass Insulation - FRK Type 100, ASTM C 553-92 (Blanket, Flexible), Density 1 pcf,  $k = 0.31$ , for temperatures up to 250 Deg. F.
  - 1. Concealed supply air ductwork within building's thermal envelope shall be 1-1/2 inch thick insulation.
  - 2. Concealed outdoor air ductwork within building's thermal envelope shall be 2-inch thick insulation.
  - 3. Concealed supply air ductwork outside building's thermal envelope shall be 2-inch thick insulation.
  - 4. Concealed return air ductwork within building's thermal envelope need not be insulated.
  - 5. Concealed return air ductwork outside building's thermal envelope shall be 2-inch thick insulation.
  - 6. Concealed exhaust air ductwork within building's thermal envelope and within 10 feet of connection to outdoors shall be 1-1/2 inch thick insulation.

7. Concealed exhaust air ductwork outside building's thermal envelope shall be 1-1/2 inch thick insulation.
  8. Concealed ductwork with acoustic lining within the building's thermal envelope need not be insulated.
  9. Concealed ductwork with acoustic lining outside building's thermal envelope shall be 1-1/2 inch thick insulation.
- B. Owens-Corning 705 Rigid Board Fiberglass Insulation, ASTM 612, 6 pcf density, with white laminated kraft-aluminum foil reinforced all-service vapor barrier facing.
1. Exposed outside air ductwork shall be 2-inch thick insulation.
  2. Exposed supply air ductwork shall be 1-1/2 inch thick insulation.
  3. Exposed return air ductwork and exhaust air ductwork in non-air conditioned spaces shall be 1-1/2 inch thick insulation.
  4. Exposed ductwork with acoustic lining need not be insulated.
- C. Owens-Corning Fiberglass SSL II ASJ Heavy Density Sectional Pipe Insulation, Fed. Spec. HH-I-558, Form D, Type III (Molded), Class 12, k = 0.24.
- D. Molded pipe fitting covering: Fed. Spec. HH-I-558, Form E. Class 16, k = 0.26, for temperatures up to 370 Deg. F.
- E. Insulation thickness and type for various piping systems shall be as indicated in the following table (Pipe Size/Insulation Thickness).

PIPE SIZE/INSULATION THICKNESS(1)

System	Temp. Range (°F)	Less than 1"	1" to 1-1/4"	1-1/2" to 3"	4" to 6"	8" & Up	Ins. Type (4)
Heating Water	140-200	1.5	1.5	2.0	2.0	2.0	A
Misc.	80-89	1.0	1.0	1.0	1.0	1.0	A,B
Condensate Drain	45-75	0.5	0.5	1.0	1.0	1.0	A,B
Refrig./ Brine	Below 40 (6)	1.0	1.0	1.5	1.5	1.5	B

NOTES:

- (1) Minimum thickness for insulation listed in preceding table is based on Thermal Conductivity, 'k' not exceeding 0.27 Btu per inch/hr. x sq. ft. x Deg. F. based on Mean Temperature of 75 Deg. F. Insulation with greater Thermal Conductivity shall have increased thickness to provide same performance characteristics as specified.
- (2) All horizontal sanitary piping above Kitchen or Dining Area only.

- (3) All horizontal storm piping above lowest floor including roof drains from underside of deck to just below fitting at top of vertical portion of stack. Fittings at top and bottom of vertical sections of horizontal offsets shall be insulated. Lap joints, tape and seal.
  - (4) A - Fiberglass type insulation; B - Elastomeric type insulation.
  - (5) Runouts to individual terminal units (not exceeding 12 ft. in length).
  - (6) Also insulate all refrigerant pipes located in hot spaces such as attics.
- 

**2.4 ELASTOMERIC INSULATION:**

- A. Armstrong Armaflex II Pipe Insulation, Fed. Spec. HH-I-573 and HH-I-1751/2,  $k = 0.27$ , flame spread not over 25, smoke developed not over 50 (1/2-inch thick test material), for temperatures from minus 40 Deg. F. to 211 Deg. F. No jacket required.

**2.5 CELLULAR GLASS INSULATION:**

- A. Pittsburgh Corning Foamglas Insulation, ASTM C 552, Type II, class 2, 8.5 pcf, closed cell rigid type.
  1. Buried steam piping, not in conduit, shall have 2 inch thick insulation.
  2. Buried pumped condensate piping, not in conduit, shall have 1 inch thick insulation.
  3. Outside piping shall have insulation thickness as indicated in table or as indicated on drawing. Protect with aluminum jacket.

**2.6 ACCESSORY MATERIALS:**

- A. Insulation inserts at pipe supports:
  1. Material: Cellular glass or calcium silicate 1/2 section of insulation, same thickness as adjacent insulation.
  2. Provide inserts for all insulated piping greater than 1-1/2 inch diameter. Install with metal insulation shields furnished with pipe supports, Section 23 00 00, HEATING, VENTILATING AND AIR-CONDITIONING (HVAC) General Requirements. Minimum insert length: 10 inches for up to 3 inch pipe, 12 inches for 3 to 6 inch pipe, 16 inches for 8 to 10 inch pipe, and 22 inches for pipe 12 inches and larger.
- B. Adhesives, Mastics, Cement:
  1. Mil. Spec. MIL-A-3316B, Class 1: Jacket and lap adhesive and protective finish coating for insulation.
  2. Mil. Spec. MIL-A-3316B, Class 2: Adhesive for laps for adhering insulation to metal surfaces.
  3. Mil. Spec. MIL-A-24179A, Type II, Class 1: Adhesive for installing flexible unicellular insulation and for laps and general use.

4. Mil. Spec. MIL-B-19565B, Type 1 or Type II and be listed on Qualified Products Database (QPD): Vapor barrier compound for outdoor use.
5. Fed. Spec. SS-C-160A, Type IIIB, (ASTM C 449): Mineral fiber hydraulic-setting thermal insulating and finishing cement.
6. Other: Insulation manufacturer's published recommendations.

C. Mechanical Fasteners:

1. Pins, Anchors: Welded pins, or metal or nylon anchors with tin-coated or fiber washer, or clips. Pin diameter shall be as recommended by the insulation manufacturer.
2. Staples: Outward clinching monel or stainless steel.
3. Wire: 18 gage soft annealed galvanized, or 14 gage copper clad steel or nickel copper alloy.
4. Bands: 3/4-inch nominal width, brass, aluminum or stainless steel.

D. Reinforcement and Finishes:

1. Glass Fabric, Open Weave: ASTM D 1668, Type III (resin treated) and Type 1 (asphalt treated).
2. Glass Fiber Fitting Tape: Mil. Spec. MIL-C-20070, Type II, Class 1.
3. Tape for Flexible Unicellular Insulation: Scotch No. 472, Nashua PE-12, or approved equal recommended by the insulation manufacturer.
4. PVC Fitting Cover: Fed. Spec. L-P-535D, Composition A, Type II, Grade GU, with Form B mineral fiber insert, for media temperature 45 Deg. F. to 250 Deg. F. Below 45 Deg. F. and above 250 Deg. F., provide double layer insert. Provide color matching, vapor barrier, pressure sensitive tape.

E. Firestopping Material: Refer to Section 23 00 00, HEATING, VENTILATING AND AIR-CONDITIONING (HVAC).

2.7 METAL JACKETS:

- A. Aluminum jackets shall be ASTM B 209, temper H14, 0.016-inch thick, smooth. Secure jackets in place with aluminum or stainless steel bands and screws.
- B. Fittings in Outdoor Locations: Finish elbows and fittings with factory-fabricated metal covers. Covers shall be same thickness and materials as jackets on adjacent piping. Secure metal covers in place with metal bands and seal with a waterproof coating. Protect fittings with a weatherproof coating prior to installation of metal covers.
- C. Protect pipe and fittings with a vapor barrier mastic prior to installation of metal covers.

**PART 3: EXECUTION**

**3.1 GENERAL:**

- A. Required pressure tests of joints and connections shall be completed before application of insulation. Surface shall be clean and dry with all foreign materials, such as dirt, oil, loose scale, and rust removed.
- B. Insulation materials and accessories shall be installed in a workmanlike manner by skilled and experienced workers who are regularly engaged in commercial insulation work. If any insulation material has become 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. No insulation material shall be installed that has become damaged in any way. The Contractor shall also use necessary means to protect his work and materials.
- C. Except for specific exceptions, insulate entire specified equipment, piping, and duct systems. Insulate each pipe and duct individually. Do not use scrap pieces of insulation where a full length section will fit.
- D. Insulation materials shall be installed in a first class manner with smooth and even surfaces, with jackets and facings drawn tight and smoothly cemented down at all laps. Insulation shall be continuous through all sleeves and openings, except at fire dampers and duct heaters (NFPA 90A). Vapor barriers shall be continuous and uninterrupted throughout systems with operating temperature 60 Deg. F. and below. Lap and seal vapor barrier over ends and exposed edges of insulation. Anchors, supports, and other metal projections through insulation on cold surfaces shall be insulated and vapor sealed for a minimum length of six inches.
- E. Insulation on hot piping and equipment shall be terminated square or beveled with insulating cement, covered with jacket, at items not to be insulated, access openings and nameplates.
- F. On cold systems, vapor barrier performance is extremely important. Particular care must be given to vapor sealing the fitting cover or finish to the insulation vapor barrier. All penetrations of the jacket and exposed ends of insulation must be sealed with vapor barrier mastic. All valve stems must be sealed with caulking which allows free movement of the stem but provides a seal against moisture incursion.
- G. HVAC Work Not To Be Insulated:
  - 1. Internally insulated ductwork and air handling units.
  - 2. Equipment: Heating water pumps, expansion tanks.
  - 3. In Hot Piping: Unions, flexible connectors, control valves and discharge vent piping.
  - 4. Factory insulated flexible ducts.
  - 5. Factory insulated supply air diffusers.

H. Plumbing Work Not To Be Insulated:

1. Piping and valves of fire protection system.
2. Chromium plated brass piping (except hot water and drain piping under handicapped lavatories).
3. Domestic Hot Water: Unions, flexible connectors, control valves, expansion tank, pump.

I. Apply insulation materials subject to the manufacturer's recommended temperature limits. Apply adhesives, mastics and coatings at the manufacturer's recommended minimum coverage.

3.2 INSTALLATION:

A. Flexible Mineral Fiber Blanket:

1. Adhere insulation to metal with 4-inch wide strips of insulation bonding adhesive at 8 inches on center. Additionally secure insulation to bottom of ducts exceeding 24 inches in width with pins welded or adhered 18 inches on centers. Secure washers on pins. Butt insulation edges and seal joints with laps and butt strips. Staples may be used to assist in securing insulation. Seal all vapor barrier penetrations with vapor barrier mastic. Sagging duct insulation will not be acceptable.
2. Supply air ductwork to be insulated includes main and branch ducts from fan discharge to room supply outlets and the bodies of ceiling outlets to prevent condensation. To prevent condensation, insulate trapeze type supports and angle iron hangers for flat oval ducts.

B. Molded Mineral Fiber Pipe and Tubing Covering:

1. Fit insulation to pipe aligning longitudinal joints. Seal longitudinal joint laps and circumferential butt strips by rubbing hard with a nylon sealing tool to assure a positive seal. Staples may be used to assist in securing insulation. Seal all vapor barrier penetrations with vapor barrier mastic. Provide inserts and install with metal insulation shields at outside pipe supports.
2. Fittings, Flange and Valve Insulation:
  - a. Fiberglass Pipe insulation shall be installed with joints butted firmly together. Valves and devices requiring access shall be insulation with mitered sections of insulation equal in thermal resistance and thickness to the adjoining insulation. Fittings shall be covered with Schuller "Zeston" type, pre-molded PVC fitting covers. Jackets on pipe insulation shall be stapled using outward clinching type staples spaced 3" apart at least 1/4" from the lap edge on systems operating at 80 Deg. F. and above; below 80 Deg. F. the laps are to be vapor sealed using self-sealing lap, lap seal gun, or adhesive. All insulation elbows, fittings, flanges, joints, laps, voids, punctures, and end tapers shall be sealed with two coats of Foster Vapor Out 30-33 or Childers Chil Out CP-33 vapor barrier mastic and reinforcing mesh (total 35 mils or 0.9 mm dry film thickness) regardless of service and before Zeston covers are applied.

- b. Fitting tape shall extend over the adjacent pipe insulation and overlap on itself at least two inches.
- C. Elastomeric Insulation:
  - 1. Apply insulation and fabricate fittings in accordance with the manufacturer's installation instructions.
  - 2. Pipe and Tubing Insulation:
    - a. Use proper size material. Do not stretch or strain insulation.
    - b. To avoid undue compression of insulation, provide inserts at supports as recommended by the insulation manufacturer. Insulation shields are provided under Section 230000, HEATING, VENTILATING AND AIR-CONDITIONING (HVAC).
    - c. Elastomeric insulation shall be slipped on the pipe prior to connection wherever possible. Pipe leak tests shall be performed prior to the insulation of fittings. Where the slip-on technique is not possible longitudinal slit insulation shall be snapped on the pipe. All seams, voids, and butt joints shall be sealed with a Foster 85-75 or Childers CP-82 vapor barrier adhesive or taped with 1-1/2 inch wide 3M #471 tape.
    - d. Fittings and valves shall be insulated with mitered sections of insulation. All joints shall be secured and sealed with vapor barrier adhesive. Approved factory-made fittings such as F & D Mfg. and Supply Co. may be used.
  - 3. On exterior refrigerant suction piping, provide two coats of Armstrong Armaflex Finish (vinyl lacquer) or Foster 30-64 on the insulation.
- D. Rigid Mineral Fiber Board: Secure rigid insulation by impaling over pins or anchors located not more than 3 inches from edge of boards and spaced not more than 18-inch centers and secured with washers and clips. Spot-weld anchor pins or attach with a Foster 85-60 or Childers CP-127 adhesive especially designed for use on metal surfaces. Apply insulation with joints tightly butted. Where vapor barrier is specified, all joints, breaks, seams, punctures, and voids shall be filled with vapor barrier mastic and covered with vapor seal material identical to that surrounding. Neatly bevel insulation around name plates and access plates and doors. Each pin or anchor shall be capable of supporting a 20-pound load. Protruding ends of clips shall be cut off flush after clips are secured and sealed with aluminum backed pressure sensitive tape and coated with vapor barrier mastic.
- E. Duct-mounted heating coils and variable air volume terminal box heating coils shall be insulated with external duct insulation as specified for cold systems. Where adjacent duct or unit is internally lined, extend external insulation minimum 2" onto adjacent item. Completely vapor seal insulation around coil and seal to adjacent surface.
- F. Hot piping serving heating coils located downstream from cooling coils including remote duct-mounted coils, coils at terminal units, etc., shall be insulated a minimum of 5 feet from the coil connection as specified for cold piping. All valves, flanges, unions, flexible connections, etc., within the insulated length shall also be insulated.



- G. Heaters and Tanks: Domestic water heaters, hot water storage tanks, and converters shall be insulated with 1-1/2" thick Hydrous calcium silicate blocks with edges tightly butted and secured with 1/2 x .015" thick galvanized steel bands not over 12" on center. Finish with Schuller No. 375 insulating cement troweled on in two 1/2" thick coats over chicken wire. Last coat shall be mixed 2-to-1 by weight with Portland cement and shall be troweled smooth.
- H. Fan: Supply fans for site-built units shall be insulated with 1" thick Schuller Spin-Glas #814 with foil-scrim-kraft paper facing. Insulation shall be impaled over metal stick clips spaced 12" on center each way. Where insulation joints occur, facing tabs shall be lapped not less than 2"; all joints, laps, voids, punctures in facing shall be effectively vapor sealed with Foster 30-33 Vapor Out or Childers CP-33 vapor-barrier mastic.
- I. Metal Jackets: Provide metal jackets on piping insulation in outdoor locations or where otherwise indicated. Metal jackets need not be installed for elastomeric insulation unless noted otherwise. Metal jackets shall have side and end laps at least 2 inches wide with the cut edge of the side lap turned under one inch to provide a smooth edge. Place laps to shed water. Seal laps on cold piping with Foster 95-44 or Childers CP-76 metal jacketing sealant. Secure jackets in place with aluminum or stainless steel band and screws. Space fasteners as recommended by the jacket manufacturer. Where pipes penetrate exterior walls or roof, continue the increased thickness required for piping exposed to weather and the metal jackets through the sleeve to a point 2 inches beyond the interior surface of the wall or roof.
- J. Exterior Duct: Exterior ductwork shall be insulated with 2" thick fiberglass rigid type duct insulation with a factory-applied facing of foil-scrim-kraft paper jacket effectively vapor sealed. Seal all surfaces watertight with Foster Vapor-Safe heavy-duty mastic 30-90, Childers Chill Low CP-38 or approved equal as follows:
1. Apply tack coat of vapor barrier mastic to clean surfaces at two (2) gallons per 100 square feet.
  2. Embed wet tack with Foster MAST-A-FAB, Childers Chil Glas #10 or equal white membrane. Smooth membrane to avoid wrinkles and overlap all seams minimum 2 inches.
  3. Apply finish coat of vapor barrier mastic within 1/2 hour of tack coat at four gallons per 100 square feet.
  4. Total dry film thickness shall be minimum 57 mils (1.4 mm).
  5. Paint with two coats of exterior grade latex of color as selected by Architect.

END OF SECTION 230700

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SECTION 230900 - INSTRUMENTATION AND CONTROL FOR HVAC

PART 1: GENERAL

1.1 CONDITIONS:

- A. The applicable provisions of Section 230000, HEATING, VENTILATING AND AIR-CONDITIONING (HVAC) are hereby made a part of this section and the Contractor is cautioned to read Section 230000 carefully, especially paragraph 2.3 Motors, Control and Electrical Wiring as items of work applicable to this section.

1.2 RELATED WORK:

- A. Section 230000, HEATING, VENTILATING AND AIR-CONDITIONING (HVAC).
- B. Section 230593, TESTING, ADJUSTING, AND BALANCING FOR HVAC
- C. Section 232000, HVAC PIPING AND PUMPS
- D. Section 233000, HVAC AIR DISTRIBUTION.
- E. Section 233400, HVAC FANS.
- F. Section 235000, CENTRAL HEATING EQUIPMENT.
- G. Section 238100, DECENTRALIZED UNITARY HVAC EQUIPMENT

1.3 COORDINATION OF SPECIFICATIONS:

- A. Control Valves: Furnish per 23 09 00; Install per 23 20 00.
- B. Motorized Dampers: Furnish Damper per 23 30 00; Furnish Actuator per 23 09 00; Install Damper per 23 30 00; Install Actuator per 23 09 00.
- C. Temperature Control Wiring: Furnish and install per 23 00 00 and 23 09 00.
- D. Wall Rough-in for Controls: Furnish and install per 23 00 00 and 23 09 00.
- E. Interlock Wiring for Smoke Detector and Fire Alarm: Furnish and install per Electrical Specifications.

**1.4 SYSTEM DESCRIPTION:**

- A. A distributed logic control system complete with all software and hardware functions shall be provided and installed. System shall be primarily based on ANSI/ASHRAE Standard 135-2001, BACnet. Alternative BACnet based systems which are not native BACnet compliant are acceptable as long as ALL requirements of Section 1.4 are met. This system is to control all mechanical equipment, including all unitary equipment such as fan-powered terminal boxes, AC units, etc. and all air handlers, lighting control and any other listed equipment using native BACnet-compliant components.
- B. Room sensors shall be provided with the room setpoint within preset limits and set desired override time. User shall also be able to start and stop unit from the sensor. Include all necessary wiring and firmware such that room sensor includes field service mode. Field service mode shall allow technician to balance VAV zones and access any parameter in zone controller. Room sensors shall be architecturally pleasing, sense temperature, allow tenant to override system and adjust temperature setpoint, and include a jack that allows the service technician to adjust any zone parameter. Include all wiring for sensor and field service tool.
- C. All application controllers for every terminal unit (FTB, CUH, UH, etc.), air handler, all central plant equipment, and any other piece of controlled equipment shall be fully programmable. Application controllers shall be mounted next to controlled equipment and communicate with building controller via BACnet LAN.

**1.5 APPROVED MANUFACTURERS:**

- A. Only approved control manufacturers may bid upon meeting all requirements of the specifications.
- B. Approved Control Manufacturers:
  - 1. The Trane Company
- C. All non-native BACnet manufacturers will be required to provide the following additional information prior to bid date. It is the responsibility of the non-native BACnet vendor or representative to lay out in intimate detail how their partially compliant BACnet system will meet the requirements of this specification. Failure to provide ALL of the documentation listed below prior to bid date will be cause for rejection of the vendor.
  - 1. Direct Digital Control System Hardware:
    - a. Complete bill of materials indicating quantity, manufacturer, model number, and relevant technical data of equipment to be used.
    - b. Manufacturer's description and technical data such as performance curves, product specifications, and installation and maintenance instructions for items listed below:

- (1) Direct digital controllers (controller panels)
    - (2) All gateway devices
    - (3) All devices used to translate proprietary communication protocols into BACNET Standard, ASHRAE/ANSI 135-2001, BACnet
    - (4) Control panels
    - (5) Power supplies
    - (6) Operator interface equipment
    - (7) Wiring
  - c. Wiring diagrams and layouts for each control panel, GATEWAY DEVICES, AND ALL DEVICES USED TO TRANSLATE PROPRIETARY COMMUNICATION PROTOCOLS INTO BACNET STANDARD. Show termination numbers.
  - d. Floor plan schematic diagrams indicating field sensor and controller locations.
2. Central System Hardware and Software:
  - a. Complete bill of material indicating quantity, manufacturer, model number, and relevant technical data of equipment used.
  - b. Manufacturer's description and technical data such as product specifications and installation and maintenance instructions for items listed below: and for relevant items furnished under this contract not listed below:
    - (1) Central Processing Unit (CPU) and web server
    - (2) Interface equipment between CPU or server and control panels
    - (3) Operating System software
    - (4) Operator interface software
    - (5) Color graphic software
    - (6) Third-party software
    - (7) ALL GATEWAY DEVICES
    - (8) ALL DEVICES USED TO TRANSLATE PROPRIETARY COMMUNICATION PROTOCOLS INTO BACNET STANDARD, ASHRAE/ANSI 135-2001, BACnet
  - c. Schematic diagrams of control, communication, and power wiring for central system installation. Show interface wiring to control system.
  - d. Network riser diagrams of wiring between central control unit and control panels.
3. Controlled Systems:
  - a. Schematic diagram of each controlled system. Label control points with point names. Graphically show locations of control elements.
  - b. Schematic wiring diagram of each controlled system. Label control elements and terminals. Where a control element is also shown on control system schematic, use the same name.

- c. Instrumentation list (Bill of Materials) for each controlled system. List each control system element in a table. Show element name, type of device, manufacturer, model number, and product data sheet number.
  - d. Complete description of control system operation including sequences of operation. Include and reference schematic diagram of controlled system. List I/O points and software points specified in Section 230900. Indicate alarmed and trended points.
- 4. BACnet Protocol Implementation Conformance Statement (PICS) for each submitted type of controller and operator interface. If a device does not meet the PICS requirement, it must be stated it does not meet the standard.

**1.6 QUALITY ASSURANCE:**

- A The BAS system shall be designed and installed, commissioned and serviced by manufacturer employed, factory trained personnel. Manufacturer shall have an in-place support facility within 2 hours response time of the site with technical staff, spare parts inventory and necessary test and diagnostic equipment. Distributors or licensed installing contractors are not acceptable.

The manufacturer shall provide full time, experienced project manager for this work, responsible for direct supervision of the design, installation, start up and commissioning of the BAS system.

The Bidder shall be regularly engaged in the manufacturing, installation and maintenance of BAS systems and shall have demonstrated technical expertise and experience in the manufacture, installation and maintenance of BAS systems similar in size and complexity to this project. Bidders shall provide a list of at least 10 projects, similar in size and scope to this project completed within the past 3 years.

- B. The BAS system manufacturer must have a Dealer or Customer Support call-in Center located at the corporate headquarters or corporate manufacturing facilities. The Customer Support call-in Center will be staffed by fully trained and certified technicians.
- C. Materials and equipment shall be the catalogued products of manufacturers regularly engaged in production and installation of automatic temperature control systems and shall be manufacturer's latest standard design that complies with the specification requirements.
- D. All BAS peer-to-peer network controllers, central system controllers and local user displays shall be UL Listed under Standard UL 916, category PAZX.
- E. All electronic equipment shall conform to the requirements of FCC Regulation, Part 15, Governing Radio Frequency Electromagnetic Interference and be so labeled.
- F. Control system shall be engineered, programmed and supported completely by representative's local office that must be within 100 miles of project site.

**1.7 REFERENCE STANDARDS:**

- A. The latest edition of the following standards and codes in effect and amended as of supplier's proposal date, and any applicable subsections thereof, shall govern design and selection of equipment and material supplied:
  - 1. American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE).
  - 2. ANSI/ASHRAE Standard 135-2001, BACnet.
  - 3. Uniform Building Code (UBC), including local amendments.
  - 4. UL 916 Underwriters Laboratories Standard for Energy Management Equipment. Canada and the US.
  - 5. National Electrical Code (NEC).
  - 6. FCC Part 15, Subpart J, Class A
  - 7. EMC Directive 89/336/EEC (European CE Mark)
  - 8. UL-864 UUKL listing for Smoke Controls for any equipment used in smoke control sequences
- B. City, county, state, and federal regulations and codes in effect as of contract date.
- C. Except as otherwise indicated the system supplier shall secure and pay for all permits, inspections, and certifications required for his work and arrange for necessary approvals by the governing authorities.

**1.8 SUBMITTALS:**

- A. Drawings:
  - 1. The system supplier shall submit engineered drawings, control sequence, and bill of materials for approval.
  - 2. Drawings shall be submitted in the following standard sizes: 11" x 17" (ANSI B).
  - 3. Eight complete sets (copies) of submittal drawings shall be provided.
  - 4. Drawings shall be available on CD-ROM.
- B. System Documentation - Include the following in submittal package:
  - 1. System configuration diagrams in simplified block format.
  - 2. All input/output object listings and an alarm point summary listing.
  - 3. Electrical drawings that show all system internal and external connection points, terminal block layouts, and terminal identification.
  - 4. Complete bill of materials, valve schedule and damper schedule.
  - 5. Manufacturer's instructions and drawings for installation, maintenance, and operation of all purchased items.
  - 6. Overall system operation and maintenance instructions—including preventive maintenance and troubleshooting instructions.

7. For all system elements—operator’s workstation(s), building controller(s), application controllers, routers, and repeaters,—provide BACnet Protocol Implementation Conformance Statements (PICS) as per ANSI/ASHRAE Standard 135-2001.
  8. Provide complete description and documentation of any proprietary (non-BACnet) services and/or objects used in the system.
  9. A list of all functions available and a sample of function block programming that shall be part of delivered system.
- C. Project Management: The vendor shall provide a detailed project design and installation schedule with time markings and details for hardware items and software development phases. Schedule shall show all the target dates for transmission of project information and documents and shall indicate timing and dates for system installation, debugging, and commissioning.
- D. BACnet Device Object Naming Conventions:
1. The BAS manufacturer’s representative shall submit a BACnet Device Object Naming Convention Plan (DONCP) to the owner and consulting engineer during the submittal process. The plan must be approved by the owner and consulting engineer prior to implementation. It is the responsibility of the BAS contractor to coordinate the DONCP with the owner and consulting engineer.
  2. The DONCP shall be designed to eliminate any confusion between individual points in a facility/campus wide EMCS system. It will also be designed to allow for future expansion and consistency. Each device on a BACnet internetwork (including other manufacturer’s devices) must have a unique device instance. This is a major consideration when adding to an existing system or interconnecting networks. Thorough and accessible site documentation is critical.
  3. A consistent object (point) naming convention shall be used to facilitate familiarity and operational ease across an eventual large campus or inventory of facilities. The following section is designed as recommendations only. It is the responsibility of the BAS contractor to coordinate the DONCP with the owner and consulting engineer
  4. BACnet requires that all devices have a Device object name that is unique throughout the entire internetwork. To comply with this requirement all BACnet devices should be configured with a Device Object Name that is based on the naming conventions described in this section. This includes all physical devices aswell as any logical BACnet devices that are represented by gateways. The vendor shall coordinate with the owner’s staff to ensure that the correct names are used. Device Object Name properties shall support strings of at least 50 characters in length.
  5. Every system device has addresses by which any other BACnet device can identify it and route information to and from it. Although there are a number of addresses to consider, the scheme is fairly straightforward. It can become complicated, however, if addresses have not been documented adequately or there is no logical addressing scheme.
  6. When you set up and plan a BACnet network or add to an existing network, considering and documenting your addressing scheme is of the utmost importance. Adopt a hierarchical and uniform addressing scheme for device instances to help you quickly identify the function and location of different devices when troubleshooting.



Additionally, it's very important to document every element of your addressing scheme and update the site documentation with any changes.

7. This section first covers the important addressing issues with respect to BACnet LANs and it gives a practical application you can use to check your understanding.
  - a. BACnet Addressing: Three types of addresses are important in any BACnet system: network numbers, media access control (MAC) addresses, and device instances. Each BACnet device has these addresses associated with it. Though all three can be thought of as addresses, they are all very different both in how they function and how they are assigned.
  - b. Network Numbers: Identifies the network to which a BACnet device belongs. Every network on a BACnet LAN has a unique numerical identifier—a network number. This network number is used by BACnet devices only; it does not rely on nor does it affect any other network protocols. LANs connected by a router must have different network numbers. No interconnected BACnet networks can have the same network number. Network number range is 1–65534, for a maximum of 65534 interconnected BACnet networks.
  - c. IMPORTANT BACnet reserves network numbers 0 and 65,535 for special purposes. Don't use network 0 or 65,535.
  - d. MAC addresses Hardware-oriented. The MAC address uniquely identifies a device on its particular network. Each network type—Ethernet and MS/TP—has its own MAC addressing scheme. A device that exists on two or more networks will have a MAC address for each one. Devices can have the same MAC addresses as long as they are on networks with different network numbers.
  - e. Note It's helpful to think of the MAC address as a house number and the network number as the street number. Two houses can have the same house number (MAC address) as long as they are on different streets (networks).
  - f. Ethernet devices - For Ethernet LANs, the IEEE assigns a certain range of MAC addresses to manufacturers of Ethernet products. manufacturer then assigns a unique MAC address to each of its Ethernet devices.
  - g. MS/TP devices - For devices on an MS/TP LAN, you assign the MAC address for each controller. For BACtalk VLCs, these are assigned with DIP switches. Devices on an MS/TP LAN are designated as either masters or slaves, which affects how they can be addressed. This is a requirement of the BACnet specification. All BACtalk MS/TP devices are masters.
  - h. IMPORTANT BACnet reserves MS/TP MAC address 255 for special purposes. Don't use MS/TP MAC 255.
  - i. Device instances Software-oriented. The device instance identifies the device to the BACnet software and is the address most often encountered. The device instance is a shortcut to having to specify a MAC address and network number each time an operation is performed. Device instances range from 0–4194302.
  - j. Note BACnet reserves device instance 4194303 for special purposes. Don't use device instance 4194303.

1.9 WARRANTY:

- A. Warranty shall cover all costs for parts, labor, associated travel, and expenses for a period of one year from completion of system acceptance.
- B. Hardware and software personnel supporting this warranty agreement shall provide on-site or off-site service in a timely manner after failure notification to the vendor. The maximum acceptable response time to provide this service at the site shall be 24 hours Monday through Friday, 48 hours on Saturday and Sunday.
- C. This warranty shall apply equally to both hardware and software.

PART 2: PRODUCTS

2.1 WEB INTERFACE:

- A. General: BAS supplier shall provide web-based access to the system as part of standard installation. User shall be able to access all displays of real-time data that are part of the BAS via a standard Web browser. Web browser shall tie into the network via owner-supplied Ethernet network connection. Web-page host shall be a separate device that resides on the BAS BACnet network, but is not the BAS server for the control system. BAS server must be a separate computer from the Web-page host device to ensure data and system integrity. The web-page software shall not require a per user licensing fee or annual fees. The web-page host must be able to support on average 50 simultaneous users with the ability to expand the system to accommodate an unlimited number of users.
- B. Browser Technology: Browser shall be standard version of Microsoft IE 7.0 or later and Netscape Navigator 4.76 or later. No special vendor-supplied software shall be needed on computers running browser. All displays shall be viewable and the Web-page host shall directly access real-time data from the BAS BACnet network. Data shall be displayed in real time and update automatically without user interaction. User shall be able to change data on displays if logged in with the appropriate user name and password.
- C. Communications:
  - 1. Web-page host shall include two Ethernet network connections. One network connection shall be dedicated to BAS BACnet network and shall be used to gather real-time data from all the BACnet devices that form the BAS. This network shall communicate via BACnet, allowing the Web-page host to gather data directly from units on the local LAN or from other projects connected over a WAN. This network shall also provide the connection to the BAS server for Web page generation.

2. The second Ethernet connection shall provide the physical connection to the Internet or an IP-based WAN. It shall be the port that is used for the browser to receive Web pages and data from the Web-page host.. The Web-page host shall act as a physical barrier between the BAS network and the WAN or Internet connection that allows the browser to receive web pages and data. The two separate network connections provide for a physical barrier to prevent raw BACnet traffic being exposed on the IP network.
3. The Web-page host shall provide for complete isolation of the IP and BACnet networks by not routing networking packets between the two networks.
4. BAS BACnet Ethernet network shall be provided and installed by the BAS supplier. Owner shall provide and incur any monthly charges of WAN/Internet connection.

**D. Display of Data:**

1. Web page graphics shown on browser shall be replicas of the BAS displays. User shall need no additional training to understand information presented on Web pages when compared to what is shown on BAS displays. Web page displays shall include animation just as BAS displays. Fans shall turn, pilot lights shall blink, coils shall change colors, and so on.
2. Real-time data shall be shown on all browser Web pages. This data must be directly gathered via the BACnet network and automatically updated on browser Web page displays without any user action. Data on the browser shall automatically refresh as changes are detected without re-drawing the complete display.
3. It shall be possible for user from browser Web page to change data if the user is logged on with the appropriate password. Clicking on a button or typing in a new value shall change digital data. Using pull-down menus or typing in a new value shall change analog data.
4. Data displays shall be navigated using pushbuttons on the displays that are simply clicked on with the mouse to select a new display. Alternatively, the standard back and forward buttons of the browser can be used for display navigation.

**E. Time Schedule Adjustment:**

1. Web access shall allow user to view and edit all schedules in the system. This includes standard, holiday and event schedules as described in BAS specification. Display of schedules shall show interaction of all schedules on a single display so user sees an overview of how all work together. User shall be able to edit schedules from this display.
2. Display of all 3 schedules must show all ON times for standard, holiday and event schedules in different colors on a given day. In addition, OFF times for each must also be shown in additional colors. User shall be able to select from standard calendar what days are to be scheduled and same display shall show all points and zones affected. User shall be able to set time for one day and select all days of the week that shall be affected as a recurrence of that same schedule for that given day.
3. Schedule list shall show all schedules currently defined. This list shall include all standard, holiday and event schedules. In addition, user shall be able to select a list that shows all scheduled points and zones.

- F. Logging of Information: User shall use standard browser technology to view all trend logs in system. User shall be able to view logged data in tabular form or graphical format. User shall be able to adjust time interval of logged data viewed and shall be able to adjust y axis of data viewed in graphical format. User shall also be able to down-load data through the web interface to local computer. Data shall be in CSV format.
- G. Alarm Handling: Web interface shall display alarms as they occur. User shall be able to acknowledge alarms using browser technology. In addition, user shall be able to view history of alarm occurrence over a user selected time frame. In addition, those alarms may be filtered for viewing per user selected options. A single selection shall display all alarms that have not been acknowledged.
- H. Web Page Generation: Web pages shall be generated automatically from the BAS displays that reside on the BAS server. User shall access Web-page host via the network and shall initiate a web page generation utility that automatically takes the BAS displays and turns them into Web pages. The Web pages generated are automatically installed on the Web page host for access via any computer's standard browser. Any system that requires use of an HTML editor for generation of Web pages shall not be considered.
- I. Password Security and Activity Log: Access via Web browser shall utilize the same hierarchical security scheme as BAS system. User shall be asked to log in once the browser makes connection to Web-page host. Once the user logs in, any and all changes that are made shall be tracked by the BAS system. The user shall be able to change only those items that the user has authority to change. A user activity report shall show any and all activity of the users that have logged in to the system regardless of whether those changes were made using a browser or via the BAS workstation.
- J. BACnet Communication: Web server shall directly communicate to all devices on the BAS network using BACnet protocol. No intermediate devices shall be necessary for BACnet communication.

## 2.2 BUILDING CONTROLLER:

- A. General Requirements:
  - 1. Building Controller shall be of modular construction such that various modules may be selected to fit the specific requirements of a given project. Modules shall consist of a power supply module, a BACnet Ethernet-MS/TP module, a BACnet MS/TP only module and a modem module for telephone communication as a minimum. Those projects that require special interfaces may use Modbus modules as needed. However, all Ethernet communications and all controllers including central plant controllers, advanced application controllers and unitary controllers supplied by BMS manufacturer shall utilize the BACnet protocol standard.
  - 2. Modules shall be selected to fit the particular project application. Up to 7 modules shall be powered by a single power supply module. All modules shall be panel mounted on DIN rail for ease of addition and shall be interconnected via simple plug

- in cable. A module in the middle shall be replaceable without removing any other modules.
3. All modules shall be capable of providing global control strategies for the system based on information from any objects in the system regardless if the object is directly monitored by the building controller module or by another controller. The software program implementing these strategies shall be completely flexible and user definable. All software tools necessary for programming shall be provided as part of project software. Any systems utilizing factory pre-programmed global strategies that cannot be modified by field personnel on-site, via a wide area network or downloaded via remote communications are not acceptable. Changing global strategies via firmware changes is also unacceptable.
  4. Programming shall be object-oriented using control function blocks, supporting DDC functions, 1000 Analog Values and 1000 Binary Values.. All flowcharts shall be generated and automatically downloaded to controller. Programming tool shall be supplied and be resident on workstation. The same tool shall be used for all controllers.
  5. Provide means to graphically view inputs and outputs to each program block in real-time as program is executing. This function may be performed via the operator's workstation or field computer.
  6. Controller shall have a memory needed to ensure high performance and data reliability. Battery shall provide power for orderly shutdown of controller and storage of data in nonvolatile flash memory. Battery back up shall maintain real-time clock functions for a minimum of 20 days.
  7. Global control algorithms and automated control functions shall execute via 32-bit processor.
  8. Schedules:
    - a. Each building controller module shall support a minimum of 80 BACnet Schedule Objects and 80 BACnet Calendar Objects.
    - b. Building controller modules shall provide normal 7 day scheduling, holiday scheduling and event scheduling.
  9. Logging Capabilities:
    - a. Each building controller shall log as minimum 320 values. Any object in the system (real or calculated) may be logged. Sample time interval shall be adjustable at the operator's workstation.
    - b. Logs may be viewed both on-site or off-site via WAN or remote communication.
    - c. Building controller shall periodically upload trended data to networked operator's workstation for long term archiving if desired.
    - d. Archived data stored in database format shall be available for use in third-party spreadsheet or database programs.
  10. Alarm Generation:
    - a. Alarms may be generated within the system for any object change of value or state either real or calculated. This includes things such as analog object value changes, binary object state changes, and various controller communication failures.

- b. Each alarm may be dialed out as noted elsewhere.
- c. Alarm log shall be provided for alarm viewing. Log may be viewed on-site at the operator's terminal or off-site via remote communications.
- d. Controller must be able to handle up to 320 alarm setups stored as BACnet event enrollment objects – system destination and actions individually configurable.

11. Demand Limiting:

- a. Demand limiting of energy shall be built in function that shall be user configurable. Each controller module shall support shedding of up to 200 loads using a minimum of two types of shed programs.
- b. Load shedding programs in Building Controller Modules shall operate as defined in section 2.1.J of this specification.

12. Tenant Activity Logging:

- a. Tenant Activity logging shall be supported by Building Controller Module. Each independent module shall support a minimum of 80 zones.
- b. Tenant Activity logging shall functions as defined in section 2.1.K of this specification.

B. Ethernet – MS/TP Module:

- 1. Ethernet – MS/TP Module shall support every function as listed under paragraph A, General Requirements, of this section and the following.
- 2. All communication with operator workstation and all application controllers shall be via BACnet. Building controller Ethernet – MS/TP module shall incorporate as a minimum, the functions of a 2-way BACnet router. Controller shall route BACnet messages between the high-speed LAN (Ethernet 10/100MHz) and master slave token passing (MS/TP) LAN. Ethernet – MS/TP module shall also route messages from all other Building Controller modules onto the BACnet Ethernet network.

- a. MS/TP LAN must be software configurable from 9.6 to 76.8Kbps.
- b. The RJ-45 Ethernet connection must accept either 10Base-T or 100Base-TX BACnet over twisted pair cable (UTP).

3. BACnet Conformance:

- a. Ethernet – MS/TP module shall as a minimum support MS/TP and Ethernet BACnet LAN types. It shall communicate directly via these BACnet LANs as a native BACnet device and shall support simultaneous routing functions between all supported LAN types. Global controller shall be a BACnet conformance class 3 device and support all BACnet services necessary to provide the following BACnet functional groups:

- (1) Clock Functional Group
- (2) Files Functional Group
- (3) Reinitialize Functional Group

- (4) Device Communications Functional Group
    - (5) Event Initiation Functional Group
  - b. Please refer to section 22.2, BACnet Functional Groups, in the BACnet standard for a complete list of the services that must be directly supported to provide each of the functional groups listed above. All proprietary services, if used in the system, shall be thoroughly documented and provided as part of the submittal data. All necessary tools shall be supplied for working with proprietary information.
  - c. Standard BACnet object types supported shall include as a minimum: Analog Value, Binary Value, Calendar, Device, File, Group, Notification Class, Program and Schedule object types. All proprietary object types, if used in the system, shall be thoroughly documented and provided as part of the submittal data. All necessary tools shall be supplied for working with proprietary information.
  - d. The Building Controller shall comply with Annex J of the BACnet specification for IP connections. This device shall use Ethernet to connect to the IP internetwork, while using the same Ethernet LAN for non-IP communications to other BACnet devices on the LAN. Must support interoperability on wide area networks (WANs) and campus area networks (CANs) and function as a BACnet Broadcast Management Device (BBMD).
- C. MS/TP Module:
  - 1. MS/TP Module shall support every function as listed under paragraph A, General Requirements, of this section and the following.
  - 2. Building Controller MS/TP module communications shall be via BACnet master slave token passing (MS/TP) LAN to all advanced application and application specific controllers. MS/TP module shall also route messages to Ethernet-MS/TP module for communication over WAN.
    - a. MS/TP LAN must be software configurable from 9.6 to 76.8Kbps
    - b. Configuration shall be via RS-232 connection.
  - 3. BACnet Conformance:
    - a. MS/TP module shall as a minimum support MS/TP BACnet LAN type. It shall communicate directly via this BACnet LAN as a native BACnet device and shall support simultaneous routing functions between all supported LAN types. Controller shall be a BACnet conformance class 3 device and support all BACnet services necessary to provide the following BACnet functional groups:
      - (1) Clock Functional Group
      - (2) Files Functional Group
      - (3) Reinitialize Functional Group
      - (4) Device Communications Functional Group
      - (5) Event Initiation Functional Group

- b. Please refer to section 22.2, BACnet Functional Groups, in the BACnet standard for a complete list of the services that must be directly supported to provide each of the functional groups listed above. All proprietary services, if used in the system, shall be thoroughly documented and provided as part of the submittal data. All necessary tools shall be supplied for working with proprietary information.
- c. Standard BACnet object types supported shall include as a minimum: Analog Value, Binary Value, Calendar, Device, File, Group, Notification Class, Program and Schedule object types. All proprietary object types, if used in the system, shall be thoroughly documented and provided as part of the submittal data. All necessary tools shall be supplied for working with proprietary information.

**D. Power Supply Module:**

- 1. Power supply module shall power up to 7 Building Controller Modules. Input for power shall accept between 17 and 30 VAC, 47 to 65 Hz.
- 2. Power supply module shall include rechargeable battery for orderly shutdown of controller modules including storage of all data in flash memory and for continuous operation of real time clocks for minimum of 20 days.

**E. Modem Module:**

- 1. Provide all functions that will allow remote communications via modem module to off-site locations. Modem module shall integrate directly into modular controller without any special software or hardware. Include one modem module along with all cabling necessary for installation for the system.
- 2. Provide Windows 2000 software for off-site computer that allows operator to view and change all information associated with system on color graphic displays. Operator shall be able to change all parameters in this section from off-site location including all programming of building controllers and all programmable application controllers including all terminal unit controllers.
- 3. Building controller shall have capability to call out alarm conditions automatically. If desired, controller may also send encoded message to digital pager. If an alphanumeric pager is in use by the operator, building controller shall be capable of sending a text or numeric string of alarm description. All building controllers connected to the local LAN shall be capable of calling out alarm messages through one or more shared modems connected to one or more of the building controllers on the local LAN.
- 4. Building controller shall have capability to call a minimum of 20 different phone numbers. Numbers called may be controlled by type of alarm or time schedule.
- 5. Owner shall provide standard voice-grade phone line for remote communication function.
- 6. Building controller and internal modem shall be capable of modem-to-modem baud rates of 33.6 Kbps minimum over standard voice-grade phone lines. Lower baud rates shall be selectable for areas where local phone company conditions require them.



F. TUX Module:

1. TUX Module shall support every function as listed under paragraph A, General Requirements, of this section and the following.
2. Building Controller TUX module communications shall be via Alerton TUX Trunk to up to 64 Alerton TUX's. TUX module shall convert TUX data into BACnet objects and create virtual BACnet devices for every TUX connected to the TUX module. TUX module shall also route messages to Ethernet-MS/TP module for BACnet Ethernet communication over WAN.
  - a. TUX Module shall support TUX communication at 4800 and 9600 baud.
  - b. Configuration shall be via RS-232 connection.
3. BACnet Translation:
  - a. All TUX data shall be automatically translated into BACnet objects by the TUX module. No configuration by the user shall be necessary. Predefined BACnet objects shall be automatically assigned for each type of TUX controller connected.
  - b. Every TUX controller shall become a virtual BACnet device for ease of use with the BACnet workstation for configuration and operation.
  - c. Standard BACnet object types supported shall include as a minimum: Analog Value, Binary Value, Calendar, Device, File, Group, Notification Class, Program and Schedule object types. All proprietary object types, if used in the system, shall be thoroughly documented and provided as part of the submittal data. All necessary tools shall be supplied for working with proprietary information.

2.3 TERMINAL UNIT APPLICATION CONTROLLERS (AC UNITS):

- A. Provide one native BACnet application controller for each piece of unitary mechanical equipment that adequately covers all objects listed in object list for unit. All controllers shall interface to building controller via MS/TP LAN using BACnet protocol. No gateways shall be used. Controllers shall include input, output and self-contained logic program as needed for complete control of unit.
- B. BACnet Conformance:
  1. Application controllers shall as a minimum support MS/TP BACnet LAN types. They shall communicate directly via this BACnet LAN at 9.6, 19.2, 38.4 and 76.8 Kbps, as a native BACnet device. Application controllers shall be of BACnet conformance class 3 and support all BACnet services necessary to provide the following BACnet functional groups:
    - a. Files Functional Group
    - b. Reinitialize Functional Group
    - c. Device Communications Functional Group

2. Please refer to section 22.2, BACnet Functional Groups in the BACnet standard for a complete list of the services that must be directly supported to provide each of the functional groups listed above. All proprietary services, if used in the system, shall be thoroughly documented and provided as part of the submittal data. All necessary tools shall be supplied for working with proprietary information.
  3. Standard BACnet object types supported shall include as a minimum—Analog Input, Analog Output, Analog Value, Binary Input, Binary Output, Binary Value, Device, File and Program Object Types. All proprietary object types, if used in the system, shall be thoroughly documented and provided as part of the submittal data. All necessary tools shall be supplied for working with proprietary information.
- C. Application controllers shall include universal inputs with 10-bit resolution that can accept 3K and 10K thermistors, 0–5 VDC, 4–20 mA, dry contact signals and a minimum of 3 pulse inputs. Any input on controller may be either analog or digital. Controller shall also include support and modifiable programming for interface to intelligent room sensor. Controller shall include binary outputs on board with analog outputs as needed.
- D. All program sequences shall be stored on board controller in EEPROM. No batteries shall be needed to retain logic program. All program sequences shall be executed by controller 10 times per second and shall be capable of multiple PID loops for control of multiple devices. Programming of application controller shall be completely modifiable in the field over installed BACnet LANs or remotely via modem interface. Operator shall program logic sequences by graphically moving function blocks on screen and tying blocks together on screen. Application controller shall be programmed using same programming tools as building controller and as described in operator workstation section. All programming tools shall be provided and installed as part of system.
- E. Application controller shall include support for intelligent room sensor (see Section 2.9.B.) Display on room sensor shall be programmable at controller and include an operating mode and a field service mode. All button functions and display data shall be programmable to show specific controller data in each mode based on which button is pressed on the sensor. See sequence of operation for specific display requirements at intelligent room sensor.
- F. Application controllers shall include universal inputs with 10-bit resolution that can accept 3K and 10K thermistors, 0–5 VDC, and dry contact signals. Inputs on controller may be either analog or digital. Controller shall also include support and modifiable programming for interface to intelligent room sensor with digital display. Controller shall also include binary outputs on board. For applications using variable speed parallel fans, provide a single analog output selectable for 0-10 V or 0-20 mA control signals. Application controller shall include microprocessor driven flow sensor for use in pressure independent control logic. All boxes shall be controlled using pressure independent control algorithms and all flow readings shall be in CFM (LPS if metric).
- G. All program sequences shall be stored on board application controller in EEPROM. No batteries shall be needed to retain logic program. All program sequences shall be executed by controller 10 times per second and shall be capable of multiple PID loops for control of multiple devices. Programming of application controller shall be completely modifiable in

the field over installed BACnet LANs or remotely via modem interface. Operator shall program logic sequences by graphically moving function blocks on screen and tying blocks together on screen. Application controller shall be programmed using the same programming tool as Building Controller and as described in operator workstation section. All programming tools shall be provided as part of system.

- H. Application controller shall include support for intelligent room sensor (see Section 2.9.B.) Display on room sensor shall be programmable at application controller and include an operating mode and a field service mode. All button functions and display data shall be programmable to show specific controller data in each mode based on which button is pressed on the sensor. See sequence for specific display requirements for intelligent room sensor.
- I. On board flow sensor shall be microprocessor driven and precalibrated at the factory. Precalibration shall be at 16 flow points as a minimum. All factory calibration data shall be stored in EEPROM. Calibration data shall be field adjustable to compensate for variations in VAV box type and installation. All calibration parameters shall be adjustable through intelligent room sensor. Operator workstation, portable computers and special hand-held field tools shall not be needed for field calibration.
- J. Provide duct temperature sensor at discharge of each terminal box that is connected to controller for reporting back to operator workstation.

#### 2.4 SENSORS and MISCELLANEOUS DEVICES:

- A. Temperature Sensors: All temperature sensors to be solid state electronic, factory-calibrated to within 0.5°F, totally interchangeable with housing appropriate for application. Wall sensors to be installed as indicated on drawings. Mount 48 inches about finished floor. Duct sensors to be installed such that the sensing element is in the main air stream. Immersion sensors to be installed in wells provided by control contractor, but installed by mechanical contractor. Immersion wells shall be filled with thermal compound before installation of immersion sensors. Outside air sensors shall be installed away from exhaust or relief vents, not in an outside air intake and in a location that is in the shade most of the day.
- B. Carbon Monoxide Detector:
  - 1. Provide Fyrnetics carbon monoxide detector or equal (120V-1PH) complete with auxiliary hearing impaired strobe light in each Mechanical Room with gas-fired equipment.
  - 2. The system shall monitor parts per million of carbon monoxide and shall alarm at a predetermined level of concentration (adjustable setpoint). The alarm shall activate the unit alarm light, horn, and a remote strobe light located at all entrances to mechanical rooms. The detector shall de-energize the horn upon safe carbon monoxide levels, however, the warning lights shall require manual reset. Detector shall be complete with remote sensors output for Building Automation System.
  - 3. Alarms shall be monitored through the DDC control system.

C. Field Service Tool:

1. Field service tool shall allow technician to view and modify all setpoints and tuning parameters stored in application controller. In addition, technician shall be able to view status of all inputs and outputs on digital readout. Each piece of data shall have a data code associated with it that is customizable.
2. Field service tool shall plug into wall sensor and provide all the functionality specified. Operator workstation shall include the capability to disable operation of the field service tool.
3. Provide XX Field Service Tools for this project or laptop PC.

D. Network Connection Tool:

1. Network connection tool shall allow technician to connect a laptop to any MS/TP network or at any MS/TP device and view and modify all information throughout the entire BACnet network. Laptop connection to tool shall be via Ethernet or PTP.
2. Provide quick connect to MS/TP LAN at each controller. Tool shall be able to adjust to all MS/TP baud rates specified in the BACnet standard.
3. Provide XX Network Connection Tools for this project.

2.5 ELECTRONIC ACTUATORS AND VALVES:

A. Quality Assurance for Actuators and Valves:

1. UL Listed Standard 873 and C.S.A. Class 4813 02 certified.
2. NEMA 2 rated enclosures for inside mounting, provide with weather shield for outside mounting.
3. Five-year manufacturers warranty. Two-year unconditional and three-year product defect from date of installation.

B. Execution Details for Actuators and Valves:

1. Furnish a Freeze-stat and install "Hard Wire" interlock to disconnect the mechanical spring return actuator power circuit for fail-safe operation. Use of the control signal to drive the actuators closed is not acceptable.
2. Each DDC analog output point shall have an actuator feedback signal, independent of control signal, wired and terminated in the control panel for true position information and troubleshooting. Or the actuator feedback signal may be wired to the DDC as an analog input for true actuator position status.
3. VAV box damper actuation shall be Floating type or Analog (2-10vdc, 4-20ma).
4. Booster-heat valve actuation shall be Floating type or Analog (2-10vdc, 4-20ma).
5. Primary valve control shall be Analog (2-10vdc, 4-20ma).

C. Actuators for Damper and Control Valves ½" to 6" shall be Electric unless otherwise specified, provide actuators as follows:

1. UL Listed Standard 873 and Canadian Standards association Class 481302 shall certify Actuators.
2. NEMA 2 rated actuator enclosures are. Use additional weather shield to protect actuator when mounted outside.
3. 5 year Manufacturers Warranty. Two-year unconditional + Three year product defect from date of installation.
4. Mechanical spring shall be provided when specified. Capacitors or other non-mechanical forms of fail-safe are not acceptable.
5. Position indicator device shall be installed and made visible to the exposed side of the Actuator. For damper short shaft mounting, a separate indicator shall be provided to the exposed side of the Actuator.
6. Overload Protection: Actuators shall provide protection against actuator burnout by using an internal current limiting circuit or digital motor rotation sensing circuit. Circuit shall insure that actuators cannot burn out due to stalled damper or mechanical and electrical paralleling. End switches to deactivate the actuator at the end of rotation are acceptable only for Butterfly Valve actuators.
7. A push button gearbox release shall be provided for all non-spring actuators.
8. Modulating actuators shall be 24Vac and consume 10VA power or less.
9. Conduit connectors are required when specified and when code requires it.

D. Damper Actuators:

1. Outside Air and Exhaust Air Damper Actuators shall be Mechanical Spring Return. Capacitors or other non-mechanical forms of fail-safe are not acceptable. The actuator mounting arrangement and spring return feature shall permit normally open or normally closed positions of the damper as required.
2. Economizer Actuators shall utilize Analog control 2-10 VDC, Floating control is not acceptable.
3. Electric damper actuators (including VAV box actuators) shall be direct shaft mounted and use a V-bolt and toothed V-clamp causing a cold weld effect for positive gripping. Single bolt or setscrew type fasteners are not acceptable.
4. One electronic actuator shall be direct shaft mounted per damper section. No connecting rods or jackshafts shall be needed. Small outside air and return air economizer dampers may be mechanically linked together if one actuator has sufficient torque to drive both and damper drive shafts are both horizontal installed.
5. Multi-section dampers with electric actuators shall be arranged so that each damper section operates individually. One electronic actuator shall be direct shaft mounted per damper section. (See below execution section for more installation details.)

E. Valve Actuators ½" to 6":

1. Mechanical spring shall be provided on all actuators for pre-heat coil and actuators for AHU heating or cooling coil when units are mounted outside. See plans for fail save flow function: Normal Open or Normal Closed. Capacitors or other non-mechanical forms of fail-safe are not acceptable.

2. All zone service actuators shall be non-spring return unless otherwise specified.
  3. The valve actuator shall be capable of providing the minimum torque required for proper valve close off for the required application.
  4. All control valves actuators shall have an attached 3-foot cable for easy installation to a junction box.
  5. Override handle and gearbox release shall be provided for all non-spring return valve actuators.
- F. Control Dampers. The BAS contractor shall furnish and size all automatic control dampers unless provided with packaged equipment. The sheet metal contractor shall install all dampers unless provided with packaged equipment.
1. All dampers used for modulating service shall be opposed blade type arrange for normally open or normally closed operation as required. The damper is to be sized so that when wide open the pressure drop is a sufficient amount of its close-off pressure drop for effective throttling.
  2. All dampers used for two-position or open-close control shall be parallel blade type arranged for normally open or closed operation as required.
  3. Damper linkage hardware shall be constructed of aluminum or corrosion resistant zinc & nickel-plated steel and furnished as follows:
  4. Bearing support bracket and drive blade pin extension shall be provided for each damper section. Sheet metal contractor shall install bearing support bracket and drive blade pin extension. Sheet metal contractor shall provide permanent indication of blade position by scratching or marking the visible end of the drive blade pin extension.
  5. Drive pin may be round only if V-bolt and toothed V-clamp is used to cause a cold weld effect for positive gripping. For Single bolt or set-screw type actuator fasteners, round damper pin shafts must be milled with at least one side flat to avoid slippage.
  6. Damper manufacturer shall supply alignment plates for all multi-section dampers.
- G. Control Valves ½” to 6”: The BAS contractor shall furnish all specified motorized control valves and actuators. BAS contractor shall furnish all control wiring to actuators. The Plumbing contractor shall install all valves. Equal Percentage control characteristic shall be provided for all water coil control valves. Linear valve characteristic is acceptable for 3-way valves 2½ inch and above.
1. Characterized Control Valves shall be used for hydronic heating or cooling applications and small to medium AHU water coil applications to 100GPM. Actuators are non-spring return for terminal unit coil control unless otherwise noted. If the coil is exposed to the Outside Air stream then see plans for Spring Return requirement.
    - a. Leakage is Zero percent, Close-off is 200psi, Maximum differential is 30psi. Rangeability is 500:1.
    - b. Valves 1/2 inch through 2 inches shall be nickel-plated forged brass body, NPT screw type connections.
    - c. Valves 1/2 inch through 1-1/4 inches shall be rated for ANSI Class 600 working pressure. Valves 1-1/2 inch and 2 inches shall be rated for ANSI Class 400 working pressure.
    - d. The operating temperature range shall be 0° to 250° F.

- e. Stainless steel ball & stem shall be furnished on all modulating valves.
  - f. Seats shall be fiberglass reinforced Teflon.
  - g. Two-way and three-way valves shall have an equal percentage control port. Full stem rotation is required for maximum flow to insure stable BTU control of the coil.
  - h. Three-way valve shall be applicable for both mixing and diverting.
  - i. The characterizing disc is made of TEFZEL and shall be keyed and held secure by a retaining ring.
  - j. The valves shall have a blow out proof stem design.
  - k. The stem packing shall consist of 2 lubricated O-rings designed for on-off or modulating service and require no maintenance.
  - l. The valves shall have an ISO type, 4-bolt flange, for mounting actuator in any orientation parallel or perpendicular to the pipe.
  - m. A non-metallic thermal isolation adapter shall separate valve flange from actuator.
  - n. One fastening screw shall secure the direct coupling of the thermal isolation adapter between the actuator and the valve. This will prevent all lateral or rotational forces from affecting the stem and it's packing O-rings.
- H. Butterfly valves: Butterfly Valves shall be sized for modulating service at 60-70 degree stem rotation. Isolation valves shall be line-size. Design velocity shall be less than 12 feet per second when used with standard EPDM seats.
- 1. Body is Cast Iron.
  - 2. Disc is Aluminum Bronze standard.
  - 3. Seat is EPDM Standard.
  - 4. Body Pressure is 200 psi, -30F to 275F.
  - 5. Flange is ANSI 125/250.
  - 6. Media Temperature Range is -22F to 240F.
  - 7. Maximum Differential Pressure is 200 psi for 2" to 6" size.
- I. Performance Verification Test:
- 1. Control loops shall cause productive actuation with each movement of the actuator and actuators shall modulate at a rate which is stable and responsive. Actuator movement shall not occur before the effects of previous movement have affected the sensor.
  - 2. Actuator shall have capability of signaling a trouble alarm when the actuator Stop-Go Ratio exceeds 30%.
  - 3. Actuator Mounting for Damper and Valve arrangements shall comply to the following:
    - a. Damper Actuators: Shall not be installed in the air stream
    - b. A weather shield shall be used if actuators are located outside. For Damper Actuators use clear plastic enclosure.
    - c. Damper or valve actuator ambient temperature shall not exceed 122 Deg. F. through any combination of medium temperature or surrounding air. Appropriate air gaps, thermal isolation washers or spacers, standoff legs, or insulation shall be provided as necessary

- d. Actuator cords or conduit shall incorporate a drip leg if condensation is possible. Water shall not be allowed to contact actuator or internal parts. Location of conduits in temperatures dropping below dew point shall be avoided to prevent water from condensing in conduit and running into actuator.
  - e. Damper mounting arrangements shall comply to the following:
    - (1) The ventilation subcontractor shall furnish and install damper channel supports and sheet metal collars.
    - (2) No jack shafting of damper sections shall be allowed.
    - (3) Multi-section dampers shall be arranged so that each damper section operates individually. One electronic actuator shall be direct shaft mounted per section.
  - f. Size damper sections based on actuator manufacturers specific recommendations for face velocity, differential pressure and damper type. In general:
    - (1) Damper section shall not exceed 24 ft-sq. with face velocity £ 1500 FPM.
    - (2) Damper section shall not exceed 18 ft-sq. with face velocity £ 2500 FPM.
    - (3) Damper section shall not exceed 13 ft-sq. with face velocity £ 3000 FPM.
  - g. Multiple section dampers of two or more shall be arranged to allow actuators to be direct shaft mounted on the outside of the duct.
  - h. Multiple section dampers of three or more sections wide shall be arranged with a 3-sided vertical channel (8'' wide by 6'' deep) within the duct or fan housing and between adjacent damper sections. Vertical channel shall be anchored at the top and bottom to the fan housing or building structure for support. The sides of each damper frame shall be connected to the channels. Holes in the channel shall allow damper drive blade shafts to pass through channel for direct shaft mounting of actuators. Open side of channel shall be faced down stream of the airflow, except for exhaust air dampers.
  - i. Multiple section dampers to be mounted flush within a wall or housing opening shall receive either vertical channel supports as descried above or sheet metal standout collars. Sheet metal collars (12'' minimum) shall bring each damper section out of the wall to allow direct shaft mounting of the actuator on the side of the collar.
4. Valve Sizing for Water Coil:
- a. On/Off Control Valves shall be line size.
  - b. Modulating Control Valve Body Size may be reduced at most two pipe sizes from the line size or not less than ½ the pipe size. The BAS contractor shall size all water coil control valves for the application as follows:
    - (1) Booster-heat valves shall be sized not to exceed 4-9psi differential pressure. Size valve for 50% Valve Authority. Valve design pressure drop is equal to the sum of coil drop plus the balance valve drop.



- (2) Primary valves shall be sized not to exceed 5-15psi differential pressure. Size valve for 50% Valve Authority. Valve design pressure drop is equal to the sum of coil drop plus the balance valve drop.
- (3) Butterfly valves shall be sized for modulating service at 60-70 degree rotation. Design velocity shall be 12 feet per second or less when used with standard EPDM seats.

c. Valve Mounting arrangements shall comply to the following:

- (1) Unions shall be provided on all ports of two-way and three-way valves.
- (2) Install three-way equal percentage Characterized Control valves in a mixing configuration with the "A" port piped to the coil.
- (3) Install 2½ inch and above, Three-Way globe valves, as manufactured for mixing or diverting service to the coil.

2.6 ENCLOSURES:

- A. All controllers, power supplies and relays shall be mounted in enclosures.
- B. Enclosures may be NEMA 1 when located in a clean, dry, indoor environment. Indoor enclosures shall be NEMA 12 when installed in other than a clean environment.
- C. Enclosures shall have hinged, locking doors.
- D. Provide laminated plastic nameplates for all enclosures in any mechanical room or electrical room. Include location and unit served on nameplate. Laminated plastic shall be 1/8" thick sized appropriately to make label easy to read.

PART 3: EXECUTION

3.1 EXAMINATION:

- A. Prior to starting work, carefully inspect installed work of other trades and verify that such work is complete to the point where work of this Section may properly commence.
- B. Notify the owners' representative in writing of conditions detrimental to the proper and timely completion of the work.
- C. Do not begin work until all unsatisfactory conditions are resolved.

3.2 INSTALLATION (GENERAL):

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

- B. Provide all miscellaneous devices, hardware, software, interconnections installation and programming required to ensure a complete operating system in accordance with the sequences of operation and point schedules.

**3.3 LOCATION AND INSTALLATION OF COMPONENTS:**

- A. Locate and install components for easy accessibility; in general, mount 48 inches above floor with minimum 3'-0" clear access space in front of units. Obtain approval on locations from owner's representative prior to installation.
- B. All instruments, switches, transmitters, etc., shall be suitably wired and mounted to protect them from vibration, moisture and high or low temperatures.
- C. Identify all equipment and panels. Provide permanently mounted tags for all panels.
- D. Provide stainless steel or brass thermowells suitable for respective application and for installation under other sections—sized to suit pipe diameter without restricting flow.

**3.4 INTERLOCKING AND CONTROL WIRING:**

- A. Provide all interlock and control wiring. All wiring shall be installed neatly and professionally, in accordance with Specification Division 16 and all national, state and local electrical codes.
- B. Provide wiring as required by functions as specified and as recommended by equipment manufacturers, to serve specified control functions. Provide shielded low capacitance wire for all communications trunks.
- C. Control wiring shall not be installed in power circuit raceways. Magnetic starters and disconnect switches shall not be used as junction boxes. Provide auxiliary junction boxes as required. Coordinate location and arrangement of all control equipment with the owner's representative prior to rough-in.
- D. Provide auxiliary pilot duty relays on motor starters as required for control function.
- E. Provide power for all control components from nearest electrical control panel or as indicated on the electrical drawings—coordinate with electrical contractor.
- F. All control wiring in the mechanical, electrical, telephone and boiler rooms to be installed in raceways. All other wiring to be installed neatly and inconspicuously per local code requirements. If local code allows, control wiring above accessible ceiling spaces may be run with plenum rated cable (without conduit).

**3.5 DDC OBJECT TYPE SUMMARY:**

- A. Provide all database generation.
- B. Displays: System displays shall show all analog and binary object types within the system. They shall be logically laid out for easy use by the owner. Provide outside air temperature indication on all system displays associated with economizer cycles.
- C. Run Time Totalization: At a minimum, run time totalization shall be incorporated for each monitored supply fan, return fan, exhaust fan, hot water and chilled water pumps. Warning limits for each point shall be entered for alarm and or maintenance purposes.
- D. Trendlog: All binary and analog object types (including zones) shall have the capability to be automatically trended.
- E. Alarm: All analog inputs (High/Low Limits) and selected binary input alarm points shall be prioritized and routed (locally or remotely) with alarm message per owner's requirements.
- F. Database Save: Provide back-up database for all stand-alone application controllers on disk.

**3.6 FIELD SERVICES:**

- A. Prepare and start logic control system under provisions of this section.
- B. Start-up and commission systems. Allow sufficient time for start-up and commissioning prior to placing control systems in permanent operation.
- C. Provide the capability for off-site monitoring at control contractor's local or main office. At a minimum, off-site facility shall be capable of system diagnostics and software download. Owner shall provide phone line for this service for 1 year or as specified.
- D. Provide Owner's Representative with spare parts list. Identify equipment critical to maintaining the integrity of the operating system.

**3.7 TRAINING:**

- A. Provide application engineer to instruct owner in operation of systems and equipment.
- B. Provide system operator's training to include (but not limited to) such items as the following: modification of data displays, alarm and status descriptors, requesting data, execution of commands and request of logs. Provide this training to a minimum of 3 persons.
- C. Provide on-site training above as required, up to 16 hours as part of this contract.

3.8 DEMONSTRATION:

- A. Provide systems demonstration under provisions of Section 23 00 00.
- B. Demonstrate complete operating system to owner's representative.
- C. Provide certificate stating that control system has been tested and adjusted for proper operation.

PART 4: SEQUENCE OF OPERATIONS

4.1 GENERAL:

- A. Provide a complete and operational temperature control and building automation system based on the following points and sequence of operation. The system shall be complete as to sequences and standard control practices. The determined point list is the minimum amount of points that are to be provided. If additional points are required to meet the sequence of operation, they will be provided.
- B. BACnet Object List: The following points as defined for each piece of equipment are designated as follows:
  - 1. Binary Out (BO) - Defined as any two-state output (start/stop) (enable/disable), etc.
  - 2. Binary In (BI) - Defined as any two-state input (alarm, status), etc.
  - 3. Analog In (AI) - Defined as any variable input (temperature) (position), etc.
  - 4. Analog Out (AO) - Defined as any electrical variable output. 0–20mA, 4–20mA and 0–10VDC are the only acceptable analog outputs. The driver for analog outputs must come from both hardware and software resident in the controllers. Transducers will not be acceptable under any circumstance.

4.2 CONTROL SEQUENCES:

- A. CAMPBELL COURT ES only: 4-Pipe Blower Coils (Single Zone, Constant Volume):
  - 1. Occupied Mode: The supply fan shall operate continuously.
    - a. Cooling: On a call for cooling, the BAS shall modulate the chilled water cooling coil valve to maintain space setpoint.
    - b. Heating: On a call for heating, the BAS shall modulate the heating coil valve to maintain space setpoint.
  - 2. Unoccupied Mode: The supply fan shall cycle and the heating coil and cooling coil valves shall modulate as required to maintain a reduced night setback or increased night setup temperature. On a manual call for override from the temperature sensor override button, the system shall return to the occupied mode of operation for a set period of time.

3. Morning Warm-Up/Cool-Down Mode: The BAS shall optimally start the supply fan and modulate the heating or cooling coil valves to reach occupied setpoint by scheduled occupied time.
- B. CARVER ES and DREWRY MASON ES only: Single Zone Packaged Rooftop Air Conditioning Unit (Constant Volume):
1. Morning Warm-up/Cool Down Mode: The controls shall optimally start the unit and modulate the space hydronic heat or energize the DX cooling to reach occupied setpoint by scheduling occupied time. The outside air damper shall be closed and the return air damper shall be open.
  2. Occupied Mode: The supply air fan shall operate continuously and the outside air damper shall open to the minimum outside air position. The DX cooling shall sequence and the hydronic heat shall modulate to maintain room temperature setpoint. The outdoor air damper shall further modulate open in the economizer cycle. The return air damper shall modulate proportionately toward the closed position.
  3. Unoccupied Mode: The supply air fan shall cycle, the outside air damper shall close, the return air damper shall open, the unit gas heat shall modulate and the DX cooling shall energize as required to maintain setback temperature.
  4. Economizer Mode: An enthalpy economizer shall compare indoor and outdoor enthalpy and modulate the unit outdoor air damper and return air damper during the cooling cycle to provide up to 100% outdoor air for free cooling. The economizer supply air temperature shall be limited to 55 Deg. F.
- C. Duct-Mounted Hot Water Heating Coil: The duct-mounted hot water heating coil shall be controlled by the associated Air Handling Unit, or a space-mounted temperature sensor through the BAS. The BAS shall modulate the heating coil control valve to maintain space temperature.

END OF SECTION 230900

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SECTION 232000 - HVAC PIPING AND PUMPS

PART 1: GENERAL

1.1 CONDITIONS:

- A. The applicable provisions of Section 230000, HEATING, VENTILATING AND AIR-CONDITIONING (HVAC) are hereby made a part of this section, and the Contractor is cautioned to read Section 230000 carefully as items of work applicable to this section are included in Section 230000.

1.2 DESCRIPTION OF WORK:

- A. Piping to connect HVAC equipment, including the following:
  - 1. Heating Water Piping
  - 2. Condensate Drain Piping
- B. Installation of control valves and instrument wells referred to in other Division 23 sections.
- C. Hydronic System Components

1.3 RELATED WORK:

- A. Section 230000, HEATING, VENTILATING AND AIR-CONDITIONING (HVAC).
- B. Section 230593, TESTING, ADJUSTING, AND BALANCING FOR HVAC.
- C. Section 230700, HVAC INSULATION.
- D. Section 230900, INSTRUMENTATION AND CONTROL FOR HVAC.
- E. Section 233000, HVAC AIR DISTRIBUTION.
- F. Section 235000, CENTRAL HEATING EQUIPMENT.
- G. Section 236000, CENTRAL COOLING EQUIPMENT.
- H. Section 237000, CENTRAL HVAC EQUIPMENT.
- I. Section 238100, DECENTRALIZED UNITARY HVAC EQUIPMENT.
- J. Section 238200, CONVECTION HEATING AND COOLING UNITS.

1.4 SUBMITTALS:

- A. In accordance with Section 23 00 00, HEATING, VENTILATING AND AIR-CONDITIONING (HVAC), furnish the following:
  - 1. Manufacturer's Literature and Data with pump curve (where applicable):
    - a. Pipe and equipment supports. Submit calculations for variable spring and constant support hangers
    - b. Pipe and tubing, with specification, class or type, and schedule
    - c. Pipe fittings, including miscellaneous adapters and special fittings
    - d. Flanges, gaskets and bolting
    - e. Valves of all types
    - f. Strainers
    - g. Gages
    - h. Refrigerant valves and components
    - i. Flexible connectors for water service
    - j. All specified hydronic system components
    - k. Water flow measuring devices
    - l. Thermometers and tests wells

PART 2: PRODUCTS

2.1 PIPE AND EQUIPMENT SUPPORTS, PIPE SLEEVES, AND WALL AND CEILING PLATES:

- A. Provide in accordance with specifications in Section 23 00 00, HEATING, VENTILATING AND AIR-CONDITIONING (HVAC).

2.2 PIPE AND TUBING:

- A. Heating Water Piping (2-Inch and Smaller):
  - 1. Copper Water Tube Option: ASTM B 88, Type L, hard drawn.
- B. Cooling Coil Condensate Drain Piping:
  - 1. From Air Handling Units: Copper water tube, ASTM B 88, Type L, hard drawn copper tubing.
- C. Refrigerant Piping:
  - 1. Copper Tubing: ASTM B 280, type ACR, cleaned, dehydrated and sealed seamless.



**2.3 FITTINGS:**

**A. Copper Tubing:**

1. Solder Joint: Wrought copper, ANSI B16.22.
  - a. Solder for Drain Piping: 95-5 tin-antimony, ASTM B 32 (95TA).
  - b. Solder for Refrigerant Piping: Silver brazing alloy.

**B. Bronze Flanges and Flanged Fittings: ANSI B16.24.**

**2.4 DIELECTRIC FITTINGS:**

**A. Provide where copper and ferrous metal are joined.**

1. 2 Inch and Less: Threaded dielectric union.
2. 2-1/2 Inch and Larger: Flange union with dielectric gasket and bolt sleeves.

**2.5 THREADED JOINTS:**

**A. Pipe Thread: ANSI B2.1.**

**B. Lubricant or Sealant: Oil and graphite or other compound approved for the intended service.**

**2.6 VALVES:**

**A. Valves shall be Stockham, Milwaukee, Nibco, or Victaulic. All valves shall be suitable for 125 psi working pressure unless noted otherwise. Valves shall have threaded or grooved connections, except where flanges are specified they shall have flanged connections or where installed in hard drawn copper lines they may have sweat connections.**

**B. Service Valves--2-1/2 Inch and Smaller:**

1. Gate valve: ASTM B-62 bronze body and solid wedge disc, rising stem MSS SP-80, Class 125.
2. Ball valve: ASTM B-584 Alloy 844 bronze body and stainless steel ball with teflon seats, conventional port, and blowout proof stems MSS SP-110, 150 PSI/600 PSI non-shock. Provide extended stem per application.

**C. Globe Valves: 2-Inch and Smaller: ASTM B-62 bronze body and disc, MSS SP-80, Class 125.**

**D. Check valves in sizes up to and including 2 inch shall be all bronze, swing type, with regrinding disc capable of being reground without removing the valve body from the line. Sizes 2-1/2 inch and larger shall be iron body, bronze-trimmed, regrinding seat, swing type, for water service.**

- E. Refrigerant components shall include sight glass, filter drier, solenoid valve, charging valve, expansion valve and isolation valves. Refrigerant valves shall conform to ANSI B31.5. Refrigerant drier shall conform to ARI 710. Refrigerant circuit access ports shall be fitted with locking type tamper resistant caps in strict accordance with the IMC.
- F. Balancing Cocks: Combination balancing and shut-off valves shall incorporate a position indicator and memory stop or locking device so the valve can be closed without disturbing the setting, and be returned to the balanced position without further adjustment.
  - 1. 3-Inch and Smaller: Resilient faced eccentric plug or lubricated plug type, iron or steel body, bronze plug and bearings, wrench operated, rated 175 psig at 200 Deg. F.

**2.7 STRAINERS:**

- A. Mueller Steam Specialty Co. No. 351 Y type.
  - 1. Steam Services: Rated 150 psig saturated steam at 450 degrees F.
    - a. 2-1/2 Inch and Larger: Flanged, iron body.
    - b. 2-Inch and Smaller: Bronze.
  - 2. Water Services: Rated 125 psig saturated steam at 450 Deg. F.
    - a. 2-1/2 Inch and Larger: Flanged, iron body, basket type (No. 165).
    - b. 2-Inch and Smaller: Bronze, threaded ends, Y type (No. 351).
  - 3. Screens: Bronze, monel metal or 18-8 stainless steel, free area not less than 2-1/2 times pipe area, with perforations as follows:
    - a. Steam Service: 0.045-inch diameter perforations.
    - b. Water Service:
      - (1) 2-1/2 Inch and Larger: 1/16-inch diameter perforations.
      - (2) 2 Inch and Smaller: 1/32-inch diameter perforations.
- B. Provide blow off outlet with pipe nipple and gate valve.

**2.8 FLEXIBLE CONNECTORS FOR REFRIGERANT PIPING:**

- A. Flexible bronze or stainless steel piping connectors shall be Spring-Flex type MFP, style BF as manufactured by Vibration Mountings and Controls, Inc.

**2.9 FLEXIBLE CONNECTORS FOR WATER SERVICE:**

- A. Flexible pipe joints shall be Flexonics Model PCS, stainless steel braided hose, pipe line size, flanged, minimum 125 psi working pressure at 250 degrees F.

2.10 EXPANSION JOINTS:

- A. Expansion joints shall be Flexonic internally guided, corrugated bellows, expansion compensator, Type HB, 2" minimum stroke, suitable for (steam) (hot water) service. Grooved pipe couplings and expansion compensators shall provide for expansion in grooved piping systems.
- B. Expansion joints shall be Kelflex GTI-M-311 (or equal) dual or single internally guided, corrugated bellows, expansion compensator, 2" minimum stroke, suitable for hot water service. Grooved pipe couplings and expansion compensators shall provide for expansion in grooved piping systems. Provide necessary pipe alignment guides as required for expansion joint installation.

2.11 FLEXIBLE CONNECTORS FOR WATER SERVICE:

- A. Flexible pipe joints shall be Flexonics Model PCS, stainless steel braided hose, pipe line size, flanged, minimum 125 psi working pressure at 250 Deg. F.

2.12 GAGES, PRESSURE AND COMPOUND:

- A. Pressure gauges shall be Ashcroft bourdon tube, general service type suitable for 125 psi service. Gauges shall not be less than 4" dial type with aluminum case and gauge cock. Gauges shall be graduated in feet of water and psi.
- B. Range of Gages: Provide range equal to at least 150 percent of normal operating range.

2.13 THERMOMETERS:

- A. Weksler Instruments Type AA, Fed. Spec. GG-T-321, non-mercury fluid filled type, blue column, clear plastic window, with 6-inch brass stem, straight, adjustable angle as required for each in reading.
- B. Scale: Not less than nine inches, range as described below, two degree graduations.
- C. Separable Socket (Well): Brass, extension neck type to clear pipe insulation.
- D. Scale ranges may be slightly greater than shown to meet manufacturer's standard.

**PART 3: EXECUTION**

3.1 PIPING INSTALLATION:

- A. General:

1. The drawings show the general arrangement of pipe and equipment but do not show all fittings and offsets that may be necessary.
2. Store materials to avoid excessive exposure to weather or foreign materials. Keep inside of piping relatively clean during installation and protect open ends when work is not in progress.
3. Support piping securely. Refer to Section 23 00 00, HEATING, VENTILATING AND AIR-CONDITIONING (HVAC). Suspended horizontal piping shall be supported by adjustable wrought steel clevis hangers, except that straight runs of piping with 40 feet or more between anchor and expansion device shall be supported on roller type hangers or supports. Protection saddle, welded to pipe, shall be provided at each roller support. All supports shall be attached to the building structure and shall in no way be attached to the supports or other equipment, piping, or ductwork. Where supports bear on copper pipe, they shall be copper plated. Chain, strap, or other makeshift devices will not be permitted as hangers or supports. Maximum pipe support spacing shall be in accordance with Table 1 – MAXIMUM PIPING SUPPORT SPACING, except where grooved couplings are used, no pipe length shall be left unsupported between any two grooved couplings:

**Table 1 - Maximum Piping Support Spacing**

<b>PIPING MATERIAL</b>	<b>MAXIMUM HORIZONTAL SPACING (feet)</b>	<b>MAXIMUM VERTICAL SPACING (feet)</b>
ABS Pipe	4	10 <sup>c</sup>
Aluminum Pipe and Tubing	10	15
Brass Pipe	10	10
Brass Tubing, 1¼-inch Diameter & Smaller	6	10
Brass Tubing, 1½-inch Diameter & Larger	10	10
Cast-Iron Pipe <sup>b</sup>	5	15
Copper or Copper-Alloy Pipe	12	10
Copper or Copper-Alloy Tubing, 1¼-inch Diameter and Smaller	6	10
Copper or Copper-Alloy Tubing, 1½-inch Diameter & Larger	10	10
CPVC Pipe or Tubing, 1-inch & Smaller	3	10 <sup>c</sup>
CPVC Pipe or Tubing, 1¼-inch & Larger	4	10 <sup>c</sup>
Lead Pipe	Continuous	4
PB Pipe or Tubing	2-2/3 (32 inches)	4
PEX Tubing	2-2/3 (32 inches)	10 <sup>c</sup>
Polypropylene (PP) Pipe or Tubing, 1-inch or Smaller	2-2/3 (32 inches)	10 <sup>c</sup>
Polypropylene (PP) Pipe or Tubing, 1¼-inch or Larger	4	10 <sup>c</sup>
PVC Pipe	4	10 <sup>c</sup>
Steel Tubing	8	10
Steel Pipe	12	15
For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm a. See Section 301.18. b. The maximum horizontal spacing of cast-iron pipe hangers shall be increased to 10 feet where 10-foot lengths of pipe are installed. c. Mid-story guide.		

4. Install piping generally parallel to walls and column centerlines, unless shown otherwise on the drawings. Space piping, including insulation, to provide one inch minimum clearance between adjacent piping or other surface. Pipe shall be installed to permit free expansion and contraction without damage to joints or hangers. Slope piping down in the direction of flow not less than one inch in 40 feet. Provide eccentric reducers to keep bottom of sloped piping flat. All high points in water lines shall be provided with manual-air vents, all low points with drains. Condensate drain lines shall slope 1/8" per foot in direction of flow.
5. Locate and orient valves to permit proper operation and access for maintenance of packing, seat and disc. Generally locate valve stems in overhead piping in horizontal position. Control valves usually require reducers to connect to pipe sizes shown on the drawings. Isolation service valves shall be installed on each side of major piece of equipment such as a pump, boiler, chiller, heating coil, cooling coil and other similar items, and at any other points indicated or required for draining, isolation or sectionalizing purposes. Control valves shall be installed in accordance with control manufacturer's recommendations.
6. Offset equipment connections to allow valving off for maintenance and repair with minimal removal of piping. Provide flexibility in equipment connections and branch line takeoffs with 3-elbow swing joints where noted on the drawings.
7. Tee water piping runouts or branches into the side of mains or other branches. Avoid bull-head tee, which is two return lines entering opposite ends of a tee and exiting out the common side or two supply lines exiting opposite ends of a tee and entering the common side.
8. Connect piping to equipment as shown on the drawings. Piping connections to equipment shall be provided with unions or flanges. (Banked water coils shall be piped in reverse return arrangement.) (Steam coils shall be trapped individually.) (Vacuum breaker shall be provided at steam supply connection to each steam coil or steam bundle.) A straight spool piece equal in length to impeller diameter shall be provided at suction connection to each pump. Install components furnished by others such as:
  - a. Flow elements (orifice unions), control valve bodies, flow switches, pressure taps with valve, and wells for sensors.
  - b. Thermometer Wells: In pipes 2-1/2 inches and smaller, increase the pipe size to provide free area equal to the upstream pipe area.

**B. Pipe Joints:**

1. Sweated: Copper tubing shall be cut square, ends reamed, and all filings and dust wiped from interior of pipe. Joints shall be soldered with solder drawn through the full fitting length. Excess solder shall be wiped from joint before solder hardens. Solder shall be 95/5 composition; 50/50 will not be allowed.
2. Threaded: Threaded joints shall be made with tapered threads properly cut. Joints shall be made tight with a stiff mixture of litharge and glycerin or other approved thread joint compound applied with a brush to the male threads only. Not more than three threads shall show after the joint is made up.
3. Grooved: Pipe coupling joints shall be assembled according to manufacturer's specifications. Pipe shall be square cut and grooved in accordance to manufacturer's specifications. Gaskets shall be verified as suitable for the intended service and shall be coated on the lips and back with a thin uniform coat of lubricant. The coupling housing shall be assembled over the gasket and shall engage both grooves. The nuts shall be uniformly tightened until the housing pads are firmly together metal to metal.

4. Welded: Joints shall be fusion-welded by qualified welders in accordance with ANSI B31.10, unless otherwise required. Changes in direction of piping shall be made with fittings only. Mitering or notching pipe to form elbows and tees or other similar type construction will not be permitted. Saddle-type welding outlets may be used for equipment take-offs from the mains.
  5. Flanges and Unions: Fittings shall be faced true and made square and tight. Unions shall be 125 psi service, bronze seat type. Flanges shall be ANSI Standard 125 psi service with 1/16" thick red rubber gaskets. Unions and flange joints shall be provided on each side of each valve 2-1/2" or larger and in each line immediately preceding the connection to each major piece of equipment such as a (pump), (converter), (boiler), (chiller), (heating coil), (cooling coil) and other similar items.
  6. Dielectric fittings such as couplings, unions, or flanges, shall be installed to isolate pipes of non-ferrous metal where connection is made to ferrous metal. Isolation shall be accomplished by non-metallic, unthreaded sleeves or gaskets or a combination of both. Fittings shall be so designed that the installing tools cannot come in contact with the insulating material. Materials shall withstand pressure and temperature as required.
- C. Leak Testing: Inspect all joints and connections for leaks and workmanship and make corrections as necessary.
1. A hydrostatic test at 1.5 times design pressure for 4 hours. Factory tested equipment (converters, exchangers, coils, etc.) need not be field tested. Avoid excessive pressure on mechanical seals and safety devices.

END OF SECTION

SECTION 232133 - VARIABLE SPEED DRIVES

PART 1: GENERAL

1.1 CONDITIONS:

- A. The applicable provisions of Section 23 00 00, HEATING, VENTILATING AND AIR-CONDITIONING (HVAC), are hereby made a part of this section and the Contractor is cautioned to read Section 23 00 00 carefully as items of work applicable to this section are included in Section 23 00 00.

1.2 DESCRIPTION OF WORK:

- A. Variable Speed Drive
- B. Variable Speed Drive Bypass

1.3 RELATED WORK:

- A. Section 23 00 00, HEATING, VENTILATING AND AIR-CONDITIONING (HVAC).
- B. Section 23 05 93, TESTING, ADJUSTING AND BALANCING FOR HVAC
- C. Section 23 09 00, INSTRUMENTATION AND CONTROL FOR HVAC
- D. Section 23 20 00, HVAC PIPING AND PUMPS.
- E. Section 23 34 00, HVAC FANS.
- F. Section 23 70 00, CENTRAL HVAC EQUIPMENT.
- G. Section 23 81 00, DECENTRALIZED UNITARY HVAC EQUIPMENT.

1.4 REFERENCES:

- A. ANSI - American National Standards Institute
- B. NEMA - National Electrical Manufacturers Association
- C. UL - Underwriters Laboratories. Inc.
- D. ETL - Electrical Testing Laboratories
- E. CSA - Canadian Standards Association

- F. NEC- National Electrical Code
- G. ISO - International Standards Organization
- H. IEC - International Electrotechnical Commission

**1.5 SUBMITTALS:**

- A. Submittals shall include the following:
  - 1. Shop drawing indicating dimensions, required clearances and location and size of each field connection.
  - 2. Power and control wiring diagrams.
- B. Submittals must be specific to this project. Generic submittals will not be accepted.

**1.6 QUALITY ASSURANCE:**

- A. The manufacturer shall have a minimum of 10 years experience in the design and construction of variable speed drives.
- B. All functions of the variable speed drive shall be tested at the factory prior to shipment. This test shall be conducted with motors connected to the VFD output and it shall test all inputs, outputs and program execution specific to this application.
- C. Manufacturer shall be listed by Underwriter's Laboratories as a manufacturer of variable speed drives.

**PART 2: PRODUCTS**

**2.1 ACCEPTABLE MANUFACTURERS:**

- A. Subject to compliance with the specifications, the following manufacturers shall be acceptable:
  - 1. Danfoss
  - 2. A.B.B.
  - 3. Graham
  - 4. Eaton



2.2 GENERAL:

- A. This section of the specifications applies variable speed drives (VSD's) for pumps, and other equipment not specified to be provided as factory installed with equipment.

2.3 VARIABLE SPEED DRIVES:

- A. Furnish and install variable speed drives for equipment where shown on the plans.
- B. The variable speed drive(s) shall be pulse width modulation (PWM) type, microprocessor-controlled design. Unit shall be the VLT 6000 Series manufactured by Danfoss or equal.
- C. The variable speed drive, including all factory installed options, shall have UL approval.
- D. Enclosure shall be NEMA 1 ventilated for installation as a wall or free-standing rack mounted unit, depending on the amp rating. Drive shall be equipped with an input disconnect switch and fuses to protect against ground faults. A hand-off-automatic switch and speed potentiometer shall be mounted on the front of the enclosure. VSD's shall be provided with phase loss protection.
  - 1. Variable speed drive shall utilize a diode bridge rectifier to convert three phase AC to a fixed DC voltage. Power factor shall remain above 0.95 regardless of speed or load. VSDs employing power factor correction capacitors shall not be acceptable.
  - 2. Insulated gate bipolar transistors shall be used in the inverter section to convert the fixed DC voltage to a three phase, adjustable frequency.
  - 3. The following customer modifiable adjustments shall be provided:
    - a. Accel time: 0.1 to 1800 seconds
    - b. Decel time: 0.1 to 1800 seconds
    - c. Minimum frequency: 0 Hz
    - d. Maximum frequency: 120 Hz
    - e. Analog input filter: 0.1 to 10 seconds
    - f. Analog outputs: 10 to 1 gain
    - g. Volts/Hertz ratio
  - 4. Speed reference signal shall be customer selectable for 0-10 VDC at 4-20 mA.
  - 5. The VSD shall be suitable for elevations to 3300 feet above sea level without derating. Maximum operating ambient temperature shall not be less than 104 Deg. F. VSD shall be suitable for operation in environments up to 95% non-condensing humidity.
  - 6. The VSD shall be capable of displaying the following information in plain English via a 40-character alphanumeric display:
    - a. Frequency
    - b. Voltage
    - c. Current

- d. Kilowatts per hour
    - e. Fault identification
    - f. Percent torque
    - g. Percent power
    - h. RPM
  - 7. All VSDs shall be warranted for a period of 24 months after shipment. This warranty shall cover parts and labor.
  - 8. VSDs shall be compatible and coordinated to operate with the control system as provided under Section 23 09 00, INSTRUMENTATION AND CONTROL FOR HVAC.
- E. Variable Speed Drive Bypass
- 1. The variable speed drive system shall be equipped with bypass for the system.
  - 2. Bypass shall consist of a main power disconnect with ground fault protection, a pair of interlocked contactors and a motor overload relay. All are to be mounted in the VSD enclosure.
  - 3. Bypass contactors shall be equipped with thermal motor overload protection.
  - 4. A drive-off-bypass switch shall be provided on the front of the VSD enclosure.

### **PART 3: EXECUTION**

#### **3.1 INSTALLATION:**

- A. Install unit and accessories in accordance with manufacturer's written instructions and NEC.
- B. Verify variable speed drive is being provided compatible with the associated motor.
- C. Variable speed drives shall be installed and coordinated to operate and communicate with the system specified in Section 23 09 00, INSTRUMENTATION AND CONTROL FOR HVAC.

#### **3.2 TESTS:**

- A. Perform tests and make reports in accordance with Section 23 00 00, HEATING, VENTILATING AND AIR-CONDITIONING (HVAC) and Section 23 05 93, TESTING, ADJUSTING AND BALANCING FOR HVAC.

**END OF SECTION 232133**

SECTION 233000 - HVAC AIR DISTRIBUTION

PART 1: GENERAL

1.1 CONDITIONS:

- A. The applicable provisions of Section 230000, HEATING, VENTILATING AND AIR-CONDITIONING (HVAC) are hereby made a part of this section, and the Contractor is cautioned to read Section 230000 carefully as items of work applicable to this section are included in Section 230000.

1.2 DESCRIPTION OF WORK:

- A. Ductwork and accessories for HVAC including the following.
  - 1. Supply air, return air, and general exhaust systems
  - 2. Low pressure corrosion resistant exhaust systems
- B. Installation of control dampers and smoke detectors referred to in other Division 23 sections.
- C. Definitions:
  - 1. Seal or Sealing: Use of liquid or mastic sealant, with or without compatible tape overlay, or gasketing of flanged joints, to keep air leakage at duct joints, seams and connections to an acceptable minimum.
  - 2. SMACNA: Sheet Metal and Air Conditioning Contractors National Association, Inc. Publication entitled HVAC Duct Construction Standards Metal and Flexible, latest recognized edition.
  - 3. Duct Pressure Classifications:
    - a. General Duct System: 1-inch water column pressure class unless noted otherwise.
    - b. Variable Volume Duct System: 2-inch water column pressure classification for duct upstream of the variable volume dampers.
    - c. (AC-\_\_ & AC-\_\_) Duct Systems: (2, 3, 4, 6, or 10) inch water column pressure classification for supply ductwork.
  - 4. Exposed Duct: Exposed to view in a finished room.
  - 5. Outside Duct: Exposed to view beyond the exterior side of walls or above the roof.

1.3 RELATED WORK:

- A. Section 230000, HEATING, VENTILATING AND AIR-CONDITIONING (HVAC).
- B. Section 230593, TESTING, ADJUSTING, AND BALANCING FOR HVAC.

- C. Section 230700, HVAC INSULATION.
- D. Section 230900, INSTRUMENTATION AND CONTROL FOR HVAC.
- E. Section 233400, HVAC FANS.
- F. Section 237000, CENTRAL HVAC EQUIPMENT.
- G. Section 238100, DECENTRALIZED HVAC EQUIPMENT.
- H. Section 238200, CONVECTION HEATING AND COOLING UNITS.

**1.4 QUALITY ASSURANCE:**

- A. Fire Safety Code: Comply with NFPA 90A.
- B. Duct System Construction: SMACNA standards are the minimum acceptable quality.
- C. Duct accessories exposed to the air stream, such as dampers of all types and access openings, shall be of the same material as the duct or provide at least the same level of corrosion resistance.

**1.5 SUBMITTALS:**

- A. In accordance with Section 230000, HEATING, VENTILATING AND AIR-CONDITIONING (HVAC), furnish the following:
  - 1. Manufacturer's Literature and Data:
    - a. Volume, Motorized, and Backdraft Dampers
    - b. Roof Mounted Duct Supports
    - c. Prefabricated Metal Ductwork: Manufacturer's details for round and oval duct and fittings.
    - d. Duct Liner
    - e. Duct Access Doors, Panels, and Sections
    - f. Flexible ducts, connections fittings and clamps, with manufacturer's installation instructions.
    - g. Flexible connections
    - h. Air Outlets and Inlets
    - i. Fire dampers

**PART 2: PRODUCTS**

**2.1 DUCT MATERIALS AND SEALANTS:**

- A. General: Except for systems specified otherwise, construct ducts, casings, and accessories of galvanized sheet steel, ASTM A 653, coating G90.
- B. All ductwork exposed to view in finished spaces shall have paint grip to accept field painting.
- C. Joint Sealing: Refer to Paragraphs 2.2 and 2.3 for sealing requirements. In addition all general duct systems shall meet Seal Class C and shall comply with South Coast Air Quality Management District (SCAQMD) Rules 1113, 1168 and Green Seal Standards GS-11 and GS03 for VOC limits.
  - 1. Sealant: Elastomeric compound, gun or brush grade, maximum 25 flame spread and 50 smoke developed (dry state) compounded specifically for sealing ductwork. Use products as recommended by the manufacturer for each applicable system pressure. Generally provide liquid sealant, with or without compatible tape, for low clearance slip joints and heavy, permanently elastic, mastic type where clearances are larger. Oil base caulking and glazing compounds are not acceptable because they do not retain elasticity and bond.
  - 2. Tape: The use of pressure sensitive tape as a general duct sealant is not acceptable.
  - 3. A few of the many satisfactory sealants are as follows:
    - a. Moore Tuff-Bond, #29 for low pressure, #12 for high pressure.
    - b. Minnesota Mining and Manufacturing Company EC 800.
    - c. Hardcast R 6350 tape and activator/adhesive.
    - d. United Sheet Metal R-5966 (N), Listing #1.
    - e. Borden Arabol E-3806 lagging adhesive plus 6 ounce canvas.
  - 4. Gaskets in Flanged Joints: Soft neoprene.
- D. Approved factory-made joints such as DUCTMATE SYSTEM may be used. Locking-type longitudinal joints and seams, other than the snap-lock and button-lock types, need not be sealed as specified in this section.

**2.2 METAL DUCTS:**

- A. Gages, Reinforcement, Joints, Seams, Sealing, Fittings, Supports, and Other Details per SMACNA: Construct ducts not shown otherwise for 2 inches wg static pressure rating.
- B. Sealing: All supply and return ductwork and plenums, regardless of pressure class, shall be sealed to SMACNA Seal Class A. Exhaust ductwork and plenums of pressure class greater than 2" shall be sealed to Seal Class A. All other exhaust ductwork and plenums shall be sealed to Seal Class C.

- C. Volume Dampers: Single louver type and multi-louver type as detailed in SMACNA. Maximum blade louver width shall be 8-inch. Volume dampers exceeding 8-inch shall be multi-louver type. Dampers shall be a minimum two gauges heavier than duct in which installed.
1. Manual dampers shall be opposed blade construction for modulating service. Manual operator mechanism shall be locking-type quadrant operator as manufactured by Young Regulator Company or equal. End of damper rod on each damper shall be grooved to show damper position. Quadrant operators shall be installed on 1-1/2" high 4-bend galvanized steel bracket allowing duct insulation to be extended and sealed under the quadrant operator. (Where dampers occur behind or above finished portions of the building, operating rods shall be extended to 301 or 315 regulators installed flush with the finished surface.)
  2. Motorized dampers shall be opposed blade construction for modulating service and parallel blade construction for two-position service. Motorized dampers shall be constructed with brass bearings, channel iron frame, interlocking blades and air-tight felt seals. Motor operators for dampers are specified in Section 23 09 00, INSTRUMENTATION AND CONTROL FOR HVAC.
- D. Backdraft Dampers: Self-operating, multi-blade damper to open fully on 0.06 inch wg pressure difference and close by gravity. Aluminum, 16 gage frame, 0.023-inch blades of flat or elliptical shape, with tie-bar to connect blades for parallel operation. Provide resilient gasket for air seal and quiet operation. Blade pivots shall be in the nylon bushings. Provide adjustable counter-balance weight(s) as necessary for proper operation.
- E. Turning Vanes: Provide in all square elbows even though not shown on the drawings. Turning vanes shall be factory fabricated. Vanes shall be hollow, double thickness in all ducts 18" or larger.
- F. Air Deflectors: Factory fabricated for air diversion and volume control with operator as required for location in an accessible position. Adjustable deflectors shall be Young Air Extractor Model 890 with worm gear operator when behind grilles, with 301 operator when above plaster ceilings, and with 433 operator when it is accessible.
- G. Provide a 4-inch diameter galvanized steel exhaust duct for all residential clothes dryers. Duct shall discharge outside the building and terminate with a weatherproof wall cap.
- H. Plenums and Casings (Site Fabricated Units): Construct of galvanized steel panels joined by standing seams on outside of casing. Rivet or bolt all seams and joints on approximately 6" centers and seal with sealant. Reinforce with steel angles and provide diagonal bracing. Access doors shall be 36" x 18" with frame welded to plenum, three brass hinges and three brass tension fasteners operable from either side of door.

## 2.3 PREFABRICATED METAL DUCTWORK:

- A. Gages, joints, seams, reinforcement, fittings, sealing, supports and other details for rectangular, round and oval duct shall be in accordance with SMACNA.

- B. All supply and return ductwork and plenums, regardless of pressure class, shall be sealed to SMACNA Seal Class A. Exhaust ductwork and plenums of pressure class greater than 2" shall be sealed to Seal Class A. All other exhaust ductwork and plenums shall be sealed to Seal Class C.
- C. Ducts and Casings: Submit details of proposed joints/sealing system. Unless shown otherwise, construct supply duct to 2 inches wg static pressure. Provide bolted construction and tie-rod reinforcement where required.
- D. Round and Oval Ducts:
  - 1. Spiral duct and all fittings shall be Semco, MKT or United McGill spiral lock-seam duct.
  - 2. Elbows: Diameters 3 through 8 inches shall be two sections die stamped, all others shall be gored construction with all seams continuously welded. Coat galvanized areas of fittings damaged by welding with corrosion-resistant aluminum paint or galvanized repair compound.
  - 3. Provide bellmouth, conical tees, laterals, reducers, and other low loss fittings as shown in SMACNA Standards.
  - 4. Double wall insulated duct: Spiral double wall insulated pipe with matching fittings constructed from galvanized steel meeting ASTM-A527 and SMACNA. Outer shell for straight spiral pipe shall be 24-gauge for duct diameters through 24 inch, 22 gauge for duct diameters 25 inch through 34 inch, and 20 gauge for duct diameters 35 inch through 48 inch. Outer shell for fittings shall be 22 gauge for duct diameters 24 inch, and 20 gauge for duct diameters up to 48 inch. Insulation between pipe walls shall be 1-inch thick fiberglass with a thermal conductivity of 0.26 BTU/Hr./Sq. Ft./Deg. F. Inner shell shall be metal solid liner. Spiral pipe liner shall be 28 gauge. Fittings liner shall be solid metal type of 26 gauge for diameters through 34 inch and 24 gauge for diameters 35 inch through 48 inch diameter. Branch takeoffs shall be bell mouth type. Elbows shall be five-section type. Transitions shall be conical type. Duct connectors and fittings shall be casketed air-tight seal. Ductwork shall be provided and handled for "exposed" installation. Duct finish shall be A-60 annealed, paintable steel. Provide duct hangers, dampers, and appurtenances for a complete installation. All "exposed" ductwork shall be installed in a neat finished workmanlike manner and without visible duct sealant. Provide dimensional duct layout with shop drawing. Coordinate duct takeoffs with roof truss system.
- E. Provide flat side reinforcement of oval ducts as recommended by the manufacturer and SMACNA. Because of high pressure loss, do not use internal tie-rod reinforcement unless approved by the Architect/Engineer.
- F. Duct Hangers and Supports: Refer to SMACNA. Avoid use of trapeze hangers for round duct.

**2.4 DUCT LINER (WHERE INDICATED ON DRAWINGS):**

- A. General: Liner shall be 1 inch thick, fiberglass duct liner with a smooth mat, bonded surface on air side. Liner shall meet ASTM C1071 with excellent abuse resistance and shall not support mold or fungus growth. Flame spread, fuel contribution, and smoke development ratings shall comply with NFPA Standard 90A and ASTM E84.
- B. 'K' Value: 0.26 at 75 Deg. F, ASTM C518.
- C. Noise Reduction Coefficient: 0.60 or higher based on "Type A mounting" and tested in accordance to ASTM C423.
- D. Air Surface Coating: Acrylic coating treated with EPA registered anti-microbial agent proven to resist microbial growth as determined by ASTM G21 and G22.
- E. Maximum Velocity: 5,000 ft/min.
- F. Adhesive: Meets ASTM C916.
- G. Fasteners: Duct liner galvanized steel pins, welded or mechanically fastened.

**2.5 DUCT ACCESS DOORS, PANELS AND SECTIONS:**

- A. Provide access doors in accordance with NFPA 90A, sized and located for maintenance work, upstream where possible, in the following locations:
  - 1. Each automatic control damper.
  - 2. Each duct mounted smoke detector.
  - 3. Each fire damper and smoke damper.
  - 4. Each apparatus requiring service or inspection.
  - 5. Each kitchen hood exhaust duct elbow and six foot intervals of horizontal grease duct.
- B. Openings shall be 15" x 18" unless noted otherwise, except where size of duct will not accommodate this size, they shall be made as large as practical. Access doors shall be of rigid type and shall be provided with gasket to make air tight. Door shall be provided with galvanized hinges having bronze pins and two approved brass fasteners. Access doors in insulated ducts shall be of the insulated type. Doors shall swing so that fan pressure or suction and direction of air flow holds the door closed.
  - 1. For Rectangular Ducts: Refer to SMACNA and provide lock type 2 (door latch, not sash lock).
  - 2. For Round Ducts: Access sections shall be not less than 20 gage housing welded or riveted to a duct section.



**2.6 FLEXIBLE AIR DUCTS:**

- A. General: Factory fabricated, complying with NFPA 90A for connectors up to 14 feet maximum length and not passing through floors of buildings. Flexible ducts shall not penetrate any fire or smoke barrier as defined in Section 23 00 00, HEATING, VENTILATING AND AIR-CONDITIONING (HVAC). Provide approximate lengths indicated on the drawings. Provide insulated, acoustical air duct connectors in supply air duct systems and elsewhere as shown.
- B. Flexible ducts shall be acoustically insulated type as manufactured by Thermaflex or Flexmaster. Duct shall be fabricated with an acoustically transparent CPE inner film, 1" fiberglass insulation, and reinforced metalized vapor barrier. Vapor barrier permeance shall be .05 per ASTM E96, Procedure A. The rated positive pressure shall be 10" water gage and the recommended operating pressure for 90 degree bends shall be 6" water gage for 12" diameter duct. The minimum 'R' value shall be minimum 4.2, except in unconditioned attic type spaces the minimum 'R' value shall be 5.5. Entire assembly shall have maximum Flame-Spread rating of 25, a Smoke Developed Rating less than 50, and shall meet all NFPA 90A requirements. Connections between flexible duct and ductwork fittings or diffusers shall be made with draw bands and sealed with an approved pressure-sensitive tape. Flexible duct shall be UL 181 listed, ETL Class1.

Duct Insertion Loss, dB

Octave Band Frequency, Hz	2 125	3 250	4 500	5 1000	6 2000
6 inch duct	7	19	34	37	38
8 inch duct	8	13	29	35	36
12 inch duct	20	26	27	33	26

- C. All round duct take-offs shall be made with SPIN-IN fittings or pre-manufactured tap fittings with flanged low-loss boot and round connection collar. Units shall have a balancing damper and a factory-installed spring-loaded retractable bearing and a positive locking wing nut for easy readjustment. Provide 2" insulation stand-off for balancing damper handle.

**2.7 FLEXIBLE CONNECTIONS:**

- A. Where duct connections are made to fans and air handling units, install a non-combustible flexible connection of 29 ounce neoprene coated fiberglass fabric approximately six inches wide. Burning characteristics shall conform to NFPA 90A. Securely fasten flexible connections to round ducts with stainless steel or zinc-coated iron draw bands with worm gear fastener. For rectangular connections, crimp fabric to sheet metal and fasten sheet metal to ducts by screws two inches on center. Fabric shall not be stressed other than by air pressure. Allow at least one inch slack to ensure that no vibration is transmitted.

**2.8 INSTRUMENT TEST FITTINGS:**

- A. Manufactured type with a minimum two-inch length for insulated duct, and a minimum one-inch length for duct not insulated. Test hole shall have a flat gasket for rectangular ducts and a concave gasket for round ducts at the base, and a screw cap to prevent air leakage.
- B. Provide instrument test holes at each duct or casing mounted temperature sensor or transmitter, and at entering and leaving side of each heating coil and cooling coil.

**2.9 AIR OUTLETS AND INLETS:**

- A. Materials:
  - 1. Steel or aluminum as indicated. Provide manufacturer's standard gasket.
  - 2. Exposed Fastenings: The same material as the respective inlet or outlet. Fasteners for aluminum may be stainless steel. Provide concealed method of fastening where available.
- B. Performance Test Data: In accordance with Air Diffusion Council Code 1062R4.
- C. Finish: White baked enamel for ceiling mounted units. Wall-mounted units shall be primed.
- D. Air Supply Outlets and Inlets: Manufacturer shall be Tuttle and Bailey, Price, Titus or Metal-Aire. Tuttle and Bailey model numbers are listed.
  - 1. Square ceiling diffusers shall be Model 1300ALT 24" x 24" adjustable pattern full louver face for lay-in mount for inverted T-bar ceiling without panel extensions or Model 1300ASF surface mount, as applicable for ceiling type. Provide opposed blade manual damper and equalizing deflectors. Construction shall be steel with mitered blade joints.
  - 2. Supply registers shall be Type A54 aluminum double deflection and shall have free area of not less than 75%. Register dampers shall be aluminum opposed blade type, face operated. Sponge rubber gasket shall be provided on frame.
  - 3. Return and exhaust registers and grilles shall be Model A70 fixed blade aluminum construction with 40 degree deflecting vanes on 3/4" centers. Units shall have free area not less than 75%. Register dampers shall be aluminum opposed-blade face-operated type. Units on watertight ducts shall be all aluminum including damper, linkage, core, and frame. Sponge rubber gasket shall be provided on frame. Wall-mounted units shall be provided with horizontal face blades.
  - 4. Return air lay-in filter grilles shall be Model A70DFB aluminum construction for nominal 24 x 24 lay-in inverted Tee Bar ceiling. Blades shall be 40 degrees deflection. Grilles shall have hinged frame with MERV 8 filters of standard size.
  - 5. The cooling inlet shall be 11" x 6"/12" x 6" with a gasketed modulating damper for VAV control and a nominal 6"/8" heating inlet. The LFG-HC shall be supplied complete with a 24 VAC floating point actuator furnished with two modular jacks for system connections and one 25 foot plenum rated modular plug-in control cable.

**2.10 FIRE DAMPERS:**

- A. General - Fire dampers shall be dynamic type. Dampers shall meet local codes and the standards of the National Fire Protection Association contained in Bulletin 90A. Dampers in ductwork shall be sized so that the free air space is not less than the connected duct free air space. (Damper installed behind grilles or registers shall be the same size as the grille or register with blades in the air stream.) Location shall be as shown on drawings or as required by local code. Dampers shall possess a 1-1/2 hour standard fire protection rating in accordance with NFPA No. 555.
- B. Material - The frame shall be constructed so as to be unaffected by corrosion or high heat. Mechanical parts shall have bronze non-corrosive pins. Vertical and horizontal dampers shall feature closure spring operation suitable for closure against the installed system air stream. When closed, the dampers shall be held closed by a catch arrangement. Blades installed in regular ductwork will not be accepted.
- C. Fuse Links - Fire curtains shall be arranged to close automatically and remain tightly closed upon the operation of an approved fusible link or other approved heat-actuated device, located where readily affected by an abnormal rise of temperature in the duct. Fusible links shall have a temperature rating approximately 50 Deg. F above the maximum temperature that would normally be encountered when the system is in operation or shut down.
- D. Access doors shall be provided in accordance with NFPA 90A. Suitable openings shall be provided to make fire dampers accessible for inspection and maintenance.

**PART 3: EXECUTION**

**3.1 INSTALLATION:**

- A. Comply with provisions of Section 23 00 00, HEATING, VENTILATING AND AIR-CONDITIONING (HVAC), particularly regarding coordination with other trades.
- B. Fabricate and install ductwork and accessories in accordance with SMACNA Standards:
  - 1. Duct clearance and lengths shall be established from measurements taken at the job site before any ducts are fabricated. The Contractor will not be allowed any extra costs for ducts fabricated and then found not to fit into the space intended. Duct sizes on the drawings are actual sheet metal dimensions which shall be altered by the Contractor to other dimensions producing the same air handling characteristics where necessary to avoid interferences and clearance difficulties. Acoustically lined duct has been sized to include the lining.
  - 2. Fire damper openings shall be established from measurements taken at the job site before any fire damper is fabricated. The Contractor will not be allowed any extra costs for dampers fabricated and then found not to fit into the space intended. The Contractor shall coordinate clearances for locating the damper blades out of the air stream as required.

3. Provide duct transitions, offsets and connections to dampers, coils, and other equipment in accordance with SMACNA. Weld sheet metal in accordance with SMACNA, Guidelines for Welding Sheet Metal. Repair damaged galvanized areas with galvanizing repair compound.
  4. Provide bolted construction and tie-rod reinforcement in accordance with SMACNA.
  5. Construct casings and pipe penetrations in accordance with SMACNA. Design casing access doors to swing against air pressure so the pressure helps to maintain a tight seal.
- C. Install duct hangers and supports in accordance with SMACNA. Duct supports shall consist of not less than 1" x 16 ga. galvanized steel strap hangers spaced not over 8'-0" on center for ducts with up to 240" perimeter.
- D. Duct floor and wall openings - Rectangular and square ducts shall have openings 1" larger than the overall duct dimensions framed in place when the wall is constructed and 1/4" larger when floors are poured. Space between duct and structure shall be filled with duct insulation, except in fire partitions or floors they shall be packed tight with non-combustible fiber rope. Flanges constructed of 22-gauge galvanized sheet metal, not less than 3" wide, shall be installed at each opening in finished areas.
- E. Flexible Duct Installation: Continuous, single pieces not over fourteen feet long (NFPA 90A), as straight and short as feasible, adequately supported. Centerline radius of bends shall be not less than two duct diameters. Make connections with adhesive and clamps or screws as recommended by the duct manufacturer. Flexible ducts shall not penetrate any chase or partition designated as a fire or smoke barrier, including corridor partitions fire rated one hour or two hours.
- F. Where diffusers, registers and grilles cannot be installed to avoid seeing inside the duct, paint the inside of the duct with flat black paint to reduce visibility.
- G. Control Damper Installation:
1. Provide necessary blank-off plates required to install dampers that are smaller than duct size. Provide necessary transitions required to install dampers larger than duct size.
  2. Assemble multiple section dampers with required interconnecting linkage and extend required number of shafts through duct for external mounting of damper motors.
  3. Provide necessary sheet metal baffle plates to eliminate stratification and provide air volumes specified. Locate baffles by experimentation, and affix and seal permanently in place, only after stratification problem has been eliminated.
- H. Duct Liner: Install in accordance with SMACNA and NAIMA (North American Insulation Manufacturers Assoc.) Apply in cut-to-size pieces to the entire interior of the duct with approved adhesive and secured with fasteners. Fasteners shall be metal washer type and mechanically secured or welded to the duct. Adhesive type fasteners are not acceptable. Edges, joints, and penetrations shall be coated with adhesive meeting ASTM C916.

- I. Protection and Cleaning: Adequately protect equipment and materials against physical damage. Place equipment in first class operating condition, or return to source of supply for repair or replacement. Protect equipment and ducts during construction against entry of foreign matter to the inside and clean both inside and outside before operation and painting.
  - J. Installation of Diffusers, Registers, and Grilles: Ducts shall be fastened securely to the building construction at each side of opening. Diffuser, register, or grille shall be securely fastened thereto, snug against the wall.
  - K. Smoke Detectors shall be provided and installed by the Electrical Contractor, as specified in Division 26.
- 3.2 DUCT LEAKAGE TESTS AND REPAIR:
- A. Low Pressure Ducts: Seal visible openings and seal air leaks audible at operating conditions.

END OF SECTION

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SECTION 238100 - DECENTRALIZED UNITARY HVAC EQUIPMENT

PART 1: GENERAL

1.1 CONDITIONS:

- A. The applicable provisions of Section 230000, HEATING, VENTILATING AND AIR-CONDITIONING (HVAC), are hereby made a part of this section and the Contractor is cautioned to read Section 230000 carefully as items of work applicable to this section are included in Section 230000.

1.2 DESCRIPTION OF WORK:

- A. Package Rooftop Air Conditioning Units
- B. Definitions:
  - 1. Energy Efficiency Ratio (EER): A ratio calculated by dividing the cooling capacity in Btuh by the power input in watts at any given set of rating conditions, expressed in Btuh per watt (Btuh/watt).
  - 2. Unitary (ARI): Consists of one or more factory-made assemblies which normally include an evaporator or cooling coil, a compressor and condenser combination, and may include a heating function.

1.3 RELATED WORK:

- A. Section 230000, HEATING, VENTILATING AND AIR-CONDITIONING (HVAC).
- B. Section 230900, INSTRUMENTATION AND CONTROLS FOR HVAC.
- C. Section 232133, VARIABLE SPEED DRIVES.
- D. Section 233000, HVAC AIR DISTRIBUTION.
- E. Section 238200, CONVECTION HEATING AND COOLING UNITS.

1.4 QUALITY ASSURANCE:

- A. Safety Standards:
  - 1. Design, manufacture and installation of mechanical refrigeration equipment: ANSI B9.1.

2. Machinery Guards: Provide guards as shown in AMCA 410 for belts, chains, couplings, pulleys, sheaves, shafts, gears, and other moving parts regardless of height above the floor. Drive guards may be excluded where motors and drives are inside factory fabricated unit casings.

- B. Unit Capacities: When providing a substitution to the basis of design manufacturer for the Variable Refrigerant System, the Contractor shall ensure the system meets the heating and cooling capacities specified in the equipment schedules and is responsible for any additional materials that include but are not limited to higher capacity outdoor and indoor units, refrigerant piping, and accessories required for proper operation.

#### 1.5 SUBMITTALS:

- A. In accordance with Section 230000, HEATING, VENTILATING AND AIR-CONDITIONING (HVAC), furnish the following:
  1. Manufacturer's Literature and Data:
    - a. Unitary Air Conditioners:
      - (1) Package Rooftop Air Conditioning Units
  2. Submit proof of specified ARI Certification.
  3. Performance Rating: Submit catalog selection data showing equipment ratings and compliance with required EER, COP, etc.
  4. Operating and Maintenance Manuals: Submit in accordance with paragraph, INSTRUCTIONS, in Section 230000, HEATING, VENTILATING AND AIR-CONDITIONING (HVAC).

#### 1.6 EXTRA MATERIALS:

- A. Furnish one set of air filters for each unit.

### PART 2: PRODUCTS

#### 2.1 PACKAGED ROOFTOP AIR CONDITIONING UNITS (3 TO 25 TONS):

- A. General - Equipment and material specified under this heading shall be furnished and installed by a certified representative of the unit manufacturer. Rooftop air conditioning unit shall be McQuay (Maverick I Single zone Heating and Cooling Unit(s) Model MPS), Carrier, Trane, or York and shall be a complete, self-contained unit with hermetic motor-compressor, cooling coil, supply fan, gas fired heating section, condenser coil and fan(s), hot gas reheat coil (where applicable), economizer/power exhaust, dampers, filters, interconnecting piping, filter-dryer, sight glass, roof curb, controls, and wiring enclosed in a weather-resistant steel enclosure suitable for roof mounting. Basis of design is McQuay. Provide electrical starters and single



point power connection. Three phase units shall be provided with phase loss relay package. Supply fan motor shall be adjustable V-belt drive. Belt drives shall be designed for 150% of the connected motor capacity, and sheaves shall be selected to drive the fan at a speed which will produce the specified capacity when set at its approximate midpoint. Provide a trap in the condensate drain piping from the evaporator coil drain pan of sufficient depth to prevent blowout or siphoning of water. Unit shall be fitted and rated in accordance with ARI Standard 240. Provide compressor anti-short cycling control and low ambient control for cooling operation to 45 Deg. F. Provide hail guards for intake and discharge openings to protect condenser fans and coils. Where units are indicated to have hot gas reheat, factory mounted hot gas reheat coil, associated piping, accessories, and controls shall be provided.

- B. Unit Casing: Unit casing shall be double wall, zinc coated, heavy gauge, galvanized steel construction. All metal-to-metal seams shall be sealed air and weather-tight, requiring no caulking at job site. Exterior surface shall be finished with weather resistant baked enamel finish suitable for outside, roof mounting. Unit casing shall be insulated with 1 inch fiberglass enclosed within double wall construction. Insulation shall meet requirements of NFPA 90A and tested to meet UL 181 erosion requirements. Hinged, insulated, and gasketed access doors shall be provided to allow full access to all refrigerant and control components for proper servicing and or replacement. Access doors shall be coordinated with the installation to allow proper clearances. Units shall be provided complete with supply and return duct flanges.
- C. Fan and Motor: Fan and motor assembly shall be belt drive, centrifugal type fan designed to provide specified air volume at specified external static pressures. Fan motors shall be permanently lubricated and provided with internal thermal overload protection. Where units are indicated as Variable Air Volume (VAV), factory mounted and wired Variable Speed Drives shall be provided as specified in Section 23 21 33 VARIABLE SPEED DRIVES. Motors for use with variable frequency drives (VFD) shall be rated for "VFD-duty", Inverter Duty, or shall be Premium Efficiency type with Class F (1500 volt) insulation and thermal overload protection.
- D. Refrigerant Piping: Units shall have a sealed refrigerant circuit including a high efficiency scroll, rotary or reciprocating compressor designed for cooling operation, a capillary tube assembly for refrigerant metering, and safety controls including a high pressure switch, low pressure switch (loss of charge), and coil low temperature sensor. Refrigerant circuit access ports shall be fitted with locking type tamper resistant caps in strict accordance with the IMC.
- E. Compressors: The compressor shall have an internal spring vibration isolation and sound muffling system. Compressor shall have internal thermal overload protection. Refrigerant to air condenser coil shall be leak tested to 200 PSIG pressure.
- F. Drain Pan: Drain Pan shall be constructed of corrosion resistant material and insulated to prevent sweating. Drain outlet shall be located at pan as to allow complete and unobstructed drainage of condensate. Drain outlet shall be connected from pan directly to IPT fitting.
- G. Filters: Filters shall be 2" thick MERV-8 fiberglass filters. All units shall be provided with filter rack and filters.

- H. Unit Controller: Unit controls for safe automatic controlled operation of the system shall be factory furnished, microprocessor based, installed, and coordinated to operate with the Control system and Sequences specified in Section 230900 - INSTRUMENTATION AND CONTROL FOR HVAC. Unit controller shall have provision for automatic control from and full communications with the specified Building Automation System (BAS).
- I. Roof Curb: Rooftop units shall be provided with factory fabricated curb suitable for vibration isolation rail. Curb shall consist of die formed galvanized steel sections. Curb shall be full perimeter type with gasketing provided for field installation between curb and unit base. Curb height shall be coordinated with the roofing system and shall be a minimum of 12" – 14" above the top of the roofing system. Curb shall be pitched to match the pitch of the roof such that the top of the curb is level without the use of shims or other similar devices. Unit curb shall fully encompass the unit perimeter (to include condensing unit section).
- J. The system shall be completely charged with refrigerant and oil and shall be guaranteed to be free of leakage for one (1) year. Compressors shall have labor and material guaranteed to be free from defective materials or workmanship for five (5) years after final acceptance of the project.
- K. A factory-trained service mechanic shall test and check out the system for safe, controlled operation. One week before final inspection, a letter from the unit manufacturer's representative shall be submitted to the Engineer certifying that the system is performing safely and satisfactorily.
- L. Warranty: Unit shall be warranted to be free from defects in material and workmanship for a period of one year from the project final completion date. Motors shall be warranted by the motor manufacturer for a period of one year from the project final completion date. Motor-compressor shall be guaranteed for 5 years from the project final completion date.
- M. Convenience Outlet: Unit shall have a 115V GFI convenience receptacle. Power for receptacle shall be field supplied through a separate circuit.
- N. Modulating Hot Gas Reheat Coil Section
  - 1. Unit shall be equipped with a hot gas reheat coil with hot gas coming from the unit condenser. (The hot gas reheat option shall have a fully modulated control. 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 and reheat leaving air temperature setpoints shall be adjustable through the unit MT III controller.)
  - 2. Hot gas coil shall be an all-aluminum 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. Each condenser coil shall be factory leak tested with high-pressure air under water. Hot gas coil shall be sized to allow for full condensing across the operation range of the unit. High temperature liquid shall be piped downstream of the unit's condenser coils into the liquid line. The refrigeration circuit shall not require receivers. The hot gas coil shall be used for refrigerant storage when the unit is not operation in a dehumidification or reheat mode.

- O. Filters: Units shall be provided with a draw-through filter section. The filter rack shall be designed to accept a 2" pre-filter 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" construction filters. The contractor shall furnish and install, at building occupancy, the final set of filters per the contract documents.
- P. Outdoor/Return Air Section:
1. Units shall be provided with an outdoor air economizer section. The 0 to 100% outside air economizer section shall include outdoor, return, and exhaust air dampers. 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. Outdoor air and return air dampers shall have factory installed direct coupled actuators. Damper actuator shall be of the modulating, spring return type. The dampers shall be opposed blade design. Damper blades shall be gasketed with side seals to provide an air leakage rate of 4 cfm / square foot of damper area at 1" differential pressure per ASHRAE 90.1 Energy Standard. Leakage rate to be tested in accordance with AMCA Standard 500.
  2. 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.
- Q. Condensing Section:
1. Condenser coils shall be an all aluminum 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. Each condenser coil shall be factory leak tested with high-pressure air under water. Condenser coils shall be protected from incidental contact to coil fins by a coil guard. Coil guard shall be constructed of cross wire welded steel with PVC coating.
  2. Condenser fans shall be direct drive, axial type designed for low tip speed and vertical air discharge. Condenser fan rpm shall be 1140 rpm maximum. Fan blades shall be constructed of steel and riveted to a steel center hub. Condenser fan motors shall be heavy-duty, inherently protected, three-phase, non-reversing type with permanently lubricated ball bearing and integral rain shield.
  3. Each circuit shall have fan cycling of at least one condenser fan to maintain positive head pressure. An ambient thermostat shall prevent the refrigeration system from operating below 20°F.
  4. Condenser coils shall be protected from hail damage as an integral part of the unit design. Hail guards shall be provided on all units with vertical mounted condenser coils.
  5. Each unit shall have multiple, heavy-duty scroll compressors. Each compressor shall be complete with gauge ports, crankcase heater, sight-glass, anti-slug protection, motor overload protection and a time delay to prevent short cycling and simultaneous starting of compressors following a power failure. Compressors shall be isolated with resilient rubber isolators to decrease noise transmission.
  6. Each unit shall have two independent refrigeration circuits. Each circuit shall be complete with a low pressure control, filter-drier, liquid moisture indicator/sight-glass,

thermal expansion valve, and a manual reset high pressure safety switch. The thermal expansion valve shall be capable of modulation from 100% to 25% of its rated capacity. Sight glasses shall be accessible for viewing without disrupting unit operation. Each circuit shall be dehydrated and factory charged with Refrigerant 410A and oil. Refrigerant circuit access ports shall be fitted with locking type tamper resistant caps in strict accordance with the IMC.

**R. Controls:**

1. Provide a complete integrated microprocessor based Direct Digital Control (DDC) system to control all unit functions including temperature control, scheduling, monitoring, unit safety protection, including compressor minimum run and minimum off times, and diagnostics. This system shall consist of all required temperature sensors, pressure sensors, controller and keypad/display operator interface. All MCBs and sensors shall be factory mounted, wired and tested. Unit controller shall have provision for automatic control from and full communications with the specified Building Automation System (BAS).
2. The stand-alone DDC controllers shall not be dependent on communications with any on-site or remote PC or master control panel for proper unit operation. The microprocessor shall maintain existing set points and operate standalone if the unit loses either direct connect or network communications. The microprocessor memory shall be protected from voltage fluctuations as well as any extended power failures. All factory and user set schedules and control points shall be maintained in nonvolatile memory. No settings shall be lost, even during extended power shutdowns.
3. The DDC control system shall permit starting and stopping of the unit locally or remotely. The control system shall be capable of providing a remote alarm indication. The unit control system shall provide for outside air damper actuation, emergency shutdown, remote heat enable/disable, remote cool enable/disable, heat indication, cool indication, optimal start, and fan operation.
4. All digital 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.
5. The DDC controller shall have a built-in time schedule. The schedule shall be programmable from the unit keypad interface. The schedule shall be maintained in nonvolatile memory to insure that it is not lost during a power failure. There shall be one start/stop per day and a separate holiday schedule. The controller shall accept up to sixteen holidays each with up to a 5-day duration. Each unit shall also have the ability to accept a time schedule via BAS network communications.
6. The keypad interface shall allow convenient navigation and access to all control 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:
7. The display shall provide the following information as required by selected unit options:
  - a. Unit status showing stages or % capacity for cooling, heating, and economizer operation.

- b. Supply, return, outdoor, and space air temperature.
  - c. Duct and building static pressure; the control contractor is responsible for providing and installing sensing tubes.
  - d. Supply fan and return fan status and airflow verification.
  - e. Supply and return VFD speed.
  - f. Outside air damper position and economizer mode.
  - g. Cooling and heating changeover status.
  - h. Occupied and unoccupied.
  - i. Date and time schedules.
  - j. Up to 10 current alarms and 25 previous alarms with time and date.
  - k. Dirty filter status.
  - l. Morning warm-up or night setback status.
  - m. System operating hours of the SAF, EAF, compressors, economizer, and heat.
8. The keypad shall provide the following set points as a minimum as required by selected unit options:
- a. Six control modes including off manual, auto, heat/cool, cool only, heat only, and fan only.
  - b. Four occupancy modes including auto, occupied, unoccupied and bypass (tenant override with adjustable duration).
  - c. Control changeover based on return air temperature, outdoor air temperature, or space temperature.
  - d. Primary cooling and heating set point temperature based on supply or space temperature.
  - e. Night setback and setup space temperature.
  - f. Cooling and heating control differential (or dead band).
  - g. Cooling and heating supply temperature reset options based on one of the following: Return air temperature, outdoor air temperature, space temperature, airflow, or external (1–5 VDC) signal.
  - h. Reset schedule temperature.
  - i. High supply, low supply, and high return air temperature alarm limits.
  - j. Ambient compressor and heat lockout temperatures.
  - k. Compressor interstage timers duration.
  - l. Duct and building static pressure.
  - m. Minimum outdoor airflow reset based on external reset (1–5 VFD) percent of cfm capacity, and fixed outdoor damper position.
  - n. Economizer changeover based on enthalpy, dry bulb or network signal.
  - o. Current time and date.
  - p. Occupied/unoccupied time schedules with allowances for holiday/event dates and duration.
  - q. Two types of service modes including timers normal (all time delays) and timers fast (all time delays 20 seconds).
  - r. Tenant override time.

9. Open Communications Protocol—The unit control system shall have the ability to communicate to an independent Building Automation System (BAS). The independent BAS system shall have access to “read only” variables and “read & write” variables. Communications shall not require field mounting of any additional sensors or devices at the unit. The BAS system shall be capable of interacting with the individual rooftop controllers in the following ways:
  - a. Monitor controller inputs, outputs, set points, parameters and alarms.
  - b. Set controller set points and parameters.
  - c. Clear alarms.
  - d. Reset the cooling and heating discharge air temperature set point.
  - e. Reset the duct static pressure set point.
  - f. Set the heat/cool changeover temperature.
  - g. Set the representative zone temperature.
10. It will be the responsibility of the Systems Integrating Contractor to integrate the rooftop data into the BAS control logic and interface stations.

### **PART 3: EXECUTION**

#### **3.1 INSTALLATION:**

- A. Handle and install units and accessories in accordance with ARI 260 and the manufacturer's printed instructions.
- B. Coordinate indoor unit location with lighting and ceiling system.
- C. Coordinate roof openings and locations with structural framing.
- D. Provide equipment rails as specified in Section 23 34 00, HVAC FANS for outdoor units mounted on the roof.

#### **3.2 TEST:**

- A. Perform tests and make reports in accordance with Section 23 00 00, HEATING, VENTILATING AND AIR-CONDITIONING (HVAC), and Section 23 05 93, TESTING, ADJUSTING, AND BALANCING FOR HVAC.

**END OF SECTION 238100**

**SECTION 260100 - BASIC REQUIREMENTS FOR ELECTRICAL SYSTEMS**

**PART 1: GENERAL**

**1.1 DESCRIPTION:**

- A. This Section specifies the basic requirements of electrical installations and includes requirements common to all sections of Divisions 26, It expands and supplements the requirements specified in sections of Division 1.
- B. Division 26 shall provide the electrical equipment, electrical wire, raceways and cable work and connections as required for complete and operable electrical systems as indicated in Division 26 Contract Documents. Refer to all other portions of these Contract Documents and apply to those portions of work relating to Electrical Work the same as if the Electrical Work was repeated herein in its entirety.
- C. Other Divisions of these Contract Documents will provide equipment that will require electrical connections - Division 26 shall coordinate with other Divisions and shall provide all necessary items and equipment for complete and code-compliant connections.

**1.2 RELATED DOCUMENTS:**

- A. The Drawings and general provisions of the Contract, including the General and Supplementary Conditions, Instructions to Bidders and sections of Division 1, apply to the work specified in this section.

**1.3 SCOPE OF THE WORK:**

- A. Work included under this section shall include complete electrical systems as shown on the Contract Documents, which includes all of the specifications, drawings, addendums, accepted change orders and the Authority Having Jurisdiction (AHJ) compliances. Provide supervision, labor, material, equipment, machinery, plant, and other items necessary to complete the systems. Items of equipment may be specified in the singular; however, provide the number of items of equipment indicated in the Contract Documents and as required for complete systems.
- B. It is the intention of these Contract Documents to call for finished work, tested and ready for operation. Wherever the word "provide" is used, it shall mean "furnish and install complete and ready for use."
- C. Minor details necessary for the complete installation and operation of the systems shall be included.

- D. Any item that is shown on the drawings but not mentioned in the specifications, or mentioned in the specifications but not shown on the drawings, shall be considered as being both shown on the drawings and mentioned in the specifications and shall be provided.
- E. The entire work provided for in the specifications and indicated on the drawings is to be accomplished even though every item and minor detail for the proper installation and successful operation of the entire work may not be mentioned in the specifications or shown on the drawings.
- F. All materials and equipment shall be new and listed by Underwriters Laboratories, Inc.

**1.4 PERMITS AND FEE:**

- A. The Contractor shall obtain and pay for all permits, bonds, licenses, and inspection certificates, and shall pay inspection fees and taxes, but permanent electrical utility fees shall be paid by the Owner.
- B. The Contractor shall file plans and prepare documents required to obtain approvals of the Authorities Having Jurisdiction (AHJ).

**1.5 DRAWINGS:**

- A. Electrical drawings are diagrammatic and indicate general arrangement of systems and work included. Consult Architectural and Structural drawings for building construction details.
- B. Should there be any discrepancy between actual measurements and those indicated, which prevents following good practice or the intent of the drawings and specifications, notify the Architect/Engineer and make modifications as directed.
- C. Where variances occur between drawings and specifications or within either document itself, include in the contract price the item or arrangement of better quality, greater quantity, or higher cost.

**1.6 ROUGH-IN:**

- A. Verify final locations for rough-ins with field measurements and with the requirements of the actual equipment to be connected. Refer to equipment specifications in Divisions 2 through 23 for rough-in requirements.
- B. Rough-in openings shall align vertically and horizontally with the building structure and shall be plumb.
- C. Verify door swings before roughing-in switch outlets.



**1.7 ELECTRICAL INSTALLATIONS:**

- A. In addition to the requirements of the General Conditions, examine areas and conditions for compliance with installation tolerances and other conditions affecting performance of electrical work. Do not proceed with installation until unsatisfactory conditions have been corrected. Verify all dimensions by field measurements.
- B. Install material and equipment in accordance with manufacturer's written installation instructions, applicable requirements of the National Electrical Contractors Association (NECA) "Standard of Installation" and applicable requirements of National Electrical Code (NEC).
- C. Coordinate electrical equipment and materials installation with other building components.
- D. Arrange for chases, slots and openings in other building components to allow for electrical installations.
- E. Coordinate the installation of required supporting devices and sleeves to be set in poured-in-place concrete and other structural components as they are constructed.
- F. Sequence, coordinate and integrate installations of electrical materials and equipment for efficient flow of the Work. Give particular attention to large equipment requiring positioning prior to closing-in the building. Where housekeeping pads are required, they shall be minimum 4" tall and shall meet Division 3 specifications.
- G. Where mounting heights are not indicated, detailed or dimensioned, bring to the attention of the engineer immediately for resolution.
- H. Install electrical equipment with National Electrical Code (NEC) required clearances to facilitate maintenance and repair or replacement of equipment components. Connect equipment in such a way as to facilitate future maintenance, with minimum of interference with other items in the vicinity. Do not run any conduits across any designated rooftop walkways – if this is unavoidable, provide a removable platform or stairs to safely walk over the conduits.
- I. Coordinate the installation of electrical materials and equipment above ceilings with suspension system, mechanical equipment and systems, and structural components. Do not block mechanical equipment access with raceways.
- J. Coordinate connection of electrical systems with exterior underground and overhead utilities and services. Comply with requirements of governing regulations, franchised service companies and controlling agencies. Provide required connection for each service.
- K. Tighten connectors and terminals, including screws and bolts, in accordance with equipment manufacturer's published torque tightening values for equipment connectors. Where manufacturer's torqueing requirements are not indicated, tighten connectors and terminals to comply with tightening torques specified in UL Std 486A.

- L. All wiring connectors and terminals (including but not limited to wiring devices, breakers, disconnects, fuses, starters, etc.) shall be rated for not less than 75 deg. C. If connectors and terminals are provided that are rated for less than 75 deg. C., the electrical contractor shall incur all costs associated with upsizing conductors and conduits as required by the NEC for lower-temperature conductors.
- M. All damages incurred to new or existing electrical installations shall be immediately reported to the general contractor project manager and repaired by the contractor at no cost to Owner.

**1.8 PROTECTION:**

- A. Protect work against theft, injury, or damage. Carefully store material and equipment off the ground and under cover. Close open ends of work or equipment with temporary covers or plugs during storage and construction to prevent entry of obstructing material.

**1.9 ACCESSIBILITY:**

- A. Furnish, for installation by others, access doors in every location necessary and as required by Code or equipment manufacturer recommendation, whether indicated or not, to allow working access to concealed electrical items which may require operation, inspection, maintenance, or adjustment. Access doors are not required in lay-in panel systems. See Division 8 for specification and installation requirements.
- B. Coordinate the final location of concealed equipment and devices requiring access with final location of access doors. Access unit shall be of adequate size and shall match the wall, floor and ceiling rating and construction type. Allow ample space for removal of all parts that will likely require replacement or servicing during the normal life of equipment.
- C. Prior to installation of equipment and materials requiring access doors, prepare, for review by the architect in ample time for proper coordination, one (1) set of architectural prints marked with size and approximate location of all access doors.

**1.10 SEALANTS:**

- A. See Division 7 for fire-stopping sealants required around conduit and/or cable penetrations through fire-rated assemblies. Also, see Division 7 joint sealants required around conduit and/or cable penetrations through joints. See Division 7 for weatherproof sealants required around conduit and/or cable penetrations through water tight assemblies such as exterior walls and roof.
- B. Apply sealant around all exterior mounted electrical devices to provide weatherproofing and pest control.

**1.11 CUTTING AND PATCHING:**

- A. This Article for general requirements for cutting and patching and specifies the cutting and patching for electrical equipment, components and materials, to include removal and legal disposal of selected materials, components, and equipment.
- B. Do not endanger or damage installed work through procedures and processes of cutting and patching.
- C. Arrange for repairs required to restore other work because of damage caused as a result of electrical installations.
- D. No additional compensation will be authorized for cutting and patching work that is necessitated by ill-timed, defective, or non-conforming installations.
- E. Perform cutting, fitting, and patching of electrical equipment and materials required to:
  - 1. Uncover work to provide for installation of ill-timed work;
  - 2. Remove and replace defective work;
  - 3. Remove and replace work not conforming to requirements of the Contract Documents;
  - 4. Remove samples of installed work as specified for testing;
  - 5. Upon written instructions from the Architect/Engineer, uncover and restore work to provide for Architect/Engineer observation of concealed work.

**1.12 SLEEVES:**

- A. Locate sleeves during normal course of work. Provide sleeves for conduit larger than 1" passing through concrete floor slabs and concrete, masonry, tile, and gypsum wall construction. Sleeves shall not be provided for conduit running embedded in concrete or slab on grade. Sleeves through structural members shall be only as directed by Architect.
- B. All conduits passing through fire-rated walls or floors or ceilings shall have sleeve assemblies to maintain the fire rating of the wall or floor or ceiling. Pack between sleeve and conduit with U.L. Listed material to maintain wall or floor or ceiling rating. See Architectural drawings for locations of fire-rated walls, floors and ceilings.
- C. Sleeves shall be constructed of 20 gauge galvanized sheet steel with lock seam joints for all sleeves set in concrete floor slabs terminating flush with the floor. All other sleeves shall be constructed of galvanized steel pipe unless otherwise indicated.
- D. Fasten sleeves securely in floors or walls so that they will not become displaced when concrete is poured or when other construction is built around them. Take precautions to prevent concrete, plaster, or other materials from being forced into the space between pipe and sleeve during construction.

1.13 MOTOR AND ELECTRICAL WIRING:

- A. Temperature control wiring, equipment control wiring, and interlock wiring necessary for the proper sequence of operation of mechanical equipment will be provided as part of the Mechanical Work.
- B. Power wiring from the power source to the motor or equipment junction box, including wiring through starters, VFD's and safety switches shall be provided as part of the Electrical Work under Division 26.
- C. Power wiring from the power source to electric heating equipment, including wiring through contactors, safety switches and line voltage control devices shall be provided as part of the Electrical Work under Division 26.

1.14 QUALITY ASSURANCE:

- A. Manufacturers: Where a list of manufacturers or a proprietary item is not specified, use manufacturers whose products have been in satisfactory use in similar service for not less than five (5) years.
- B. Installer's Qualifications: Firms with at least three (3) years of successful installation experience on projects utilizing material similar to that required for this project.
- C. Codes and Standards: Comply with applicable requirements of the following codes and standards.
  - 1. National Electrical Manufacturers Association (NEMA) Standards.
  - 2. 2020 NFPA 70 - National Electrical Code (NEC)
  - 3. 2019 NFPA 72 – National Fire Alarm and Signaling Code
  - 4. 2021 VUSBC – Virginia Uniform Statewide Building Code (VCC – Virginia Construction Code)
  - 5. 2021 IBC - International Building Code as adopted and modified by the VUSBC (VCC)
  - 6. 2021 IFC – International Fire Code
  - 7. 2021 NFPA 101 – Life Safety Code
  - 8. 2021 VECC – Virginia Energy Conservation Code
  - 9. 2010 Americans with Disabilities Act Accessibility Guidelines (ADAAG)
  - 10. 2010 ADA Standards for Accessible Design
  - 11. Institute of Electrical and Electronics Engineers (IEEE) Standards
  - 12. National Electrical Safety Code (NESC)
  - 13. Other applicable ANSI/NFPA & UL Standards as required for the project
  - 14. 2023 “Virginia Tech Design and Construction Standards”

- D. Provide material and equipment which is listed by Underwriters Laboratories, Inc. (UL) and which bears the UL label. This applies to materials and equipment for which UL Standards have been established and for which label service is regularly furnished. Assemble materials and equipment, for which no UL Product Category exists for the completed unit, with UL-listed components.

**1.15 ELECTRICAL SUBMITTALS:**

- A. Refer to the Conditions of the Contract (General and Supplementary) and Division 1 for submittal definitions, requirements and procedures.
- B. Submittal of shop drawings, product data and samples will be accepted only when submitted by the General Contractor. Data submitted from subcontractors and material suppliers directly to the Architect/Engineer will not be processed.
- C. Submittals that are not acceptable must be resubmitted until returned as approved by the engineer. If the third submittal is not approved, the contractor will be responsible for paying additional fees for subsequent reviews of submittals at a rate of \$200 per hour, and the specified item may be required to be provided at the engineer's discretion at no additional cost to the contract. Submittals will not be returned until payment is received.

**1.16 BIDDING INSTRUCTIONS:**

- A. Products are generally specified by a performance specification and/or by manufacturer's name and model number or trade name.
  - 1. When specified only by a performance specification, the Contractor may use any manufacturer who meets the performance specification and applicable codes.
  - 2. When several products/manufacturers are specified together, then the Contractor has the option of using any product/manufacturer listed. The Contractor shall be subject to the requirements of paragraph 1.16 - ELECTRICAL SUBMITTALS. The Contractor's bid shall be compiled on the use of the listed products without exception. Substitutions will only be considered after the contract has been signed and shall be subject to the requirements of paragraph 1.18 - SUBSTITUTIONS.
  - 3. When several products/manufacturers are specified together and the system design is based on one of the listed products by specific model number(s) or catalog number(s), the Contractor has the option of using the one specific product or any product/manufacturer listed. However, when another listed product/manufacturer is used, the Contractor shall be responsible for determining that the product(s) are compatible with building design, electrical design, and mechanical design; are equal to the basis-of-design product in quality, appearance, construction and performance (including lamping and lenses for lighting fixtures); and will not necessitate design modifications by the Architect/Engineer. The Contractor's bid shall be compiled on the use of the listed products/manufacturers without exception. Substitutions will only be considered after the Contract has been signed and shall be subject to the requirements of paragraph 1.18 - SUBSTITUTIONS.

4. When only one manufacturer's name is listed with the catalog number, this shall be the basis of the bid. The Contractor's bid shall be compiled on the use of the listed product(s) only. Substitutions will only be considered after the Contract has been signed and shall be subject to the requirements of paragraph 1.18 - SUBSTITUTIONS.
5. A request for substitution shall be made in writing from the General Contractor only. Requests by distributors, manufacturers, or manufacturer's representatives will not be considered. Oral requests will not be considered. Request for deviations from product specifications will not be considered.
6. Request for substitutions will not be considered during bidding unless the specified product is discontinued.
7. If approval for a substitution is granted, samples shall be submitted if and as requested by Engineer.
8. Approval of substitutions prior to shop drawing submittal will not be granted.

**1.17 SUBSTITUTIONS:**

- A. Substitutions are understood to mean that the Contractor:
  1. Has personally investigated the proposed substitute and has determined that it is equal or superior in all respects, including appearance, to the item specified.
  2. Will provide the same guarantee for the substitution that he would for the equipment specified,
  3. Has coordinated the installation of the substitute, providing design modifications and changes as required for the work to be complete in all respects.
  4. Has coordinated the installation of the substitute with the General Contractor pertaining to changes required for the work to be complete with all trades (all changes shall be provided without additional cost to the contract).
  5. All required design modifications and/or changes shall be submitted with the shop drawings for the substitute equipment.
  6. Has provided the amount of credit due the Owner if the substitution is accepted.
- B. The Engineer will indicate on which of these items the Contractor may submit shop drawings for review. The acceptance by the Engineer of any or all of those items listed by the Contractor for review shall not constitute an approval of the substitute but shall mean that the Contractor may then submit detailed shop drawings for review. When a request for substitution is granted, the Engineer will review shop drawings as follows:
  1. If shop drawings for the substitute equipment are marked "AMEND & RESUBMIT" on first submittal, the Contractor is allowed to resubmit for two additional reviews, unless the Architect/Engineer provides other instructions. If after the third review, the substitute equipment is not accepted, the specified equipment shall be provided without any additional cost to the contract.

2. If shop drawings for the substitute equipment are marked "REJECTED – SEE REMARKS" at any submittal level, the Contractor shall stop any further submittals of any substitute equipment. The Architect/Engineer will not review any additional substitute equipment and the Contractor shall submit and provide the specified equipment without any additional cost to the contract.

**1.18 SIMILAR PRODUCTS:**

- A. When two or more items of same material or equipment are required, they shall be of the same manufacturer. Product manufacturer uniformity does not apply to raw materials, bulk materials, conductors, conduit, fittings, sheet metal, steel bar stock, welding rods, solder, fasteners and similar items used in Work, except as otherwise indicated.
- B. Provide products which are compatible within systems and other connected items.

**1.19 NAMEPLATE DATA:**

- A. Provide permanent operational data nameplate on each item of power-operated equipment, indicating manufacturer, product name, model number, serial number, capacity, operating and power characteristics, labels of tested compliances, and similar essential data. Locate nameplates in an accessible location. Provide the manufacturer's nearest authorized servicing agency, address and emergency telephone number.

**1.20 DELIVERY, STORAGE AND HANDLING:**

- A. Deliver products to project properly identified with names, model numbers, types, grades, compliance labels, and similar information needed for distinct identifications. Products shall be adequately packaged and protected to prevent damage during shipment, storage, and handling. The contractor must coordinate with the owner for pre-purchased electrical equipment for handling, moving, storage, etc.
- B. Store equipment and materials at the site, unless off-site storage is authorized in writing. Protect stored equipment and materials from damage.
- C. Coordinate deliveries of electrical materials and equipment to minimize construction site congestion. Limit each shipment of materials and equipment to the items and quantities needed for the smooth and efficient flow of installations.

**1.21 RECORD DOCUMENTS:**

- A. Mark Contract Documents to indicate accepted substitutions, Change Orders and actual equipment and material used on the project.

- B. Within 30 days after the date of system acceptance, as-built record drawings of the following shall be provided to the Owner in accordance with energy codes
  - 1. Single-line diagram of the building electrical distribution system
  - 2. Floor plans indicating the location and area served for all electrical distribution equipment.
- C. Within 90 days after the date of system acceptance, as-built record drawings of the actual lighting and associated controls installations shall be provided to the Owner, including the location, luminaire identifier, and control & circuiting for each piece of lighting equipment, in accordance with energy codes

**1.22 OPERATING AND MAINTENANCE DATA:**

- A. Include the following information:
  - 1. Submittal data stating equipment rating and selected options for each piece of equipment requiring maintenance. Include description of function, normal operating characteristics and limitations, performance curves, engineering data and tests, and complete nomenclature and commercial numbers of all replaceable parts.
  - 2. Manufacturer's printed operating procedures to include start-up, break-in, routine and normal operating instructions; regulation, control, stopping, shut-down, and emergency instructions; and summer and winter operating instructions.
  - 3. Operations and maintenance manuals for each piece of equipment requiring maintenance. Include maintenance procedures for routine preventative maintenance and troubleshooting, disassembly, repair and reassembly, aligning and adjusting instructions. Required regular maintenance actions shall be clearly stated and incorporated on a readily accessible label; the label shall include the title or publication number for the operation and maintenance manual for that particular model and type of product.
  - 4. Servicing instructions and lubrication charts and schedules.
  - 5. Names and addresses of at least one qualified service agency for each piece of equipment or system.
  - 6. A complete narrative of how each system is intended to operate.
- B. Compile and assemble the manuals for Divisions 26, 27 and 28 into a separated set of vinyl covered, three ring binders, tabulated and indexed for easy reference. Only one copy of each manual needs to be submitted for engineer review.
- C. For the Owner's use, provide 2 copies of all O&M manuals, diagnostic tools, software and sufficient training for all electrical systems and their components (generator, fire alarm, lighting controls, digital meters, etc.).



1.23 WARRANTIES:

- A. Provide complete warranty information for each product or piece of equipment, including date of beginning of warranty or bond; duration of warranty or bond; and names, addresses, and telephone numbers and procedures for filing a claim and obtaining warranty services. Only one copy of each warranty needs to be submitted for engineer review.

1.24 CLEANING:

- A. Clean all electrical equipment of constructure materials, dust, unused wire, metals, etc.

1.25 SITE VISIT REPORTS:

- A. Respond in writing to each item of discrepancy noted on all site visit reports.

END OF SECTION 260100

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**SECTION 260519 - LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES**

**PART 1: GENERAL**

**1.1 DESCRIPTION:**

- A. This section specifies the furnishing, installation and connection of the low voltage power and lighting wiring. Extent of electrical wire and cable shall be as indicated and required for complete and operable electrical systems. The contractor must megger all existing wiring and new wiring under this scope of work. The contractor shall provide test results for all. If any conductors fail, the contractor must report to the owner and the engineer before moving forward.

**1.2 RELATED WORK SPECIFIED ELSEWHERE:**

- A. The Drawings and general provisions of the Contract, including the General and Supplementary Conditions, Instructions to Bidders and sections of Division 1, apply to the work specified in this section.
- B. Refer to other Division 26 sections for requirements for penetration firestopping, requirements for electrical installations, grounding and bonding, raceway and boxes and earthwork.

**1.3 REFERENCES AND CODES:**

- A. NEMA WC 70 - Standard for Non-shielded Power Cable 2000 volts or Less for the Distribution of Electrical Energy (2009).
- B. 2020 NFPA 70 - National Electrical Code

**1.4 SUBMITTALS:**

- A. In accordance with sections of Division 1, furnish the manufacturer's literature and data showing each conductor and cable type and rating.

**1.5 QUALITY ASSURANCE:**

- A. Testing Agency Qualifications: Testing agency as defined by OSHA in 29 CFR 1910.7 or a member company of the International Electrical Testing Association and that is acceptable to Authorities Having Jurisdiction.

- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70 Article 100 by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- C. Comply with applicable requirements of NFPA 70 (NEC) pertaining to the construction and installation of electrical wires and cables.

**1.6 DELIVERY, STORAGE AND HANDLING:**

- A. Deliver wire and cable properly packaged in factory fabricated containers or wound on NEMA-specified wire and cable reels. Each coil or reel shall contain only one continuous cable without splices.
- B. Handle wire and cable carefully to avoid abrading, puncturing or tearing wire and cable insulation and sheathing. Ensure the dielectric resistance integrity of the wire and cable is maintained.
- C. Store wire and cable in a clean, dry space in original containers. Protect products from weather, damaging fumes, construction debris and traffic.

**PART 2: PRODUCTS**

**2.1 CONDUCTORS AND CABLES:**

- A. General: Provide electrical conductors and cables of manufacturer's standard materials, as indicated by published product information, designed and constructed as recommended by manufacturer for a complete installation and for applications indicated.
- B. Line Voltage (100 to 600 volts): Provide [only] copper conductors with conductivity of not less than 98% at 20 degrees C (68 degrees F). All indicated conductor sizes in construction documents are based on copper [except where specifically noted otherwise]. Provide impregnated color-coding for all new or extended, spliced conductors. For 208Y/120 volt or 120/240 volt delta systems, provide black for phase A, red for phase B, blue for phase C, and white for neutral. For 480Y/277 volt systems, provide brown for phase A, orange for phase B, yellow for phase C, and gray for neutral. Provide green ground conductor color as required by the NEC.
  - 1. Provide factory-fabricated copper conductors of sizes, ampacity ratings, and materials for applications and services indicated. Provide conductors with Type XHHW or XHHW-2 or THHN or THWN-2 insulation with a minimum rating of 90 degrees C, which are the indicated conductors scheduled [except where specifically noted otherwise].
  - 2. Provide solid conductors for sizes #10 AWG and smaller. Provide stranded conductors for sizes #8 AWG and larger. Provide minimum conductor size of #12 AWG, larger where indicated.

3. For 120-volt 15 amp and 20 amp branch circuits, use minimum 12 AWG up to 60 feet, 10 AWG for 61-95 feet, 8 AWG for 96-155 feet and 6 AWG for branch circuits longer than 155 feet. Conductors shall be same size for entire length of run, except if all outlets are in the same room (1200 square feet or less) the oversized conductors may be run only to the first outlet.

## 2.2 CONNECTORS:

- A. General: Provide proper current-carrying material suitable for conductors used. Provide per the contract documents for splices, extended, etc.

## PART 3: EXECUTION

### 3.1 INSTALLATION OF CONDUCTORS, CABLES AND CONNECTORS:

- A. Coordinate conductors/cable installation work, including electrical raceway and equipment installation work, as necessary to properly interface installation of conductors/cables with other work.
- B. Unless otherwise indicated, install individual conductors in raceways.
- C. Install exposed cables parallel and perpendicular to surfaces of exposed structural members, and follow surface contours where possible.
- D. Support cables according to NEC and cable manufacturer's instructions.
- E. Cables penetrating fire-rated elements shall be sealed according to Division 7.
- F. Type cable may be used in areas where permitted by NEC and local codes, but only for branch circuits above accessible ceilings and in stud walls. Only cables with 75 or 90 degree C rated insulation are permitted and as noted on the contract documents. Where running into a panel where the ceiling space is inaccessible, conduit shall be run from the panel to a junction box above the nearest accessible ceiling. Cables shall be run neatly in straight parallel runs with proper support and limited sag.
- G. Provide cables in plenum spaces in metallic raceways or with cable jackets approved for use in plenum spaces.
- H. Provide listed bushing or grommets where non-metallic-sheathed cables pass through openings in metal studs and other metal members in accordance with NEC 300.4. Where cables are installed at roof decking, follow requirements of NEC 300.4(E).
- I. Pull conductors simultaneously where more than one is being installed in same raceway.

- J. Use manufacturer-approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.
- K. Use pulling means, including fish tape, cable, rope and basket weave conductor/cable grips, which will not damage cables or raceway. Remove and replace all conductors/cables with damaged jacket or insulation.
- L. Install splices and tapes which possess equivalent-or-better mechanical strength and insulation ratings than conductors being spliced.
- M. Where ground conductors are required to be run in same raceway as phase conductors, the ground conductor shall be run continuous throughout each circuit and the ground conductor pigtailed to the device to ensure ground continuity.
- N. Do not install a shared neutral on any circuit. Install capped neutral conductors in switch boxes where required by NEC 404.2(C).
- O. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.
- P. Comply with all emergency system wiring requirements in NEC 700.10.

**3.2 INSTALLATION OF CONDUCTORS AND CABLES FOR POWER LIMITED CIRCUITS:**

- A. Wiring for signaling and power limited circuits may be run exposed in the following locations:
  - 1. Above accessible ceilings where not exposed to view.
- B. Provide signaling and wiring for power limited circuits in raceways in the following locations:
  - 1. In all locations not specifically listed above.
  - 2. Where concealed in inaccessible locations.
  - 3. In elevator equipment rooms and hoistways.
- C. Install exposed conductors or cable parallel and perpendicular to building surfaces, or exposed structural members, and follow surface contours where possible.
- D. Install conductors and cables in a neat and workmanlike manner.

- E. Support conductors and cables frequently to prevent excessive sag. Support a minimum of 6" above suspended ceilings. Do not support conductors or cables from conduit or other raceway.
- F. Parallel cable runs shall be installed adjacent to each other. Tie adjacent runs in neat bundles.
- G. Install conductors and cables without splices. Make connections at terminal strips in cabinets or at equipment terminals.
- H. Provide conductors and cables in accordance with requirements of manufacturer.

**3.3 FIELD QUALITY CONTROL:**

- A. Prior to energization of circuitry, check low voltage installed conductors and cables with megohm meter to determine insulation resistance levels to ensure requirements are fulfilled.
- B. Prior to energization, test low voltage conductors and cables for electrical continuity, short circuits and grounds. Also, test conductor phase-to-phase and phase-to-ground.

END OF SECTION 260519

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SECTION 260526 - GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1: GENERAL

1.1 DESCRIPTION:

- A. This section specifies general grounding and bonding requirements of electrical equipment operations for safety and to provide a low impedance path for possible ground fault currents. Extent of grounding and bonding work is indicated by drawings and schedules and as specified herein. Grounding and bonding work is defined to encompass systems, circuits and equipment.

1.2 RELATED DOCUMENTS:

- A. The Drawings and general provisions of the Contract, including the General and Supplementary Conditions, Instructions to Bidders and sections of Division 1, apply to the work specified in this section.

1.3 RELATED WORK SPECIFIED ELSEWHERE:

- A. Refer to other Division 26 sections for conductors/cables, electrical raceways, boxes and fittings which are required in conjunction with electrical grounding and bonding work.

1.4 REFERENCES AND CODES:

- A. Electrical Code Compliances: Comply with applicable requirements of the 2020 NFPA-70 (NEC) pertaining to electrical grounding and bonding, pertaining to systems, circuits, and equipment. Particular attention is called to Article 250.
- B. U.L. Compliance: Comply with applicable requirements of UL Standards Nos. 467, "Electrical Grounding and Bonding Equipment", and 869, "Electrical Service Equipment", pertaining to grounding and bonding of systems, circuits, and equipment. In addition, comply with UL Std. 486A, "Wire Connectors and Soldering Lugs for Use with Copper Conductors." Provide grounding and bonding products which are U.L. Listed and labeled for their intended usage.
- C. IEEE Compliance: Comply with applicable requirements and recommended installation practices of IEEE Standards 80, 81, 141, and 142 pertaining to grounding and bonding of systems, circuits, and equipment.

1.5 SUBMITTALS:

- A. Submit manufacturer's data on grounding and bonding products and associated accessories.

**PART 2: PRODUCTS**

**2.1 GROUNDING SYSTEMS:**

- A. General: Except as otherwise indicated, provide electrical grounding and bonding systems in accordance with the NEC, with assembly of materials including, but not limited to: conductors/cables, connectors, terminals (solderless lugs), compression connectors, mechanical connectors and/or exothermic process connections, grounding electrodes and bonding jumpers, and additional accessories needed for complete installation. Where more than one type unit meets indicated requirements, selection is Contractor's option. Where materials or components are not indicated, provide products complying with NEC, UL, IEEE and established industry standards for applications indicated
- B. Conductors: Unless otherwise indicated, provide electrical grounding conductors matching power supply wiring materials and sized according to NEC.

**2.2 MISCELLANEOUS MATERIAL:**

- A. Bonding Jumper Braid: Copper braided tape constructed of 30 gauge bare copper wires and properly sized for indicated applications.
- B. Bonding Plates, Connectors, Terminals and Clamps: Provide electrical bonding plates, connectors, terminals and clamps for indicated applications.
- C. Ground Busbar: Provide ground busbar of 1/4" thick, tin-plated copper; 15 1/2"L x 4"W; tower mounting with nylon polyamide insulators and stainless steel brackets and bolts for a total stand-off height of 2"; predrilled with 19 pairs of 5/16" holes and 3 pairs of 7/16" holes.
- D. Grounding Electrodes (Rods): Steel with copper welded exterior, 3/4 inch diameter and 10 feet length.
- E. Electrical Grounding Connection Accessories: Provide electrical insulating tape, heat-shrinkable insulating tubing, welding materials and bonding jumpers, as recommended by accessories manufacturers for type services indicated.
- F. Compression Connectors: Compression connectors shall be manufactured from pure, wrought copper in compliance with ASTM B187.

**PART 3: EXECUTION**

**3.1 EXAMINATION:**

- A. Examine areas and conditions under which electrical grounding and bonding connections are to be made and notify Contractor in writing of conditions detrimental to proper completion of work. Do not proceed with work until satisfactory conditions have been corrected in a manner acceptable to Installer.

**3.2 INSTALLATION OF ELECTRICAL GROUNDING AND BONDING SYSTEMS:**

- A. General: Install electrical grounding and bonding systems required in accordance with manufacturer's instructions and applicable portions of the NEC, NECA's "Standard of Installation", and in accordance with recognized industry practices to ensure that products comply with requirements.
- B. Provide insulated equipment grounding conductors in the same raceway with phase conductors for all feeders (panelboards, control centers and distribution transformers), motor circuits, branch circuits and site lighting. Ground conductors shall be continuous from the equipment to the ground bus of the switchboard, panelboard or control center serving the equipment.
- C. Coordinate with other electrical work as necessary to interface installation of electrical grounding and bonding system with other work.
- D. install standard cable bonding jumpers with ground clamps on water piping to electrically bypass water meters, water heaters, insulated joints and any equipment which is likely to be disconnected for repairs or replacement, refer to NEC 250.53 (D) (1).
- E. Install clamp-on connectors only on thoroughly cleaned metal contact surfaces, to ensure electrical conductivity and circuit integrity.
- F. Ground electrical service system neutral at service entrance equipment to grounding electrodes. Make ground connections in accordance with NEC and local utility company requirements. Bonding jumpers at the service shall comply with NEC 250.92.
- G. Connect together system neutral, service equipment enclosures, exposed non-current carrying metal parts of electrical equipment, metal raceway systems, grounding conductor in raceways and cables, wiring device ground connectors and plumbing systems. Particular attention is called to NEC 250.92, 250.97 and 250.98 for metal raceway bonding requirements. Ground cord-and-plug connected equipment in accordance with NEC 250.114.
- H. Terminate feeder and branch circuit insulated equipment grounding conductors with grounding lug to ground bar or bus.
- I. Connect grounding electrode conductors to metallic cold water pipe and sprinkler main within 5 feet of the entrance point into the building using a suitably sized ground clamp, refer to NEC 250.68 (C) (1). Also bond gas piping, metallic water piping and metal structural members to system ground where applicable in compliance with NEC 250.104.
- J. Route grounding connections and conductors to ground and protective devices in shortest and straightest paths as possible to minimize transient voltage rises.
- K. Apply corrosion-resistant finish to field-connections, buried metallic grounding and bonding products and places where factory applied protective coatings have been destroyed, which are subjected to corrosive action.

- L. All ground connectors shall be designed for fault-duty loading and shall have the fault capacity of the maximum sized conductor for which it is designed.
- M. Bolt hole connectors and in-line splices shall accommodate only one conductor size. All other ground connectors shall be range taking.
- N. Structural steel and busbar ground connectors shall accommodate only one rigid member conductor.
- O. All ground connectors shall be provided with a corrosion-inhibiting compound preapplied to the contact surfaces. The compound shall be compatible with the conductors accommodated by the connector.
- P. All ground connectors shall be capable of being provided with tin plating, if required by the application.
- Q. Tighten grounding and bonding connectors and terminals, including screws and bolts, in accordance with manufacturer's published torque tightening values for connectors and bolts. Where manufacturer's torqueing requirements are not indicated, tighten connections to comply with tightening torque values specified in UL 486A to assure permanent and effective grounding.
- R. Compression Connector Marking:
  - 1. All connectors shall be clearly and permanently marked with the following information:
    - a. Manufacturer's inspection symbol
    - b. Catalog number
    - c. Conductor accommodation(s)
    - d. Installation die index or die catalog number (compression)
    - e. Underwriters Laboratories Listing Mark
    - f. The words "Suitable for Direct Burial," or "Direct Burial," or "Burial" as specified per ANSI/UL467.
  - 2. The smallest unit package shall contain the information listed under Y.1 and shall also include installation tooling.
- S. Ground Connector Installation Using Compression:
  - 1. Installation of connectors shall be made in accordance with the manufacturer's recommendations. The instructions typically include conductor preparation (cleaning, pre-crimp), installation tool and die selection, and application of the proper number of crimps.
  - 2. Connectors shall be installable under all types of weather/field conditions without special safety precautions or procedures.
  - 3. Connectors shall be installable without using or producing hazardous materials or by-products.

- T. Provide labels on all ground electrode conductors and bonding conductors that indicate what they are connected to.
1. Main Service Ground Buss Bar:
    - a. Ground electrode conductor to Metal Underground Water Pipe ground electrode shall be labeled: "Water Main".
    - b. Ground electrode conductor to Metal Frame of Building or Structure ground electrode shall be labeled: "Building Steel".
    - c. Ground electrode conductor to Concrete-Encased ground electrode shall be labeled: "Concrete Encasement".
    - d. Ground electrode conductor to Ground Ring ground electrode shall be labeled: "Ground Ring".
    - e. Ground electrode conductor to Ground Rod Triad ground electrode shall be labeled: "Ground Rods".
    - f. Ground conductor to Lightning Protection System ground terminals shall be labeled: "Lightning Protection System".
    - g. Ground conductor to Telecommunication Systems ground buss bar (located at the telecommunication services) shall be labeled: "Telecommunication Systems".
    - h. Ground conductor to Interior Gas Metal Piping shall be labeled: "Gas Piping".
    - i. Ground conductor to Interior Sprinkler Metal Piping shall be labeled: "Sprinkler Piping".
  2. Test Wells: Provide labels of all ground conductors terminated within the test wells.

### 3.3 FIELD QUALITY CONTROL:

A. Ground Connector Inspection:

1. Compression dies shall provide embossment of the connector upon successful installation. The embossed index shall match the marking on the installed connector.
2. Connector marking information specified above shall be legible after installation for inspector cross-reference.
3. Closed barrel connectors shall have inspection holes at the appropriate location to verify proper cable insertion.

B. Performance:

1. All system connectors shall be Listed by Underwriters Laboratories for direct burial in earth or embedment in concrete per ANSI/UL467 Standard for Grounding and Bonding Equipment.
2. Connectors shall be suitable for lightning protection applications. Listing to UL96 Lightning Protection Components is required on applicable items.

- C. Upon completion of installation of electrical grounding and bonding systems, test ground resistance of rod, pipe or plate electrodes [and ground test wells] with ground resistance tester. Where tests show resistance to ground is over 25 ohms, provide additional electrodes as listed by the NEC to reduce resistance to 25 ohms or less. Retest to demonstrate compliance. This test does not apply to supplementary grounding electrodes such as a ground rod provided for exterior lighting fixture poles.

3.4 O&M MANUAL:

- A. Provide O&M Manual as specified in specification section 260100. Include both a paper copy and digital pdf copy of the O&M Manual.

END OF SECTION 260526

**SECTION 260529 - HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS**

**PART 1: GENERAL**

**1.1 DESCRIPTION:**

- A. This section specifies the extent of supports, anchors, sleeves and seals for electrical equipment installations as indicated by drawings and schedules, as specified in the Division 26 sections and as required by the NEC.

**1.2 RELATED DOCUMENTS:**

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions, Instructions to Bidders and sections of Division 1, apply to the work specified in this section.

**1.3 REFERENCES AND CODES:**

- A. Electrical Code Compliances: Comply with applicable requirements of the 2020 NFPA-70 (NEC) pertaining to construction and installation of electrical supporting devices.
- B. NECA Compliance: Comply with National Electrical Contractors Association's "Standard of Installation" pertaining to anchors, fasteners, hangers, supports, and equipment mounting.
- C. U.L. Compliance: Provide electrical components which are U.L. Listed and U.L. Labeled.

**1.4 PERFORMANCE REQUIREMENTS:**

- A. Design supports for multiple raceways capable of supporting combined weight of supported systems and its contents.
- B. Design equipment system supports capable of supporting combined operating weight of supported equipment and connected systems and components.
- C. Rated Strength: Adequate in tension, shear and pullout force to resist maximum loads calculated or imposed under this Project, with a structural safety factor of five times the applied force.

**PART 2: PRODUCTS**

**2.1 MANUFACTURERS:**

- A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
  - 1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, manufacturers specified.
  - 2. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

**2.2 SUPPORT, ANCHORAGE AND ATTACHMENT COMPONENTS:**

- A. Steel Slotted Support Systems: Comply with MFMA-4, factory-fabricated components for field assembly.
  - 1. Manufacturers:
    - a. Cooper B-Line; a division of Cooper Industries.
    - b. ERICO International Corporation.
    - c. Allied Support Systems; Power-Strut Unit.
    - d. GS Metals Corp.
    - e. Michigan Hanger Co., Inc.; O-Strut Div.
    - f. National Pipe Hanger Corp.
    - g. Thomas & Betts Corporation.
    - h. Unistrut; Tyco International, Ltd.
    - i. Wesanco, Inc.
    - j. Bridgeport Fittings, Inc.
  - 2. Finishes:
    - a. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.
    - b. Nonmetallic Coatings: Manufacturer's standard PVC, polyurethane, or polyester coating applied according to MFMA-4.
    - c. Painted Coatings: Manufacturer's standard painted coating applied according to MFMA-4.
  - 3. Channel Dimensions: Selected for applicable load criteria.
- B. Raceway and Cable Supports: As described in NECA 1 and NECA 101.
- C. Conduit and Cable Support Devices: Steel and malleable-iron hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.



- D. Structural Steel for Fabricated Supports and Restraints: ASTM A 36/A 36M, steel plates, shapes and bars; black and galvanized.
- E. Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for non-armored electrical conductors or cables in riser conduits. Plugs shall have number, size and shape of conductor gripping pieces as required to suit individual conductors or cables supported. Body shall be malleable iron.
- F. Mounting, Anchoring and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:
  - 1. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened Portland cement concrete, steel, or wood, with tension, shear and pullout capacities appropriate for supported loads and building materials where used.
    - a. Manufacturers:
      - (1) Hilti, Inc.
      - (2) ITW Construction Products.
      - (3) MKT Fastening, LLC.
      - (4) Simpson Strong-Tie Co. Inc.
  - 2. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated, steel, for use in hardened Portland cement concrete with tension, shear and pullout capacities appropriate for supported loads and building materials in which used.
    - a. Manufacturers:
      - (1) Cooper B-Line; a division of Cooper Industries.
      - (2) Empire Tool and Manufacturing Co., Inc.
      - (3) Hilti, Inc.
      - (4) ITW Construction Products.
      - (5) MKT Fastening, LLC.
      - (6) Powers Fasteners.
  - 3. Concrete Inserts: Steel or malleable-iron slotted-support-system units similar to MSS Type 18; complying with MFMA-3 or MSS SP-58.
  - 4. Clamps for Attachment to Steel Structural Elements: MSS SP-58, type suitable for attached structural element.
  - 5. Through Bolts: Structural type, hex head, high strength. Comply with ASTM A 325.
  - 6. Toggle Bolts: All-steel springhead type.
  - 7. Hanger Rods: Threaded steel.

**2.3 FABRICATED METAL EQUIPMENT SUPPORT ASSEMBLIES:**

- A. Description: Welded or bolted structural-steel shapes, shop or field fabricated to fit dimensions of supported equipment.

- B. Materials: Comply with requirements in Division 5 for steel shapes and plates.

### **PART 3: EXECUTION**

#### **3.1 APPLICATION:**

- A. Comply with NECA 1 and NECA 101 for application of hangers and supports for electrical equipment and systems, except if requirements in this Section are stricter.
- B. Maximum Support Spacing and Minimum Hanger Rod Size for Raceway: Space supports for EMT, IMC and RMC as required by NFPA 70. Minimum rod size shall be 1/4 inch (6 mm) in diameter.
- C. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted or other support system, sized so capacity can be increased by at least 25 percent in future without exceeding specified design load limits.
  - 1. Secure raceways and cables to these supports with two-bolt conduit clamps or single-bolt conduit clamps.
- D. Spring-steel clamps designed for supporting single conduits without bolts may be used for 1-1/2 inch (38 mm) and smaller raceways serving branch circuits and communication systems above suspended ceilings, and for fastening raceways to trapeze supports.

#### **3.2 SUPPORT INSTALLATION:**

- A. Comply with NECA 1 and NECA 101 for installation requirements, except as specified in this Article.
- B. Raceway Support Methods: In addition to methods described in NECA 1, [EMT] [IMC] [RMC] [EMT, IMC, and RMC] may be supported by openings through structure members, as permitted in NFPA 70.
- C. 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 (90 kg).
- D. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise required by code:
  - 1. To Wood: Fasten with lag screws or through bolts.
  - 2. To New Concrete: Bolt to concrete inserts.

3. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
  4. To Existing Concrete: Expansion anchor fasteners.
  5. Instead of expansion anchors, powder-actuated driven threaded studs provided with lock washers and nuts may be used in existing standard-weight concrete 4 inches (100 mm) thick or greater. Do not use for anchorage to lightweight-aggregate concrete or for slabs less than 4 inches (100 mm) thick.
  6. To Steel: Beam clamps or Spring-tension clamps.
  7. To Light Steel: Sheet metal screws.
  8. Items Mounted on Hollow Walls and Nonstructural Building Surfaces: Mount cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers and other devices on slotted-channel racks attached to substrate.
- E. Drill holes for expansion anchors in concrete at locations and to depths that avoid reinforcing bars.

**3.3 INSTALLATION OF FABRICATED METAL SUPPORTS:**

- A. Comply with installation requirements in Division 5 for site-fabricated metal supports.
- B. Cut, fit and place miscellaneous metal supports accurately in location, alignment and elevation to support and anchor electrical materials and equipment.
- C. Field Welding: Comply with AWS D1.1/D1.1M.

**3.4 INSTALLATION OF SUPPORTING DEVICES:**

- A. Install hangers, anchors, sleeves and seals as required, in accordance with manufacturer's written instructions and with recognized industry practices to ensure supporting devices comply with requirements. Comply with requirements of NECA and NEC for installation of supporting devices.
- B. Coordinate with other electrical work, including raceway and wiring work, as necessary to interface installation of supporting devices with other work.
- C. Install hangers, supports, clamps, and attachments to support conduit properly from building structure. Arrange for grouping of parallel runs of horizontal conduits to be supported together on trapeze type hangers where possible. Install supports in compliance with NEC requirements.

END OF SECTION 260529

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**SECTION 260533 - RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS**

**PART 1 GENERAL**

**1.1 DESCRIPTION:**

- A. This section specifies the furnishing, installation and connection of conduit, fittings and boxes to form complete, coordinated, grounded raceway systems. Raceways are required for all wiring unless shown or specified otherwise. Extent of raceway work is indicated by drawings and schedules and as required by the NEC.

**1.2 RELATED DIVISIONS AND SECTIONS:**

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions, Instructions to Bidders and sections of Division 1, apply to the work specified in this section.
- B. Refer to other Division 7 and Division 26 sections for requirements for penetration firestopping, requirements for electrical installations, grounding and bonding and wiring devices and miscellaneous equipment.

**1.3 REFERENCES AND CODES:**

- A. NEMA Compliance: Comply with applicable requirements of NEMA Standards Publication pertaining to raceways.
- B. U.L. Compliance and Labeling: Comply with applicable requirements of U.L. Safety Standards pertaining to electrical raceway systems. Provide raceway products and components which have been U.L. Listed and labeled.
- C. Electrical Code Compliance: Comply with applicable requirements of the 2020 NFPA-70 (NEC) pertaining to the construction and installation of raceway systems.

**1.4 SUBMITTALS:**

- A. Product Data: Submit manufacturer's data on [electrical boxes and fittings] [floor boxes] [raceways] [surface metal raceways] [surface non-metallic raceways] [overhead metal raceways] [thru-wall/floor firestop devices] [plug-in flexible wiring system] [cable tray].

## PART 2 PRODUCTS

### 2.1 ALL RACEWAYS:

- A. General: Provide complete assembly of all raceways, including but not limited to fittings, couplings, conduit bodies, underground raceway seals, service heads, expansion fittings, straps, hangers and other components and accessories as required to complete raceway system.

### 2.2 METAL RACEWAYS:

- A. Rigid Steel Conduit: Rigid steel, zinc-coated, threaded type conforming to ANSI C80.1. Provide zinc coating fused to inside and outside walls.
- B. Intermediate Metal Conduit (IMC): Rigid intermediate grade steel, hot-dip galvanized conforming to ANSI C80.6.
- C. Electrical Metallic Tubing (EMT): ANSI C80.3. The Contractor has the option of using aluminum EMT where sizes 2" through 4" are required, except where UL firestop assemblies require steel.
- D. PVC Externally Coated Rigid Steel Conduit: Rigid steel zinc-coated with additional external coating of PVC conforming to NEMA RN 1.
- E. Liquid-Tight Flexible Metal Conduit: Constructed of single strip, flexible, continuous, interlocked, and double-wrapped steel; galvanized inside and outside; coated with liquid-tight jacket of flexible polyvinyl chloride (PVC).
- F. Rigid Metal Conduit Fittings: Cast malleable iron, galvanized or cadmium plated, compatible with conduit materials conforming to NEMA FB-1.
- G. Liquid-Tight Flexible Metal Conduit Fittings: Cadmium plated, malleable iron fittings with compression type steel ferrule and neoprene gasket sealing rings, with insulated throat.
- H. EMT Fittings: Galvanized steel fittings, compression watertight type, except where aluminum EMT is used provide UL listed fittings for use with aluminum EMT.

### 2.3 NON-METALLIC RACEWAYS:

- A. Electrical Plastic Conduit:
  - 1. Heavy Wall Conduit: Schedule 40, 90 deg. C, UL-rated, constructed of polyvinyl chloride and conforming to NEMA TC-2, for direct burial, or normal above ground use, UL-listed and in conformity with NEC Article 352.

2. Extra Heavy Wall Conduit: Schedule 80, UL-rated, constructed of polyvinyl chloride compound C-200 PVC conforming to NEMA TC-2, and UL-listed in accordance with NEC Article 352 for direct burial, or above ground use.
  - B. PVC Conduit and Tubing Fittings: NEMA TC 3, mate and match to conduit or tubing type and material.
  - C. Conduit and Tubing Accessories: Provide conduit, tubing and duct accessories of types, sizes, and materials complying with manufacturer's published product information, which mate and match conduit and tubing.
  - D. Conduit and Fitting Bonding: Use only manufacturer's recommended sealing compounds to produce watertight joints.
- 2.4 WIREWAYS:
- A. General: Provide complete assembly of raceway including, but not limited to, couplings, offsets, elbows, expansion joints, adapters, holddown straps, end caps, and other components and accessories as required for a complete system.
  - B. Lay-in Wireways: Construct lay-in wireways with hinged covers, in accordance with UL 870 and with components UL-listed, including lengths, connectors, and fittings. Select units to allow fastening hinged cover closed without use of parts other than standard lengths, fittings and connectors. Construct units to be capable of sealing cover in closed position with sealing screws. Provide wireways with knockouts.
    1. Connectors: Provide wireway connectors suitable for "lay-in" conductors, with connector covers permanently attached so that removal is not necessary to utilize the lay-in feature.
    2. Finish: Protect sheet metal parts with rust inhibiting coating and baked enamel finish. Plate finish hardware to prevent corrosion. Protect screws installed toward inside of wireway with spring nuts to prevent wire insulation damage.
  - C. Raintight Wireway: Construct raintight lay-in wireways with hinged covers, in accordance with UL 870 and with components UL-listed, including lengths, connectors and fittings. Design units to allow fastening hinged cover closed without use of parts other than standard lengths, fittings and connectors. Construct units to be capable of sealing cover in closed position with sealing screws. Provide wireway units with knockouts only in bottom of wireway.
  - D. Raintight Troughs: Construct in accordance with UL 870, with components UL-listed.
    1. Construction: 16-gauge galvanized sheet metal parts for 4" x 4" to 6" x 6" sections, and 14-gauge parts for 8" x 8" and larger sections. Provide knockouts only in bottom of troughs, with suitable adapters to facilitate attaching to other NEMA 3R enclosures. Do not use gasketing that can rip or tear during installation, or would

compromise raintight capability of the trough. Do not use cover screws that protrude into the trough area and damage wire insulation.

2. Finish: Provide 14-gauge and 16-gauge galvanized sheet metal parts with corrosion-resistant phosphate primer and baked enamel finish. Plate hardware to prevent corrosion.

**2.5 CABLE TRAY: – if contractor uses**

- A. Cable Tray: Shall be aluminum ladder (9" rung minimum) type as follows:

1. Cable trays shall not have any sharp edges that can cut or damage cable jackets or conductors while being installed (pulled) over the cable tray assemblies.
2. Provide cable tray splices, radius drops or rises, bends, supports, connectors and fittings for a complete wireway system. The contractor shall provide a ground jumper at each splice plate on one side of the entire length of the cable tray system.
3. Provide Cooper B-Line or approved equal.

**2.6 INTERIOR AND ABOVE-GRADE EXTERIOR JUNCTION AND PULL BOXES:**

- A. Provide galvanized code-gauge sheet steel junction and pull boxes, with screw-on covers; of types, shapes and sizes to suit each respective location and installation. For exterior above-grade locations, provide NEMA [3R] boxes with welded seams and equipped with stainless steel nuts, bolts, screws and washers. If knockouts are provided on the sides of the box for conduit entry, use watertight conduit hubs. Large pullboxes with any dimension over 6 feet shall be complete with built-in wire support systems to prevent wire from pressing on connectors or other wire to prevent damage to insulation. Pullboxes in high-rise installations shall be complete with insulating wedge type connectors to provide proper support of conductors. The number and locations of pullboxes shall be as required by NEC to provide proper support of conductors, where required due to the number of bends in the raceway and where required due to length of raceway to not exceed the maximum pulling tension recommended by the cable manufacturer. Exterior exposed pullboxes shall be provided with screened raintight openings to allow heat to escape.

**2.7 MISCELLANEOUS CABINETS:**

- A. Provide flat-rolled sheet-steel cabinets, flush or surface mounted as indicated, hinged door with flush latch and lock. Provide a framed directory with clear plastic protective cover on inside of door; trim clamps; gaskets where required by atmospheric conditions; single point latching for doors under 36"; 3 point latching for doors 36" and larger. Door and trim shall have factory applied finish to match panelboard cabinets.
- B. Manufacturers: Provide cabinets of one of the following:
1. Anchor
  2. Austin



3. Keystone
4. Electromate
5. Hoffman
6. Westinghouse
7. General Electric
8. Square D

**2.8 THRU-WALL/FLOOR FIRESTOP DEVICE:**

- A. The firestop device shall meet UL1479 (ASTM E 814) and bear the U.S. UL Classification Mark. The device shall be classified for use in one-, two-, three-, and four-hour rated gypsum, concrete and block walls. The device shall also have been tested by Underwriters Laboratories Inc. To UL2043 and determined to be suitable for use in air handling spaces. The firestop device shall stop or inhibit the spread of both fire and smoke as required by the IBC for fire and smoke rated partitions and barriers.
- B. Sizes: The firestop device shall be for 2" and 4" trade size EMT conduit.
- C. At each location where conduits and/or sleeves penetrate a fire or smoke rated partition or barrier for a pathway for I.T. cables, provide sufficient quantity of units to completely cover and properly seal all conduits and sleeves.
- D. Installation shall be in strict accordance with
  1. Manufacturer's installation instructions.
  2. All written and graphic requirements in the test assembly documentation published by the listing agency.
- E. The firestop device shall be the Wiremold FlameStopper. Other acceptable products are Hilti Speed Sleeve, STI EZ-Path and Metacaulk Pass-Thru.

**2.9 BLANK FINISHED OUTLET COVERS:**

- A. Provide Arlington Industries, Inc. CP3540 blank covers on all future ceiling paddle fans and on any outlet or junction box that is for a future luminaires in finished space.

**PART 3 EXECUTION**

**3.1 INSTALLATION OF RACEWAYS:**

- A. Install raceways level and plumb, and maintain manufacturer's recommended clearances.
- B. Coordinate with other work including wires/cables, boxes and panel work as necessary to interface installation of electrical raceways and components with other work.

**3.2 INSTALLATION OF CONDUITS:**

- A. Conduit runs are not shown on floor plans unless specifically noted or indicated otherwise.
- B. Applications:
  - 1. Use rigid steel conduit in moist or damp locations, in hazardous or refrigerated areas, in poured concrete, underground, beneath slab-on-grade and where exposed outdoors.
  - 2. EMT may be used for all installations not requiring rigid
  - 3. Rigid conduit may be steel Contractor's option, except do not use aluminum conduit or aluminum products in cast-in-place concrete installations or where UL firestop assemblies require steel..
  - 4. Rigid PVC conduit may be used in lieu of rigid steel for conduits installed in poured concrete, underground or beneath slab-on-grade. Convert to metallic conduit at no more than 48" above ground or slab if concealed in wall; otherwise, convert to metallic conduit before exiting ground or slab. Do not use PVC conduit above-grade unless specifically indicated otherwise.
  - 5. Use PVC-coated rigid conduit and fittings in all highly-corrosive atmospheres.
- C. General:
  - 1. Install conduits concealed in new construction work, either in walls, slabs or above hung ceiling, except in mechanical or electrical equipment rooms in which they may be exposed. Install conduits concealed in stairs, except in stairs without suspended ceilings a short horizontal section conduit to feed each light fixture mounted to underside of landing may be exposed. Run conduits concealed in existing work where practicable. Where conduits cannot be concealed in finished areas, notify the Architect for permission to use surface raceways. Where installed at roof decking, follow requirements of NEC 300.4(E).
  - 2. Provide penetration firestopping in smoke barriers and fire-resistance-rated walls, floors and ceilings for electrical raceway penetrations in accordance with Division 7 and with requirements of this section.
  - 3. Mechanically fasten together metal conduits, enclosures, and raceways for conductors to form continuous electrical conductor. Connect to electrical boxes, fittings and cabinets to provide electrical continuity and firm mechanical assembly.
  - 4. Avoid use of dissimilar metals throughout systems to eliminate possibility of electrolysis. Where dissimilar metals are in contact, coat surfaces with corrosion inhibiting compound before assembling.
  - 5. Install miscellaneous fittings such as reducers, chase nipples, 3-piece unions, split couplings, long radius elbows and plugs that have been specifically designed and manufactured for their particular application. Install expansion/deflection fittings in raceways every 200' linear run or wherever structural expansion joints are crossed, per NEC 300.4(H).
  - 6. Cut conduits straight, properly ream, and cut threads for heavy wall conduit deep and clean.
  - 7. Use factory-made elbows or field-bend conduit with benders designed for purpose so as not to distort nor vary internal diameter.

8. Size conduits to meet NEC, except no conduit smaller than 3/4 inch shall be used unless noted otherwise. Conduits below-grade and in-slab shall be minimum 3/4 inch.
9. Fasten conduit terminations in sheet metal enclosures by 2 locknuts, and terminate with bushing. Install locknuts inside and outside enclosure.
10. Conduits shall not touch sprinkler pipes, or cross pipe shafts or ventilating duct openings.
11. Keep conduits a minimum distance of 6" from parallel runs of flues, hot water pipes and other sources of heat. Wherever possible, install raceway runs below hot water and steam piping where necessary to cross piping.
12. Use of running threads at conduit joints and terminations is prohibited. Where required, use 3-piece union or split coupling.
13. Complete installation of electrical raceways before starting installation of cables/wire within raceways.
14. Install conduits so as not to damage the integrity of the structural members. Avoid horizontal or cross runs in building partitions or side walls.
15. Install temporary closures to prevent foreign matter from entering raceways.
16. Protect stub-ups from damage where conduits rise through floor slabs. Arrange so curved portions of bends are not visible above the finished slab.
17. Provide bushings on all conduit stubs.

**D. Concealed Conduits:**

1. Metallic raceways installed underground, in floors, below-grade or outside shall have conduit threads painted with corrosion inhibiting compound before couplings are assembled. Draw up coupling and conduit sufficiently tight to ensure watertightness.
2. Mark Record Documents with conduit size and location.

**E. Conduits in Concrete Slabs:** Install conduits in concrete slabs only under the following conditions:

1. In slab-on-grade.
2. In structural concrete deck.
3. In concrete-on-metal deck for short runs to isolated floor outlets.

**F. Exposed Conduits:**

1. Install exposed conduit work so as not to interfere with ceiling inserts, lights, ventilation ducts, HVAC unit clearances, or outlets.
2. Support exposed conduits by use of hangers, clamps, or clips. Support conduits on each side of bends and on spacing not to exceed the requirements of the NEC. Support multiple runs of conduit from trapeze hangers.
3. Set anchors in waterproof cement for the support of conduits where run on waterproof walls.
4. Above requirements for exposed conduits also apply to conduits installed in space above hung ceilings and in crawl spaces.

G. Conduit Fittings:

1. Use locknuts for securing conduit to metal enclosure with sharp edge for digging into metal, and ridged outside circumference for proper fastening.
2. Bushings for terminating conduit smaller than 1-1/4" shall have flared bottom and ribbed sides, with smooth upper edges to prevent injury to cable insulation.
3. Install insulated type bushings for terminating conduits 1-1/4" and larger. Bushings shall have flared bottom and ribbed sides. Upper edge shall have phenolic insulating ring molded into bushing.
4. Bushings of standard or insulated type shall have screw type grounding terminal where required by the NEC.
5. Miscellaneous fittings such as reducers, chase nipples, 3-piece unions, split couplings, and plugs shall be specifically designed for their particular application.
6. Install raceway sealing fittings at suitable, approved, and accessible locations and fill them with U.L. Listed sealing compound. For concealed raceways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install raceway sealing fittings at the following points:
  - a. Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.
  - b. Where otherwise required by NFPA 70, such as in 225.27 and 300.5(G).

3.3 INSTALLATION OF WIREWAYS AND SURFACE METAL RACEWAYS:

- A. Mechanically assemble metal enclosures and raceways for conductors to form continuous electrical conductor, and connect to electrical boxes, fittings and cabinets in order to provide effective electrical continuity and rigid mechanical assembly.
- B. Avoid use of dissimilar metals throughout system to eliminate possibility of electrolysis. Where dissimilar metals are in contact, coat all surfaces with corrosion inhibiting compound before assembling.
- C. Install expansion fittings in all wireways and raceways wherever structural expansion joints are crossed.
- D. Make changes in direction of raceway run with proper fittings, supplied by raceway manufacturer. No field bends of raceway sections will be permitted.
- E. Properly support and anchor raceways for their entire length by structural materials. Raceways shall not span any space unsupported.
- F. Use boxes as supplied by raceway manufacturer wherever junction, pull or devices boxes are required. Standard electrical "handy" boxes, etc. shall not be permitted for use with surface raceway installations.

**3.4 INSTALLATION OF CABLE TRAYS:**

- A. Individual sections of cable trays shall be evenly aligned and secured together in a way to keep the hardware from damaging the jacket and conductors of the cable and to keep sections of cable trays from separating away from each other.
- B. Cable trays shall be supported uniformly from wall or structure overhead, capable of supporting the total weight of the cables and cable trays (approximately 40 to 50 pounds per foot) as detailed by the manufacturer of the cable tray.
- C. Cable trays shall be suspended above the drop ceiling and allow for the removal of acoustical ceiling tiles. Provide minimum 4" clearance above cable tray to piping, ductwork and other items to allow cables to be added to or removed from tray. Keep trays at least 6" away from lighting fixtures.
- D. The Contractor shall provide all materials, labor, and equipment and supervision necessary to install the cable trays of route and length as indicated on the contract drawings.
- E. Cable trays shall be run in a horizontal plane where possible. Provide all components and transition sections as required to offset cable trays horizontally and/or vertically to fully coordinate with all ceiling components.
- F. Provide penetration firestopping in smoke barriers and fire-resistance-rated walls, floors and ceilings for cable tray penetrations in accordance with Division 7 and this specification.
- G. Install expansion connectors where cable tray crosses building expansion joints and in cable tray runs that exceed 90 feet (27 m). Space connectors and set gaps according to NEMA VE 1.
- H. Ground cable trays according to manufacturer's written instructions.
- I. Follow all requirements of NEC Article 392.

**3.5 INSTALLATION OF ELECTRICAL BOXES AND FITTINGS:**

- A. All wall-mounted wiring device boxes shall be mounted with long dimension vertically unless otherwise noted.
- B. Coordinate installation of electrical boxes and fittings with conductors/cable, wiring devices, raceway installation work, and equipment requiring electrical connections.
- C. Provide raintight outlets for interior and exterior locations exposed to weather or moisture.
- D. Provide surface mounted boxes only where recessed mounting is not possible.
- E. Provide knockout closures to cap unused knockout holes where blanks have been removed in new and existing boxes and fittings.

- F. Install electrical boxes in those locations which ensure ready accessibility to enclosed electrical wiring.
- G. Do not install boxes back-to-back in walls, unless “putty pads” are provided for sound attenuation. Back-to-back boxes may be used for switch outlets next to a cased wall opening (no door).
- H. Provide not less than 6" separation between sides of boxes in opposite sides of acoustic walls, unless “putty pads” are provided for sound attenuation.
- I. Fasten electrical boxes firmly and rigidly to substrates or structural surfaces to which attached, or solidly embed electrical boxes in concrete or masonry. Box support shall be independent of conduit.

3.6 O&M MANUAL:

- A. Provide O&M Manual as specified in specification section 26 01 00. Include both a paper copy and digital pdf copy of the O&M Manual.

END OF SECTION 260533

SECTION 260553 - IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1: GENERAL

1.1 DESCRIPTION:

- A. Extent of electrical identification work is as herein specified.
- B. Types of electrical identification work specified in this section include the following:
  - 1. Electrical power, control, fire alarm and communication conductors and/or conduits.
  - 2. Operational instructions and warnings.
  - 3. Danger signs.
  - 4. Equipment/system identification signs.

1.2 RELATED DOCUMENTS:

- A. The Drawings and general provisions of the Contract, including the General and Supplementary Conditions, Instructions to Bidders and sections of Division 1, apply to the work specified in this section.

1.3 REFERENCES AND CODES:

- A. Electrical Code Compliances: Comply with applicable requirements of the 2020 NFPA-70 (NEC) pertaining to installation of identifying labels and markers for wiring and equipment.
- B. U.L. Compliance: Comply with applicable requirements of UL Std. 969, "Marking and Labeling Systems", pertaining to electrical identification systems.
- C. NEMA Compliance: Comply with applicable requirements of NEMA Std. Nos. WC-1 and WC-2 pertaining to identification of power and control conductors.

1.4 COORDINATION:

- A. Coordinate identification names, abbreviations, colors, and other features with requirements in the Contract Documents, Shop Drawings, manufacturer's wiring diagrams and the manuals, and with those required by codes, standards, and 29 CFR 1910.145. Use consistent designations throughout Project.
- B. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.
- C. Coordinate installation of identifying devices with location of access panels and doors.

- D. Install identifying devices before the installation of acoustical ceilings and similar concealment.

1.5 SUBMITTALS:

- A. Product Data: Submit manufacturer's data on electrical identification materials and products.

PART 2: PRODUCTS

2.1 ELECTRICAL IDENTIFICATION MATERIALS:

- A. General: Except as otherwise indicated, provide manufacturer's standard products of categories and types required for each application. Where more than single type is specified for an application, selection is Contractor's option, but provide single selection for each application.
- B. Color-Coded Conduit Markers: Provide manufacturer's standard pre-printed, flexible or semi-rigid, permanent, plastic-sheet conduit markers, extending 360 degrees around conduits; designed for attachment to conduit by adhesives, adhesive lap joint or marker-matching adhesive plastic tape at each end of marker, or pre-tensioned snap-on. Except as otherwise indicated, provide lettering which indicates voltage of conductor(s) in conduit. Provide 8" minimum length for 2" and smaller conduit, 12" length for larger conduit. Unless otherwise indicated or required by governing regulations, provide white markers with black letters.
- C. Baked Enamel Danger Signs: Provide manufacturer's standard "DANGER" signs of baked enamel finish on 20 gage steel with standard red, black and white graphics. Provide following minimum sizes: 20" x 14", 14" x 10", or 10" x 7", where signs are sized according to the largest size which can be applied where needed, or where a larger size is needed for adequate vision. Provide signs with recognized standard explanation wording, e.g., HIGH VOLTAGE, KEEP AWAY, BURIED CABLE, DO NOT TOUCH SWITCH.
- D. Cable/Conductor Identification Bands: Provide manufacturer's standard vinyl-cloth self-adhesive cable/conductor markers of wrap-around type, either pre-numbered plastic coated type, or write-on type with clear plastic self-adhesive cover flap, numbered to show circuit identification.
- E. Engraved Plastic-Laminate Signs:
  - 1. General: Provide engraving stock melamine plastic laminate, complying with FS L-P-387, in sizes and thickness indicated, engraved with engraver's standard lettering style of sizes and wording indicated, punched for mechanical fastening except where adhesive mounting is necessary because of substrate, and color codes as indicated below:



- a. Normal Power Systems: Black face with White lettering.
  - b. Life Safety Power Systems: Yellow face with Black lettering.
  - c. Critical Power Systems: Orange face with White lettering.
  - d. Equipment Power Systems: Red face with White lettering.
2. Thickness: 1/16", for units up to 20 sq. in. or 8" length; 1/8" for larger units.
3. Fasteners: Self-tapping stainless steel screws, except contact-type permanent adhesive where screws cannot or should not penetrate substrate.

## **2.2 LETTERING AND GRAPHICS:**

- A. Coordinate names, abbreviations and other designations used in electrical identification work, with corresponding designations shown, specified or scheduled. Provide numbers, lettering and wording as indicated or, if not otherwise indicated, as recommended by manufacturer or as required for proper identification and operations/maintenance of electrical systems and equipment.

## **PART 3: EXECUTION**

### **3.1 GENERAL INSTALLATION REQUIREMENTS:**

- A. Install electrical identification products as specified in accordance with the manufacturer's written instructions and the requirements of the NEC.
- B. Coordination: Where identification is to be applied to surfaces which require finish, install identification after completion of finish work.
- C. Regulations: Comply with governing regulations and requests of governing authorities for identification of electrical work.
- D. Identification: Coordinate all room number designations with the final room numbers. Use final room numbers for all final documentation and display, including but not limited to, programming, alarm displays, annunciator displays, panelboard schedules, signage, labels and engraved labels. The room numbers shall be as directed by the Owner and may not be the same as shown on Contract Drawings. Include final room numbers on the drawings for the Record Documents.

### **3.2 CONDUIT IDENTIFICATION:**

- A. Where conduit is concealed above accessible ceilings or exposed, apply color-coded identification at equipment termination, at outlet boxes, pull boxes and junction boxes, within each room, and at 20' on-center within an area.
  1. Color-code conduit using plastic tape with the following band colors between orange background bands.

SERVICE	COLOR BAND
240 or 208/120 Volt Normal Circuits	Black
240 or 208/120 Volt Life Safety Emergency Circuits	Black/Yellow
240 or 208/120 Volt Critical Emergency Circuits	Black/Orange
240 or 208/120 Volt Equipment Emergency Circuits	Black/Red
480/277 Volt Circuits	Blue
480/277 Volt Life Safety Emergency Circuits	Blue/Yellow
480/277 Volt Critical Emergency Circuits	Blue/Orange
480/277 Volt Equipment Emergency Circuits	Blue/Red
Grounding Electrode	Green

**3.3 CONDUCTOR/CABLE COLOR CODING:**

- A. only impregnated color coded wire, no color tape will be accepted, the contractor will be directed to remove and replace with the correct colored code wire.

**3.4 CONDUCTOR/CABLE CIRCUIT IDENTIFICATION:**

- A. Apply cable/conductor identification, including panelboard and circuit number on power wiring, on each cable/conductor in each box/enclosure/cabinet. Match identification with marking system used in panelboards, shop drawings, contract documents, and similar previously established identification for project's electrical work.

**3.5 EQUIPMENT/SYSTEM IDENTIFICATION:**

- A. Signs: Install engraved plastic-laminate sign on outside of each major unit of electrical equipment in building, including central or master unit of each electrical system, including communication/control/signal systems, unless unit is specified with its own self-explanatory identification or signal system. Provide three (3) lines of text, with 1/2" high lettering for first line and 1/4" high lettering for other lines; first line of text shall indicate name of unit, second line of text shall indicate voltage and phase and number of wires, and third line of text shall indicate origin of feeder. Provide text matching terminology and numbering of the contract documents and shop drawings. Provide signs for each unit of the following categories of electrical work:

1. Panelboards, control panels, relay panels, electrical cabinets, and enclosures.
2. Access panel/doors for concealed electrical items.
3. Major electrical switchgear and switchboards (including individual breakers, i.e. main breakers, sub-breakers, etc.).
4. Enclosed switches (safety switches) and circuit breakers.
5. Motor starters (magnetic and manual starters).
6. Motor control centers (including individual components).
7. Variable frequency drives.
8. Electrical substations (including individual components).

- 9. Automatic transfer switches.
  - 10. Transformers.
  - 11. Push-button stations.
  - 12. Provide permanent SERVICE ENTRANCE label for all service entrance equipment.
- B. Special Service Signs: Install signs or plaques at the location of each main service equipment location, including existing and new locations, as indicated and as required by NEC or local codes.
- C. Provide identification, labeling and signs for emergency and standby systems as required by 700.7, 700.10, 701.7 and 702.7 of NEC.
- D. Series Rated Systems: Where circuit breakers or fuses are applied in compliance with series combination ratings as permitted by NEC, the equipment shall be identified as required in NEC 110.22(B) and 110.22(C).
- E. Install signs at locations indicated and, where not otherwise indicated, at locations for best convenience of viewing without interference with operation and maintenance of equipment.
- F. Provide labeling in accordance with all requirements in NEC 110.21 and 110.22.
- G. Provide fault current labeling on service equipment per NEC 110.24(A).
- H. Provide enclosure type labeling as required in NEC 110.28.
- I. Where transformer disconnecting means are remote from the transformer, the disconnect location shall be permanently marked on the transformer.
- J. Provide label on each fire alarm control panel and power supply clearly indicating the branch circuit feeding it. Provide another label on each fire alarm control panel and power supply that indicates the room location of the panelboard that is powering the fire alarm control panel and power supply.
- 3.6 O&M MANUAL:
- A. Provide O&M Manual as specified in specification section 260100. Include both a paper copy and digital pdf copy of the O&M Manual.

END OF SECTION 260553

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SECTION 260583 - WIRING CONNECTIONS FOR ELECTRICAL SYSTEMS

PART 1: GENERAL

1.1 DESCRIPTION:

- A. This section specifies the basic requirements of electrical connections for equipment specified in Division sections division 26 sections making reference to electrical connections for equipment specified herein.
- B. Extent of electrical connections for equipment is indicated by drawings and schedules. Electrical connections are hereby defined to include connections used for providing electrical power to equipment.

1.2 RELATED DOCUMENTS:

- A. The Drawings and general provisions of the Contract, including the General and Supplementary Conditions, Instructions to Bidders and sections of Division 1, apply to the work specified in this section.

1.3 REFERENCES AND CODES:

- A. Refer to other Division 26 sections for motor starters, controllers and disconnects not furnished as integral part of equipment.
- B. Refer to sections of other Divisions for motor starters, controllers, VFD's and disconnects furnished integrally with equipment and for specific individual equipment power requirements.
- C. Refer to other Division 26 sections for junction boxes, raceways and conductors/cables required for connecting motors and other electrical units of equipment.

PART 2: PRODUCTS

2.1 MANUFACTURERS:

- A. Refer to other Division 26 sections for manufacturers of electrical connection products.

2.2 MATERIALS AND COMPONENTS:

- A. General: For each electrical connection indicated, provide complete assembly of materials, including but not necessarily limited to, junction boxes, raceways, conductors/cables, disconnect switches, starters, controllers, pressure connectors, terminals (lugs), electrical

insulating tape, cable ties, solderless wirenuts, and other items and accessories as needed to complete splices, terminations, and connections.

- B. Connectors and Terminals: Provide electrical connectors and terminals which mate and match, including sizes and ratings, with equipment terminals as recommended by equipment manufacturer for intended applications.

### **PART 3: EXECUTION**

#### **3.1 INSPECTION:**

- A. Inspect area and conditions under which electrical connections for equipment are to be installed and notify Contractor in writing of conditions detrimental to proper completion of the work. Do not proceed with the work until unsatisfactory conditions have been corrected in a manner acceptable to Installer.

#### **3.2 INSTALLATION OF ELECTRICAL CONNECTIONS:**

- A. Connect electrical power supply conductors to equipment conductors or terminals in accordance with equipment manufacturer's written instructions and wiring diagrams. Mate and match conductors of electrical connections for proper interface between electrical power supplies and installed equipment.
- B. Cover splices with electrical insulating material equivalent to or greater than electrical insulation rating of those conductors being spliced.
- C. Prepare cables and conductors by cutting and stripping covering armor, jacket, and insulation properly to ensure uniform and neat appearance where cables and wires are terminated. Exercise care to avoid cutting through tapes which will remain on conductors. Also avoid "ringing" conductors while stripping wire.
- D. Trim cables and wires as short as practicable and arrange routing to facilitate inspection, testing and maintenance.
- E. Tighten connectors and terminals, including screws and bolts, in accordance with the equipment manufacturer's published torque tightening values for equipment connectors.

#### **3.3 CONNECTIONS TO EQUIPMENT:**

- A. Final electrical connections to equipment furnished under other sections of these specifications or specified to be furnished by the Owner shall be provided as required for the individual item of equipment. Provide the conduit, outlet boxes, and power wiring from the power source to the motor or equipment junction box, wiring devices, transformers, relays, starters, VFD's, disconnect switches or circuit breakers, including wiring through starters, VFD's or safety switches, in accordance with the manufacturer's installation

instructions. The presumed location of all presently envisioned equipment having electrical connections is shown or scheduled, but these locations are for estimating purposes only and the contractor shall prepare the bid to allow for any possible rearrangement of the equipment listed or as shown or scheduled. Prior to roughing in conduit, receptacles, or other outlets or equipment, verify the locations and characteristics of equipment and verify heights and locations of required connections from an approved shop drawing or roughing-in drawing. Use roughing-in dimensions of electrically operated units furnished by the supplier.

**3.4 FIELD QUALITY CONTROL:**

- A. Final connections and proper operation of equipment connected under this contract shall be supervised by the equipment supplier. This Contractor shall certify in writing to the Architect that the connected equipment is properly connected and the equipment is operating properly in accordance with these contract specifications, the equipment manufacturer's wiring diagrams, and instructions of the equipment supplier or manufacturer.

END OF SECTION 260583

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SECTION 262813 - FUSES

PART 1: GENERAL

1.1 DESCRIPTION:

- A. This section specifies the furnishing and installation of low voltage circuit protective devices or fuses. Extent of the work is indicated on drawings and as required by the NEC. The contractor shall only provide busman RK-1, LOW PEAK, DUAL ELEMENT, TIME DELAY YELLOW FUSES if fuses are required. NO RK-5.

1.2 REFERENCES AND CODES:

- A. UL Compliance and Labeling: Comply with applicable provisions of UL 198D, "High-Interrupting-Capacity Class K Fuses". Provide overcurrent protective devices which are U.L. Listed and Labeled.
- B. NEC Compliance: Comply with 2020 NFPA-70 (NEC) as applicable to construction and installation of fusible devices.
- C. NFPA Compliance: Comply with applicable requirements of NFPA 70E, "Standard for Electrical Safety Requirements for Employee Workplaces."
- D. ANSI Compliance: Comply with applicable requirements of ANSI C97.1 "Low-Voltage Cartridge Fuses 600 Volts or Less".

1.3 SUBMITTALS:

- A. Product Data: Submit manufacturer's technical product data on fuses used on this project, including specifications and electrical characteristics. In addition, include voltages and current ratings, interrupting ratings, current limitation ratings, and time-current trip characteristics curves.

PART 2: PRODUCTS

2.1 MANUFACTURERS:

- A. Obtain all fuses used on the project from a single manufacturer. Provide fuses by Cooper Bussmann, Mersen or Littelfuse.

**PART 3: EXECUTION**

**3.1 INSTALLATION OF FUSES:**

- A. Provide fuses in all fusible devices. Size of fuses shall be as noted or in accordance with fuse manufacturer's tables for back-up motor running protection. Install fuses so rating information is readable without removing fuses. Install labels indicating fuse replacement information on inside door of each fused switch.

**END OF SECTION 262813**