

SECTION 23 05 11
COMMON WORK RESULTS FOR HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and General Provisions of the Contract, including but not limited to Division 25 – INTEGRATED AUTOMATION, Section 018113 – SUSTAINABLE DESIGN REQUIREMENTS and other Division 1 Specification Sections shall apply to this Section.
- B. Examine all other Sections of the specifications for requirements which affect work under this Section whether or not such work is specifically mentioned in this Section.
- C. Coordinate work with that of all other Trades affecting, or affected by work of this Section. Cooperate with such Trades to ensure the steady progress of all work under the Contract.

1.2 DEFINITIONS

- A. Words in the singular shall also mean and include the plural, wherever the context so indicates and words in the plural shall mean the singular, wherever the context so indicates.
- B. Wherever the terms "shown on drawings" are used in the specifications, they shall mean "noted", "indicated", "scheduled", "detailed", or any other diagrammatic or written reference made on the drawings.
- C. Wherever the term "provide" is used in the specifications it will mean "furnish" and "install", "connect", "apply", "erect", "construct", or similar terms, unless otherwise indicated in the specifications.
- D. Wherever the term "material" is used in the specifications it will mean any product, "equipment", "device", "assembly", or "item" required under the Contract, as indicated by trade or brand name, manufacturer's name, standard specification reference or other description.
- E. The terms "approved", or "approval" shall mean the written approval of the Architect.
- F. The term "specification" shall mean all information contained in the bound or unbound volume, including all "Contract Documents" defined therein, except for the drawings.
- G. The terms "directed", "required", "permitted", "ordered", "designated", "prescribed" and similar words shall mean the direction, requirement, permission, order, designation or prescription of the Architect. The terms "approved", "acceptable", "satisfactory" and similar words shall mean approved by, acceptable or satisfactory to the Architect. The terms "necessary", "reasonable", "proper", "correct" and similar words shall mean necessary, reasonable, proper or correct in the judgment of the Architect.
- H. "Piping" includes in addition to pipe or mains, all fittings, flanges, unions, valves, strainers, drains, hangers and other accessories relative to such piping.
- I. "Concealed" means hidden from sight in chases, furred spaces, shafts, hung ceilings, embedded in construction or in crawl spaces.

- J. "Exposed" means not installed underground or "concealed" as defined above.
- K. "HVAC and/or Mechanical Contractor" shall refer to the Contractor or his Subcontractors responsible for furnishing and installation of all work indicated on the HVAC and Mechanical drawings and Division 23 specifications and as applicable or referenced to each Trade in the Architectural and/or Structural documents.
- L. "Mechanical Contractor" shall refer to the HVAC Contractor, as applicable.
- M. "Architect" shall refer to the Architect "Studio Nova" and/or Engineer "Bard, Rao + Athanas Consulting Engineers, LLC" and/or Owner.
- N. "Owner" shall refer to the designated representatives of the Project Owner, Government Representative.
- O. "General Contractor" shall refer to the Contractor(s) performing work under other sections of the Contract Specifications.
- P. "Commissioning Agent (CA)" shall refer to the party employed by the Owner to witness the demonstration of all systems according to the commissioning plan.
- Q. Option or Optional: Contractor's choice of an alternate material or method.
- R. RE: Resident Engineer
- S. COTR: Contracting Officer's Technical Representative

1.3 RELATED WORK

- A. Section 01 00 00, GENERAL REQUIREMENTS.
- B. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.
- C. Section 01 81 13, SUSTAINABLE DESIGN REQUIREMENTS
- D. Section 01 91 13, COMMISSIONING
- E. Concrete and Grout: Section 03 30 00, CAST-IN-PLACE CONCRETE.
- F. Building Components for Attachment of Hangers: Section 05 31 00, STEEL DECKING, and Section 05 36 00, COMPOSITE METAL DECKING.
- G. Section 05 50 00, METAL FABRICATIONS.
- H. Section 07 84 00, FIRESTOPPING.
- I. Flashing for Wall and Roof Penetrations: Section 07 60 00, FLASHING AND SHEET METAL.
- J. Section 07 92 00, JOINT SEALANTS.
- K. Section 08 90 00, LOUVERS AND VENTS.
- L. Section 09 91 00, PAINTING.

- M. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS
- N. Section 26 29 11, LOW-VOLTAGE MOTOR STARTERS.
- O. Division 21, FIRE PROTECTION.
- P. Division 22, PLUMBING.
- Q. Division 25, INTEGRATED AUTOMATION.
- R. Division 26, ELECTRICAL.
- S. Division 28, ELECTRONIC SAFETY AND SECURITY.

1.4 QUALITY ASSURANCE

- A. Mechanical, electrical and associated systems shall be safe, reliable, efficient, durable, easily and safely operable, maintainable, accessible, and in compliance with applicable codes as specified. The systems shall be comprised of high quality institutional-class and industrial-class products of manufacturers that are experienced specialists in the required product lines. All construction firms and personnel shall be experienced and qualified specialists in industrial and institutional HVAC as applicable.
- B. Flow Rate Tolerance for HVAC Equipment: Section 23 05 93, TESTING, ADJUSTING AND BALANCING FOR HVAC.
- C. Equipment Vibration Tolerance:
 - 1. Refer to Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT. Equipment shall be factory-balanced to this tolerance and re-balanced on site, as required.
 - 2. After HVAC air balance work is completed and permanent drive sheaves are in place, perform field mechanical adjustments required to meet the specified vibration tolerance.
- D. Products Criteria:
 - 1. Standard Products: Material and equipment shall be the standard products of a manufacturer regularly engaged in the manufacture of the products for at least 3 years or as noted in each section. The design, model and size of each item shall have been in satisfactory and efficient operation on at least three installations for approximately three years. However, digital electronics devices, software and systems such as controls, instruments, computer work station, shall be the current generation of technology and basic design that has a proven satisfactory service record of at least three years. See other specification sections for any exceptions.
 - 2. All items furnished shall be free from defects that would adversely affect the performance, maintainability and appearance of individual components and overall assembly.
 - 3. Conform to codes and standards as required by the specifications. Refer any conflicts to the Resident Engineer (RE)/Contracting Officers Technical Representative (COTR).
 - 4. 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.
 - 5. Assembled Units: Manufacturers of equipment assemblies, which use components made by others, assume complete responsibility for the final assembled product.

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6. Nameplates: Nameplate bearing manufacturer's name or identifiable trademark shall be securely affixed in a conspicuous place on equipment, or name or trademark cast integrally with equipment, stamped or otherwise permanently marked on each item of equipment.
 7. Asbestos products or equipment or materials containing asbestos shall not be used.
- E. Equipment Service Organizations:
1. HVAC: Products and systems shall be supported by service organizations that maintain a complete inventory of repair parts and are located reasonably close to the site.
- F. HVAC Mechanical Systems Welding: Before any welding is performed, contractor shall submit a certificate certifying that welders comply with the following requirements:
1. Qualify welding processes and operators for piping according to ASME "Boiler and Pressure Vessel Code", Section IX, "Welding and Brazing Qualifications".
 2. Comply with provisions of ASME B31 series "Code for Pressure Piping".
 3. Certify that each welder has passed American Welding Society (AWS) qualification tests for the welding processes involved, and that certification is current.
- G. Execution (Installation, Construction) Quality:
1. Apply and install all items in accordance with manufacturer's written instructions. Refer conflicts between the manufacturer's instructions and the contract drawings and specifications to the RE/COTR for resolution. Provide written hard copies or computer files of manufacturer's installation instructions to the RE/COTR at least two weeks prior to commencing installation of any item. Installation of the item will not be allowed to proceed until the recommendations are received. Failure to furnish these recommendations is a cause for rejection of the material.
 2. All items that require access, such as for operating, cleaning, servicing, maintenance, and calibration, shall be easily and safely accessible by persons standing at floor level, or standing on permanent platforms, without the use of portable ladders. Examples of these items include, but are not limited to: all types of valves, filters and strainers, transmitters, control devices. Prior to commencing installation work, refer conflicts between this requirement and contract drawings to the RE/COTR for resolution.
 3. Provide complete layout drawings required by Paragraph, SUBMITTALS. Do not commence construction work on any system until the layout drawings have been approved.
- H. Commissioning of a system or systems specified in this section shall be part of the construction process. Documentation and testing of these systems; as well as training of the VAMC operation and maintenance personnel, is required in cooperation with the VA Resident Engineer and the Commissioning Authority. Project Close-out is dependent on successful completion of all commissioning procedures, documentation, and issue closure. Refer to Section 019113, COMMISSIONING, for detailed commissioning requirements.
- 1.5 CODES, STANDARDS AND REFERENCES
- A. All materials and workmanship shall comply with all applicable Codes, Specifications, Local and State Ordinances, Industry Standards and Utility Company Regulations, latest editions.
- B. In case of difference between Building Codes, State Laws, Local Ordinances, Industry Standards and Utility Company Regulations and the Contract Documents, the Mechanical Contractor, as applicable, shall promptly notify the Architect in writing of any such difference.

- C. In case of conflict between the Contract Documents and the requirements of any Code or Authorities having jurisdiction, the most stringent requirements of the aforementioned shall govern for budgetary purposes. However, no work will proceed until the Architect determines the correct method of installation.
- D. Applicable Codes and Standards shall include VA Standards and the applicable requirements of the following accepted Codes and Standards, without limiting the number, as follows:
1. National Electrical Code (NEC)
 2. Environmental Protection Agency (EPA)
 3. International Building Codes (IBC)
 4. National Fire Protection Association (NFPA), latest applicable edition adopted, in general and in particular:
 - a. NFPA 101 – Life Safety Code (2009)
 - b. NFPA 90A, 90B – HVAC (2009)
 - c. NFPA 30 (2008)
 - d. NFPA 37 (2006)
 - e. NFPA 45 (2004)
 - f. NFPA 54 (2009)
 - g. NFPA 96 (2008)
 5. Recommendations of ASHRAE (American Society of Heating, Refrigeration and Air Conditioning Engineers), including:
 - a. ASHRAE 90.1 – Energy Standard for Buildings Except Low-Rise Residential
 - b. ANSI/ASHRAE 62-Ventilation for Acceptable Indoor Air Quality
 - c. ANSI/ASHRAE 55-Thermal Environmental Conditions for Human Occupancy
 - d. ANSI/ASHRAE 15 – Safety Standard for Refrigeration Systems.
- E. Mechanical Contractor for the work under his charge, shall give all necessary notices, obtain and pay for all permits, pay all Owner taxes, fees and other costs in connection with his work; file for necessary approvals with the jurisdiction under which the work is to be performed. Mechanical Contractor shall obtain all required Certificates of Inspection for his work and deliver same to the Architect before request for acceptance of his portion of work and before final payment is made.
- F. All equipment shall be installed per manufacturer's recommendations and requirements. The Contractor shall notify the Engineer in writing when they intend to deviate from manufacturer's installation guidelines. The Engineer shall advise if the installation is acceptable prior to installation.

1.6 SUBMITTALS

- A. Submit in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES, and with requirements in the individual specification sections.
- B. Documents submitted shall show the following:
1. Principal dimensions and details of construction.
 2. Operating and maintenance clearances.
 3. Weights of principal parts and total weights with information required for the design of supports and foundations.
 4. Sizes and location of piping and connections.

5. Performance data, including pump and fan curves; sound data including sound power dB levels in 1/3 octave bands.
 6. Data on electric motors, including brake horsepower of driven equipment, nameplate ratings and classes, sound data, starting and running full load currents, required starter size and recommended overload relay heater ratings.
 7. Approval stamp of Underwriters' and other authorities having jurisdiction of Contract Drawings requiring such approval.
 8. Certified performance guarantees.
- C. Submit brochures that contain only that information which is relative to the particular equipment or materials to be furnished. Do not submit catalogs that describe several different items other than those items to be used unless irrelevant information is marked out and relevant material is clearly marked.
- D. Specifications Compliance Statement
1. The manufacturer shall submit a point by point statement of compliance with the specifications.
 2. The statement of compliance shall consist of a complete copy of the project specifications with a line by line compliance statement.
 3. Where the proposed system complies fully, such shall be indicated by placing the word "comply" opposite the line or paragraph number.
 4. Where the proposed system does not comply, or accomplishes the stated function in a manner different from that described, a full description of the deviation shall be provided.
 5. Where a full description of a deviation is not provided, it shall be assumed that the proposed system does not comply with the paragraph in question.
 6. Submissions which do not include a point by point statement of compliance as specified shall be disqualified.
- E. Contractor shall make all necessary field measurements and investigations to assure that the equipment and assemblies will meet contract requirements.
- F. If equipment is submitted which differs in arrangement from that shown, provide drawings that show the rearrangement of all associated systems. Approval will be given only if all features of the equipment and associated systems, including accessibility, are equivalent to that required by the contract.
- G. Prior to submitting shop drawings for approval, contractor shall certify in writing that manufacturers of all major items of equipment have each reviewed drawings and specifications, and have jointly coordinated and properly integrated their equipment and controls to provide a complete and efficient installation.
- H. Upon request by Owner, provide lists of previous installations for selected items of equipment. Include contact persons who will serve as references, with telephone numbers and e-mail addresses.
- I. Submittals and shop drawings for interdependent items, containing applicable descriptive information, shall be furnished together and complete in a group. Coordinate and properly integrate materials and equipment in each group to provide a completely compatible and efficient installation. Final review and approvals will be made only by groups.

- J. Samples: Samples will not be required, except for insulation or where materials offered differ from specification requirements. Samples shall be accompanied by full description of characteristics different from specification. The Owner, at the Owner's expense, will perform evaluation and testing if necessary. The Contractor may submit samples of additional material at the Contractor's option; however, if additional samples of materials are submitted later, pursuant to Owner request, adjustment in contract price and time will be made as provided under Article CHANGES of Section 01 00 00, GENERAL REQUIREMENTS.
- K. Layout Drawings:
1. Submit complete consolidated and coordinated layout drawings for units in REVIT 3D Autodesk. Refer to Section 01 00 00, GENERAL REQUIREMENTS, Article, SUBCONTRACTS AND WORK COORDINATION.
 2. Refer to Section 23 05 11.10 – 3D Building Information Modeling (BIM) for the development and use of a 3-dimensional computer program simulation to represent a virtual model of the facility and the process for constructing the facility. From this coordinated composite model, views and data appropriate to users' needs, construction drawings shall be extracted and submitted for approval.
 3. The drawings shall include plan views, elevations and sections of all systems and shall be on a scale of not less than 1:32 (3/8-inch equal to one foot). Clearly identify and dimension the proposed locations of the principal items of equipment. The drawings shall clearly show locations and adequate clearance for all equipment, piping, valves, control panels and other items. Show the access means for all items requiring access for operations and maintenance. Provide detailed layout drawings of all piping and duct systems.
 4. Do not install equipment foundations, equipment or piping until layout drawings have been approved.
 5. In addition, for HVAC systems, provide details of the following:
 - a. Mechanical equipment rooms.
 - b. Interstitial space.
 - c. Hangers, inserts, supports, and bracing.
 - d. Pipe sleeves.
 - e. Duct or equipment penetrations of floors, walls, ceilings, or roofs.
- L. Manufacturer's Literature and Data: Submit under the pertinent section rather than under this section.
1. Submit belt drive with the driven equipment where applies. Submit selection data for specific drives when requested by the Resident Engineer.
 2. Submit electric motor data and variable speed drive data with the driven equipment.
 3. Equipment and materials identification.
 4. Fire-stopping materials.
 5. Hangers, inserts, supports and bracing.
 6. Wall, floor, and ceiling plates.
- M. HVAC Maintenance Data and Operating Instructions:
1. Maintenance and operating manuals in accordance with Section 01 00 00, GENERAL REQUIREMENTS, Article, INSTRUCTIONS, for systems and equipment.
 2. Provide a listing of recommended replacement parts for keeping in stock supply, including sources of supply, for equipment. Include in the listing belts for equipment: Belt manufacturer, model number, size and style.

- N. Provide copies of approved HVAC equipment submittals to the Testing, Adjusting and Balancing Subcontractor.
- O. Provide copies of all required factory test results to the Owner, Construction Manager, and Commissioning Authority.

1.7 APPLICABLE PUBLICATIONS

- A. Publications of the associations listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.
 - 1. Air Conditioning and Refrigeration Institute (ARI)
 - 2. American National Standards Institute (ANSI)
 - 3. Rubber Manufacturers Association (ANSI/RMA)
 - 4. Air Movement and Control Association (AMCA)
 - 5. American Society of Mechanical Engineers (ASME)
 - 6. American Society of Heating, Refrigeration and Air-Conditioning Engineers (ASHRAE)
 - 7. National Electrical Manufacturers Association (NEMA)
 - 8. National Fire Protection Association (NFPA)
 - 9. Manufacturer's Standardization Society (MSS)
 - 10. Underwriter's Laboratories (UL)

1.8 DELIVERY, STORAGE AND HANDLING

- A. Protection of Equipment:
 - 1. Equipment and material placed on the job site shall remain in the custody of the Contractor until phased acceptance, whether or not the Owner has reimbursed the Contractor for the equipment and material. The Contractor is solely responsible for the protection of such equipment and material against any damage.
 - 2. Place damaged equipment in first class, new operating condition; or, replace same as determined and directed by the RE/COTR. Such repair or replacement shall be at no additional cost to the Owner.
 - 3. Protect interiors of new equipment and piping systems against entry of foreign matter. Clean both inside and outside before painting or placing equipment in operation.
- B. Cleanliness of Piping and Equipment Systems:
 - 1. Exercise care in storage and handling of equipment and piping material to be incorporated in the work. Remove debris arising from cutting, threading and welding of piping.
 - 2. Piping systems shall be flushed, blown or pigged as necessary to deliver clean systems.
 - 3. Clean interior of all tanks prior to delivery.
 - 4. Contractor shall be fully responsible for all costs, damage, and delay arising from failure to provide clean systems.

1.10 GUARANTEE

- A. Attention is directed to provisions of the General Conditions and Supplementary General Conditions regarding guarantees and warranties for work under this Contract.

- B. Manufacturers shall provide their standard guarantees for work under this Contract, unless specified otherwise. However, such guarantees shall be in addition to and not in lieu of all other liabilities which the manufacturer and GC may have by Law or by other provisions of the Contract Documents. In any case, such guarantees and warranties shall commence when the Owner accepts the various systems, as applicable and as determined by the Architect. The guarantees and warranties will remain in effect for a minimum period of (1) year thereafter except where longer periods are specifically stated and specified.
- C. All materials, items of equipment and workmanship furnished under HVAC, shall carry the warranty against all defects in material and workmanship. Any fault due to defective or improper material, equipment, workmanship or design which may develop shall be made good, forthwith, by and at the expense of the Contractor responsible, including all other damage done to areas, materials and other systems resulting from this failure.
 - 1. Contractor shall guarantee that all elements of the systems provided under his Contract, are of sufficient capacity to meet the specified performance requirements as set forth herein or as indicated on the drawings.
 - 2. Upon receipt of notice from the Owner of failure of any part of the systems or equipment during the guarantee period, the affected part or parts shall be replaced by the responsible Contractor.
- D. Contractor shall furnish, before the final payment is made, a written guarantee covering the above requirements.

1.11 FUNCTIONAL PERFORMANCE AND INTEGRATED SYSTEMS TESTING

- A. Functional Performance and Integrated Systems Testing (FP & IST) is part of the commissioning process. FP & IST shall be performed by the Contractor, and witnessed and documented by the Commissioning Authority. Refer to Section 019113, COMMISSIONING, for FP & IST requirements.

PART 2 - PRODUCTS

2.1 FACTORY-ASSEMBLED PRODUCTS

- A. Provide maximum standardization of components to reduce spare part requirements.
- B. Manufacturers of equipment assemblies that include components made by others shall assume complete responsibility for final assembled unit.
 - 1. All components of an assembled unit need not be products of same manufacturer.
 - 2. Constituent parts that are alike shall be products of a single manufacturer.
 - 3. Components shall be compatible with each other and with the total assembly for intended service.
 - 4. Contractor shall guarantee performance of assemblies of components, and shall repair or replace elements of the assemblies as required to deliver specified performance of the complete assembly.
- C. Components of equipment shall bear manufacturer's name and trademark, model number, serial number and performance data on a name plate securely affixed in a conspicuous place, or cast integral with, stamped or otherwise permanently marked upon the components of the equipment.

- D. Major items of equipment, which serve the same function, must be the same make and model. Exceptions will be permitted if performance requirements cannot be met.

2.2 COMPATIBILITY OF RELATED EQUIPMENT

- A. Equipment and materials installed shall be compatible in all respects with other items being furnished and with existing items so that the result will be a complete and fully operational plant that conforms to contract requirements.

2.3 BELT DRIVES

- A. Type: ANSI/RMA standard V-belts with proper motor pulley and driven sheave. Belts shall be constructed of reinforced cord and rubber.
- B. Dimensions, rating and selection standards: ANSI/RMA IP-20 and IP-21.
- C. Minimum Horsepower Rating: Motor horsepower plus recommended ANSI/RMA service factor (not less than 20 percent) in addition to the ANSI/RMA allowances for pitch diameter, center distance, and arc of contact.
- D. Maximum Speed: 25 m/s (5000 feet per minute).
- E. Adjustment Provisions: For alignment and ANSI/RMA standard allowances for installation and take-up.
- F. Drives may utilize a single V-Belt (any cross section) when it is the manufacturer's standard.
- G. Multiple Belts: Matched to ANSI/RMA specified limits by measurement on a belt measuring fixture. Seal matched sets together to prevent mixing or partial loss of sets. Replacement, when necessary, shall be an entire set of new matched belts.
- H. Sheaves and Pulleys:
1. Material: Pressed steel, or close grained cast iron.
 2. Bore: Fixed or bushing type for securing to shaft with keys.
 3. Balanced: Statically and dynamically.
 4. Groove spacing for driving and driven pulleys shall be the same.
 5. Minimum Diameter of V-Belt Sheaves (ANSI/RMA recommendations) in millimeters and inches:

Fractional Horsepower		Standard			
Cross Section	Min. od mm (in)	Cross Section	Min. od mm (in)		
2L	20 (0.8)	A	83 (3.25)		
3L	38 (1.5)	B	146 (5.75)		
4L	64 (2.5)	C	239 (9.40)		
5L	89 (3.5)	D	345 (13.60)		
		E	554 (21.80)		

- I. Drive Types, Based on ARI 435:

1. Provide adjustable-pitch or fixed-pitch drive as follows:
 - a. Fan speeds up to 1800 RPM: 7.5 kW (10 horsepower) and smaller.

- b. Fan speeds over 1800 RPM: 2.2 kW (3 horsepower) and smaller.
- 2. Provide fixed-pitch drives for drives larger than those listed above.
- 3. The final fan speeds required to just meet the system CFM and pressure requirements, without throttling by fan law calculation if a fixed-pitch drive is used initially.

2.4 DRIVE GUARDS

- A. For machinery and equipment, provide guards as shown in AMCA 410 for belts, couplings, pulleys, sheaves, shafts, gears and other moving parts regardless of height above the floor to prevent damage to equipment and injury to personnel.
- B. Pump shafts and couplings shall be fully guarded by a sheet steel guard, covering coupling and shaft but not bearings. Material shall be minimum 16-gage sheet steel; ends shall be braked and drilled and attached to pump base with minimum of four 6 mm (1/4-inch) bolts. Reinforce guard as necessary to prevent side play forcing guard onto couplings.
- C. V-belt and sheave assemblies shall be totally enclosed, firmly mounted, non-resonant. Guard shall be an assembly of minimum 22-gage sheet steel and expanded or perforated metal to permit observation of belts. 25 mm (one-inch) diameter hole shall be provided at each shaft centerline to permit speed measurement.
- D. 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.
- E. Access for Speed Measurement: 25 mm (One inch) diameter hole at each shaft center.

2.5 LIFTING ATTACHMENTS

- A. Provide equipment with suitable lifting attachments to enable equipment to be lifted in its normal position. Lifting attachments shall withstand any handling conditions that might be encountered, without bending or distortion of shape, such as rapid lowering and braking of load.

2.6 ELECTRIC MOTORS

- A. All material and equipment furnished and installation methods shall conform to the requirements of Section 23 05 12, GENERAL MOTOR REQUIREMENTS FOR HVAC EQUIPMENT; Section 26 29 11, LOW-VOLTAGE MOTOR STARTERS; and, Section 26 05 21, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES (600 VOLTS AND BELOW). Provide all electrical wiring, conduit, and devices necessary for the proper connection, protection and operation of the systems. Provide special energy efficient motors as scheduled. Unless otherwise specified for a particular application use electric motors with the following requirements.
- B. Single-phase Motors: Capacitor-start type for hard starting applications. Motors for centrifugal fans and pumps may be split phase or permanent split capacitor (PSC).
- C. Three phase Motors: NEMA Design B, Squirrel cage, induction type.

- D. Rating: Continuous duty at 100 percent capacity in an ambient temperature of 40 degrees centigrade (104 degrees F); minimum horsepower as shown on drawings; maximum horsepower in normal operation not to exceed nameplate rating without service factor.
- E. Special Requirements:
1. Where motor power requirements of equipment furnished deviate from power shown on plans, provide electrical service designed under the requirements of NFPA 70 without additional time or cost to the Owner.
 2. Assemblies of motors, starters, controls and interlocks on factory-assembled and wired devices shall be in accordance with the requirements of this specification.
 3. Select motor sizes so that the motors do not operate into the service factor at maximum required loads on the driven equipment. Motors on pumps shall be sized for non-overloading at all points on the pump performance curves.
 4. Motors utilized with variable frequency drives shall be rated "inverter-ready" per NEMA Standard, MG1, Part 31.4.4.2. Provide motor shaft grounding apparatus that will protect bearings from damage from stray currents.
- F. Motor Efficiency and Power Factor: All motors, when specified as "high efficiency" by the project specifications on driven equipment, shall conform to efficiency and power factor requirements in Section 23 05 12, GENERAL MOTOR REQUIREMENTS FOR HVAC AND STEAM GENERATION EQUIPMENT, with no consideration of annual service hours. Motor manufacturers generally define these efficiency requirements as "NEMA premium efficient" and the requirements generally exceed those of the Energy Policy Act of 1992 (EPACT). Motors not specified as "high efficiency" shall comply with EPACT.
- G. Insulation Resistance: Not less than one-half meg-ohm between stator conductors and frame, to be determined at the time of final inspection.

2.7 VARIABLE SPEED MOTOR CONTROLLERS

- A. Refer to Section 23 05 14, VARIABLE FREQUENCY DRIVES, Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS and Section 26 29 11, LOW-VOLTAGE MOTOR STARTERS for specifications.
- B. The combination of controller and motor shall be provided by the manufacturer of the driven equipment, such as pumps and fans, and shall be rated for 100 percent output performance. Multiple units of the same class of equipment, i.e. air handlers, fans, pumps, shall be product of a single manufacturer.
- C. Motors shall be energy efficient type and be approved by the motor controller manufacturer. The controller-motor combination shall be guaranteed to provide full motor nameplate horsepower in variable frequency operation. Both driving and driven motor/fan sheaves shall be fixed pitch. Controller shall not add any current or voltage transients to the input AC power distribution system, DDC controls, sensitive medical equipment, etc., nor shall be affected from other devices on the AC power system.

2.8 EQUIPMENT AND MATERIALS IDENTIFICATION

- A. Use symbols, nomenclature and equipment numbers specified, shown on the drawings and shown in the maintenance manuals. Identification for piping is specified in Section 09 91 00, PAINTING.

- B. Use symbols, nomenclature and equipment numbers specified, shown on the drawings and shown in the maintenance manuals. In addition, provide bar code identification nameplate for all equipment which will allow the equipment identification code to be scanned into the system for maintenance and inventory tracking. Identification for piping is specified in Section 09 91 00, PAINTING.
- C. Interior (Indoor) Equipment: Engraved nameplates, with letters not less than 48 mm (3/16-inch) high of brass with black-filled letters, or rigid black plastic with white letters specified in Section 09 91 00, PAINTING permanently fastened to the equipment. Identify unit components such as coils, filters, fans, etc.
- D. Exterior (Outdoor) Equipment: Brass nameplates, with engraved black filled letters, not less than 48 mm (3/16-inch) high riveted or bolted to the equipment.
- E. Control Items: Label all temperature and humidity sensors, controllers and control dampers. Identify and label each item as they appear on the control diagrams.
- F. Valve Tags and Lists:
 - 1. HVAC: Provide for all valves other than for fan coil equipment in Division 23.
 - 2. Valve tags: Engraved black filled numbers and letters not less than 13 mm (1/2-inch) high for number designation, and not less than 6.4 mm (1/4-inch) for service designation on 19 gage 38 mm (1-1/2 inches) round brass disc, attached with brass "S" hook or brass chain.
 - 3. Valve lists: Typed or printed plastic coated card(s), sized 216 mm(8-1/2 inches) by 280 mm (11 inches) showing tag number, valve function and area of control, for each service or system. Punch sheets for a 3-ring notebook.
 - 4. Provide detailed plan for each floor of the building indicating the location and valve number for each valve. Identify location of each valve with a color coded thumb tack in ceiling.

2.9 FIRESTOPPING

- A. Section 07 84 00, FIRESTOPPING specifies an effective barrier against the spread of fire, smoke and gases where penetrations occur for piping and ductwork. Refer to Section 23 07 11, HVAC INSULATION, for firestop pipe and duct insulation.

2.10 GALVANIZED REPAIR COMPOUND

- A. Mil. Spec. DOD-P-21035B, paint form.

2.11 HVAC PIPE AND EQUIPMENT SUPPORTS AND RESTRAINTS

- A. Vibration Isolators: Refer to Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT.
- B. Supports for Exposed Piping and Ductwork Items:
 - 1. Pipe pedestals: Provide a galvanized Unistrut channel welded to U-shaped mounting brackets which are secured to side of rail with galvanized lag bolts.

2. Provide additional support and bracing to all exposed, equipment piping and ductwork installed on the roof or outside of the building to withstand wind velocity of 130 MPH.
 3. Guy wire support systems for stacks above roof shall be as detailed on the drawings and as follows:
 - a. Guy Wire Roof Support Anchor: Tubular anchor body as specified in Section 11 24 24, FALL PROTECTION ANCHORS.
 - b. Guy Wire and Accessories: Stainless steel.
 4. The Contractor shall engage the services of a Professional Engineer registered within the state wherein the project is located to prepare complete design drawings and structural design computations based on, and closely following, the design and details on the drawings. The design drawings and structural design computations, with the Engineer's seal affixed thereto, shall be submitted to the Architect for review. The structural design computations shall provide a complete structural analysis, including anchors and fastening devices, and shall certify as to conformation to governing laws and codes. These submittals, upon review, must be sufficient, when taken in conjunction with this Specification to provide the complete basis of the fabrication and erection. Refer to Section 01 81 13, SUSTAINABLE DESIGN REQUIREMENTS for wind loads and additional submittal requirements.
- C. Pipe Supports: Comply with MSS SP-58. Type Numbers specified refer to this standard. For selection and application comply with MSS SP-69. Refer to Section 05 50 00, METAL FABRICATIONS, for miscellaneous metal support materials and prime coat painting requirements.
- D. Attachment to Concrete Building Construction:
1. Concrete insert: MSS SP-58, Type 18.
 2. Self-drilling expansion shields and machine bolt expansion anchors: Permitted in concrete not less than 102 mm (four inches) thick when approved by the Resident Engineer for each job condition.
 3. Power-driven fasteners: Permitted in existing concrete or masonry not less than 102 mm (four inches) thick when approved by the Resident Engineer for each job condition.
- E. Attachment to Steel Building Construction:
1. Welded attachment: MSS SP-58, Type 22.
 2. Beam clamps: MSS SP-58, Types 20, 21, 28 or 29. Type 23 C-clamp may be used for individual copper tubing up to 23mm (7/8-inch) outside diameter.
- F. Attachment to Steel Roof Decking or concrete slabs on Composite Metal Deck:
1. Steel Roof Decking (Section 05 31 00): Do not hang any type or kind of building component from steel roof deck, including electrical light fixtures, plumbing, heating or air conditioning pipes or ducts, or electrical conduits.
 2. Composite Metal Deck (Section 05 36 00): After the concrete is placed and cure on the composite metal deck, hangers with a maximum load of 500 pounds can be attached to the underside of the slab using appropriate anchors. Minimum spacing between such hangers shall be 4'-0" each way.
- G. Hanger Rods: Hot-rolled steel, ASTM A36 or A575 for allowable load listed in MSS SP-58. For piping, provide adjustment means for controlling level or slope. Types 13 or 15 turn-buckles shall provide 38 mm (1-1/2 inches) minimum of adjustment and incorporate locknuts. All-thread rods are acceptable.

- H. Hangers Supporting Multiple Pipes (Trapeze Hangers): Galvanized, cold formed, lipped steel channel horizontal member, not less than 41 mm by 41 mm (1-5/8 inches by 1-5/8 inches), 2.7 mm (No. 12 gage), designed to accept special spring held, hardened steel nuts. Not permitted for steam supply and condensate piping.
1. Allowable hanger load: Manufacturers rating less 91kg (200 pounds).
 2. Guide individual pipes on the horizontal member of every other trapeze hanger with 6 mm (1/4-inch) U-bolt fabricated from steel rod. Provide Type 40 insulation shield, secured by two 13mm (1/2-inch) galvanized steel bands, or pre-insulated calcium silicate shield for insulated piping at each hanger.
- I. Supports for Piping Systems:
1. Select hangers sized to encircle insulation on insulated piping. Refer to Section 23 07 11, HVAC, AND BOILER PLANT INSULATION for insulation thickness. To protect insulation, provide Type 39 saddles for roller type supports or pre-insulated calcium silicate shields. Provide Type 40 insulation shield or pre-insulated calcium silicate shield at all other types of supports and hangers including those for pre-insulated piping.
 2. Piping Systems except High and Medium Pressure Steam (MSS SP-58):
 - a. Standard clevis hanger: Type 1; provide locknut.
 - b. Riser clamps: Type 8.
 - c. Wall brackets: Types 31, 32 or 33.
 - d. Roller supports: Type 41, 43, 44 and 46.
 - e. Saddle support: Type 36, 37 or 38.
 - f. Turnbuckle: Types 13 or 15. Pre-insulate.
 - g. U-bolt clamp: Type 24.
 - h. Copper Tube:
 - 1) Hangers, clamps and other support material in contact with tubing shall be painted with copper colored epoxy paint, plastic coated or taped with non adhesive isolation tape to prevent electrolysis.
 - 2) For vertical runs use epoxy painted or plastic coated riser clamps.
 - 3) For supporting tube to strut: Provide epoxy painted pipe straps for copper tube or plastic inserted vibration isolation clamps.
 - 4) Insulated Lines: Provide pre-insulated calcium silicate shields sized for copper tube.
 - i. Supports for plastic or glass piping: As recommended by the pipe manufacturer with black rubber tape extending one inch beyond steel support or clamp.
3. High and Medium Pressure Steam (MSS SP-58):
 - a. Provide eye rod or Type 17 eye nut near the upper attachment.
 - b. Piping 50 mm (2 inches) and larger: Type 43 roller hanger.
 - c. Piping with Vertical Expansion and Contraction:
 - 1) Movement up to 20 mm (3/4-inch): Type 51 or 52 variable spring unit with integral turn buckle and load indicator.
 - 2) Movement more than 20 mm (3/4-inch): Type 54 or 55 constant support unit with integral adjusting nut, turn buckle and travel position indicator.
4. Convertor and Expansion Tank Hangers: May be Type 1 sized for the shell diameter. Insulation where required will cover the hangers.

J. Pre-insulated Calcium Silicate Shields:

1. Provide 360 degree water resistant high density 965 kPa (140 psi) compressive strength calcium silicate shields encased in galvanized metal.
2. Pre-insulated calcium silicate shields to be installed at the point of support during erection.
3. Shield thickness shall match the pipe insulation.
4. The type of shield is selected by the temperature of the pipe, the load it must carry, and the type of support it will be used with.
 - a. Shields for supporting chilled or cold water shall have insulation that extends a minimum of 1 inch past the sheet metal. Provide for an adequate vapor barrier in chilled lines.
 - b. The pre-insulated calcium silicate shield shall support the maximum allowable water filled span as indicated in MSS-SP 69. To support the load, the shields may have one or more of the following features: structural inserts 4138 kPa (600 psi) compressive strength, an extra bottom metal shield, or formed structural steel (ASTM A36) wear plates welded to the bottom sheet metal jacket.
 - c. Shields may be used on steel clevis hanger type supports, roller supports or flat surfaces.

2.12 PIPE PENETRATIONS

- A. Install sleeves at pipe penetration of walls, partitions, floors and roofs as specified in Section 01 73 29, CUTTING/PATCHING AND SLEEVES.
- B. To prevent accidental liquid spills from passing to a lower level, provide the following:
 1. For sleeves: Extend sleeve 25 mm (one inch) above finished floor and provide sealant for watertight joint.
 2. For blocked out floor openings: Provide 40 mm (1-1/2 inch) angle set in silicone adhesive around opening.
 3. For drilled penetrations: Provide 40 mm (1-1/2 inch) angle ring or square set in silicone adhesive around penetration.
- C. Penetrations are not allowed through beams or ribs, but may be installed in concrete beam flanges. Any deviation from these requirements must receive prior approval of Resident Engineer.
- D. Sheet Metal, Plastic, or Moisture-resistant Fiber Sleeves: Provide for pipe passing through floors, interior walls, and partitions, unless brass or steel pipe sleeves are specifically called for below.
- E. Cast Iron or Zinc Coated Pipe Sleeves: Provide for pipe passing through exterior walls below grade. Make space between sleeve and pipe watertight with a modular or link rubber seal. Seal shall be applied at both ends of sleeve.
- F. Galvanized Steel or an alternate Black Iron Pipe with asphalt coating Sleeves: Provide for pipe passing through concrete beam flanges, except where brass pipe sleeves are called for. Provide sleeve for pipe passing through floor of mechanical rooms. Except in mechanical rooms, connect sleeve with floor plate.
- G. Brass Pipe Sleeves: Provide for pipe passing through quarry tile, terrazzo or ceramic tile floors. Connect sleeve with floor plate.

- H. Sleeves are not required for wall hydrants for fire department connections or in drywall construction.
- I. Sleeve Clearance: Sleeve through floors, walls, partitions, and beam flanges shall be one inch greater in diameter than external diameter of pipe. Sleeve for pipe with insulation shall be large enough to accommodate the insulation. Interior openings shall be caulked tight with fire stopping material and sealant to prevent the spread of fire, smoke, and gases.
- J. Provide firestopping for openings through fire and smoke barriers, maintaining minimum required rating of floor, ceiling or wall assembly. See section 07 84 00, FIRESTOPPING
- K. Sealant and Adhesives: Shall be as specified in Section 07 92 00, JOINT SEALANTS.

2.13 DUCT PENETRATIONS

- A. Provide curbs for roof penetration ductwork.
 - 1. Curbs shall be galvanized steel 9 inches high with continuously welded seams, treated wood nailer 1-1/2 thick, 3 pound/cubic feet density rigid mineral fiberboard insulation with metal liner, built-in cant strip, interior baffle with acoustic insulation, curb bottom, hinged curb adapter.
 - 2. Roof curbs shall be designed and installed for minimum 130 mph design wind conditions.
 - 3. The Contractor shall engage the services of a Professional Engineer registered within the state wherein the project is located to prepare complete design drawings and structural design computations based on, and closely following, the design and details on the drawings. The design drawings and structural design computations, with the Engineer's seal affixed thereto, shall be submitted to the Architect for review. The structural design computations shall provide a complete structural analysis, including anchors and fastening devices, and shall certify as to conformation to governing laws and codes. These submittals, upon review, must be sufficient, when taken in conjunction with this Specification to provide the complete basis of the fabrication and erection. Refer to Section 01 81 13, SUSTAINABLE DESIGN REQUIREMENTS for wind loads and additional submittal requirements.
- B. Provide sleeves for duct penetrations of concrete and masonry walls, fire and smoke rated walls, walls of sound sensitive spaces, and as specified in Section 01 73 29, CUTTING/PATCHING AND SLEEVES.
 - 1. Sleeves for penetrations through concrete or masonry construction shall be minimum 20 gauge galvanized steel.
 - 2. Sleeves for penetrations through fire or smoke rated partitions shall be minimum 16 gauge steel.
 - 3. Sleeves for penetrations of non-rated, un-framed, drywall construction shall be minimum 20 gauge galvanized steel.
 - 4. Sleeves shall be of sufficient size to allow 1/2 inch air space around duct, including insulation for externally insulated ductwork.
 - 5. Sleeves shall be set into concrete or masonry construction with grout.
- C. Provide firestopping for openings through fire and smoke barriers, maintaining minimum required rating of floor, ceiling or wall assembly. See section 07 84 00, FIRESTOPPING

- D. Provide mineral fiber packing and non-hardening acoustic sealant on both sides of duct penetration of sound sensitive walls in locations as indicated on the drawings. See Section 07 92 00, JOINT SEALANTS.

2.14 SPECIAL TOOLS AND LUBRICANTS

- A. Furnish, and turn over to the RE/COTR, special tools not readily available commercially, that are required for disassembly or adjustment of equipment and machinery furnished.
- B. Grease Guns with Attachments for Applicable Fittings: One for each type of grease required for each motor or other equipment.
- C. Tool Containers: Hardwood or metal, permanently identified for intended service and mounted, or located, where directed by the Resident Engineer.
- D. Lubricants: A minimum of 0.95 L (one quart) of oil, and 0.45 kg (one pound) of grease, of equipment manufacturer's recommended grade and type, in unopened containers and properly identified as to use for each different application.

2.15 WALL, FLOOR AND CEILING PLATES

- A. Material and Type: Chrome plated brass or chrome plated steel, one piece or split type with concealed hinge, with set screw 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 2.4 mm (3/32-inch) for floor plates. For wall and ceiling plates, not less than 0.64 mm (0.025-inch) for up to 80 mm (3-inch pipe), 0.89 mm (0.035-inch) for larger pipe.
- C. Locations: Use where pipe penetrates floors, walls and ceilings in exposed locations, in finished areas only. Use also where insulation ends on exposed water supply pipe drop from overhead. Provide a watertight joint in spaces where brass or steel pipe sleeves are specified.

2.16 ASBESTOS

- A. Materials containing asbestos are not permitted.

2.17 HOUSEKEEPING PADS

- A. Coordinate housekeeping pads for:
 - 1. All equipment indoors or outdoors
 - 2. All floor supports or braces
- B. Pads shall be 6" above the finished floor.
- C. Each pad shall be a minimum of 6" larger than the equipment, support or isolation base in all directions.
- D. Pads shall be formed, poured with concrete, and tooled by the General Contractor.

2.18 MISCELLANEOUS IRON AND STEEL

- A. Each trade shall provide all primary and secondary steel supports and hangers as shown on the drawings and/or as required to support equipment, ductwork, piping, exhaust fans, or any other materials provided under the work of this Section.
- B. The work of this Section of designing, furnishing and installing all miscellaneous metal work associated with the system, and related items as indicated on the drawings and/or as specified herein, and includes, but is not limited to the items listed herein below.
- C. The scope of work shall include:
 - 1. Exhaust fan support.
 - 2. Outdoor piping supports.
 - 3. Support of ductwork and piping in shafts in addition to support provided by structure.
 - 4. Support of ductwork via floor stands as required.
 - 5. Heat exchanger support racks.
 - 6. Pipe anchors in the building.
 - 7. Hangers, brackets, angel irons or rods required for the support and protection of HVAC equipment.
 - 8. Field prime painting of galvanized steel and field finish painting.
- D. Shop Drawings for General Miscellaneous Items
 - 1. Submit Shop Drawings of all miscellaneous metal items to Architect for approval, showing sizes and thickness of all members, types of materials, methods of connection and assembly, complete dimensions, clearances, anchorage, relationship to surrounding work by other Trades, shop paint, and other pertinent details of fabrication and installation.
- E. The Subcontractor shall engage the services of a Professional Engineer registered within the state wherein the project is located to prepare complete design drawings and structural design computations based on, and closely following, the design and details on the drawings. The design drawings and structural design computations, with the Engineer's seal affixed thereto, shall be submitted to the Architect for review. The structural design computations shall provide a complete structural analysis, including anchors and fastening devices, and shall certify as to conformation to governing laws and codes. These submittals, upon review, must be sufficient, when taken in conjunction with this Specification to provide the complete basis of the fabrication and erection. Refer to Section 01 81 13, SUSTAINABLE DESIGN REQUIREMENTS for wind loads and additional submittal requirements.
- F. Do not order materials or begin fabrication until Architect's approval of submittals has been obtained.
- G. In addition to the governing laws and codes, the following Specifications and Codes form a part of this Specification:
 - 1. American Iron and Steel Institute applicable standards.
 - 2. American Institute of Steel Construction "Specifications for the Design, Fabrication and Erection of Structural Steel for Buildings".
 - 3. American Welding Society Code: Standard Code for Arc and Gas Welding in Building Construction.

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- H. All materials shall be new stock, free from defects impairing strength, durability or appearance and of best commercial quality for each intended purpose.
1. Unless other wise specifically called for, work of this Section shall be fabricated of structural steel conforming to ASTM Specification A36.
 2. Steel pipe shall be seamless steel pipe conforming to ASTM Specification A53, Schedule 40.
 3. Steel tubing shall be seamless steel tubing conforming to ASTM Specifications A500 to A501.
 4. Non-ferrous metals shall be as specified under descriptions of specific items, herein below.
- I. Provide all anchors, bolts, sockets, sleeves, and other parts required for securing each item of work of this Section to the construction, including furnishing to concrete workers all required insets and sleeves for use at concrete.
1. All exposed fastenings shall be of the same material and finish as the metal to which applied, unless otherwise noted.
 2. Welding rods shall conform to AWS Standards and the recommendation of the welding rod manufacturer.
- J. Metal surfaces shall be clean and free from mill scale, flake, rust and rust pitting. Metal work shall be well formed and finished to required shape and size, true to details, with straight, sharp lines and angles and smooth surfaces. Curved work shall be true radii. Exposed sheared edges shall be eased.
- K. Weld all permanent connections. Welds shall be continuous on all exposed surfaces and where required for strength on concealed surfaces. Exposed welds shall be ground flush and smooth, with voids filled with metallic filling compound (metallic filling compound not permitted on surfaces to receive hot-dip galvanizing). Tack-welding will not be permitted unless specifically called for. Do not use screws or bolts where they can be avoided. Where used, heads shall be countersunk, screwed up tight, and threads nicked to prevent loosening.
- L. Fastenings shall be concealed where practicable. Thickness of metal and details of assembly and supports shall give ample strength and stiffness. Joints exposed to weather shall be formed to exclude water.
- M. Do all cutting, punching, drilling and tapping required for attachment of anchor bolts and other hardware and for attachment of work by other Trades. All such cutting, punching, drilling, etc., shall be done prior to hot-dip galvanizing of the various components.
- N. Live loads shall be not less than the minimum required by law. Where specific live load are not set forth in the laws and codes applicable to this work, and are not given on the Drawings or in this Specification, designs shall be such as to support the live loads which may normally be imposed without failure, without deflection of more than 1/360 of length of any member, and without permanent deformation, all with a factor of safety of not less than 2 1/2 to 1.
- O. Shop Painting see Section 09 91 00 - PAINTING
- P. Installation
1. All materials shall be carefully handled and stored under cover in manner to prevent deformation and damage to the materials and to shop finishes, and to prevent rusting and the accumulation of foreign matter on the metal work. All such work shall be repaired and cleaned prior to erection.

2. Work shall be erected square, plumb and true, accurately fitted, and with the tight joints and intersections. All anchors, inserts and other members to be set in concrete or masonry shall be furnished loose by this Trade to be built-into concrete and masonry and by those Trades as the work progresses. Later cutting or drilling shall be avoided wherever possible.
3. All metal work shall be rigidly braced and secured to surrounding construction, and shall be tight and free of rattle, vibration, or noticeable deflection after installed.
4. Where members, other than expansion bolts or inserts, are fastened into concrete, set such members in holes formed as specified below, and secure permanently in place by installation of proprietary-type expanding grout manufactured specifically for such purpose, used strictly in accordance with manufacturer's directions. Holes to receive members shall be formed with galvanized sheetmetal sleeves, expanded polystyrene foam, or other approved method to provide at least 1/2 inch clearance around entire perimeter. At exposed applications, hold expanding grout back 1/2 inch from finish surface and fill voids with Portland cement grout to match color and texture of surrounding concrete surface.
5. Electrolytic Isolation
 - a. Where dissimilar metals are to come into contact with one another, isolate by application of a heavy coating of bituminous paint on contact surfaces in addition to shop coat specified above. Do not permit the bituminous paint in any way to remain on surfaces to be exposed or to receive sealant.

Q. Miscellaneous Items

1. Carefully review all Drawings for miscellaneous metal items required but not specifically listed above, such as miscellaneous steel clip angles, miscellaneous steel bracketing, and other miscellaneous metal items as indicated on the Drawings, reasonably implied there from, or reasonably necessary for the thorough completion of the work.
2. Provide rigid and secure anchorage of all components whether or not specifically described in complete detail on the Drawings.

- R. Piping supports shall be coordinated with the building structure and shall span between roof beams as required.

PART 3 - EXECUTION

3.1 ARRANGEMENT AND INSTALLATION OF EQUIPMENT AND PIPING

- A. Coordinate location of piping, sleeves, inserts, hangers, ductwork and equipment. Locate piping, sleeves, inserts, hangers, ductwork and equipment clear of windows, doors, openings, light outlets, and other services and utilities. Prepare equipment layout drawings to coordinate proper location and personnel access of all facilities. Submit the drawings for review as required by Part 1. Follow manufacturer's published recommendations for installation methods not otherwise specified.
- B. Operating Personnel Access and Observation Provisions: Select and arrange all equipment and systems to provide clear view and easy access, without use of portable ladders, for maintenance and operation of all devices including, but not limited to: all equipment items, valves, filters, strainers, transmitters, sensors, control devices. All gages and indicators shall be clearly visible by personnel standing on the floor or on permanent platforms. Do not reduce or change maintenance and operating space and access provisions that are shown on the drawings.

- C. Equipment and Piping Support: Coordinate structural systems necessary for pipe and equipment support with pipe and equipment locations to permit proper installation.
- D. Location of pipe sleeves and chases shall be accurately coordinated with equipment and piping locations.
- E. Cutting Holes:
 - 1. Cut holes through concrete and masonry by rotary core drill. Pneumatic hammer, impact electric, and hand or manual hammer type drill will not be allowed, except as permitted by RE/COTR where working area space is limited.
 - 2. Locate holes to avoid interference with structural members such as beams or grade beams. Holes shall be laid out in advance and drilling done only after approval by RE/COTR. If the Contractor considers it necessary to drill through structural members, this matter shall be referred to RE/COTR for approval.
 - 3. Do not penetrate membrane waterproofing.
- F. Interconnection of Instrumentation or Control Devices: Generally, electrical interconnections are not shown but must be provided.
- G. Minor Piping: Generally, small diameter pipe runs from drips and drains, water cooling, and other service are not shown but must be provided.
- H. Electrical Interconnection of Controls and Instruments: This generally not shown but must be provided. This includes interconnections of sensors, transmitters, transducers, control devices, control and instrumentation panels, instruments and computer workstations. Comply with NFPA-70.
- I. 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 and as approved by the Resident Engineer. Damaged or defective items in the opinion of the Resident Engineer shall be replaced.
 - 2. 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. At completion of all work thoroughly clean fixtures, exposed materials and equipment.
- J. Concrete and Grout: Use concrete and shrink compensating grout 5000 psi minimum, specified in Section 03 30 00, CAST-IN-PLACE CONCRETE.
- K. Install gages, thermometers, valves and other devices with due regard for ease in reading or operating and maintaining devices. Locate and position thermometers and gages to be easily read by operator or staff standing on floor or walkway provided. Servicing shall not require dismantling adjacent equipment or pipe work.
- L. Install steam piping expansion joints as per manufacturer's recommendations.
- M. Switchgear Drip Protection: Every effort shall be made to eliminate the installation of pipe above electrical and telephone switchgear. If this is not possible, encase pipe in a second pipe with a minimum of joints.

N. Animal Research Area Sealing of Penetrations

1. Seal all pipe, duct and conduit penetrations with silicone sealant to prevent entrance of insects and vermin. Refer to Section 07 92 00, JOINT SEALANTS.

O. Inaccessible Equipment:

1. Where the Owner determines that the Contractor has installed equipment not conveniently accessible for operation and maintenance, equipment shall be removed and reinstalled or remedial action performed as directed at no additional cost to the Owner.
2. The term "conveniently accessible" is defined as capable of being reached without the use of ladders, or without climbing or crawling under or over obstacles such as motors, fans, pumps, belt guards, transformers, high voltage lines, piping, and ductwork.

3.2 RIGGING

- A. Design is based on application of available equipment. Openings in building structures are planned to accommodate design scheme.
- B. Alternative methods of equipment delivery may be offered by Contractor and will be considered by Owner under specified restrictions of phasing and maintenance of service as well as structural integrity of the building.
- C. Close all openings in the building when not required for rigging operations to maintain proper environment in the facility for Owner operation and maintenance of service.
- D. Contractor shall provide all facilities required to deliver specified equipment and place on foundations. Attachments to structures for rigging purposes and support of equipment on structures shall be Contractor's full responsibility. Upon request, the Owner will check structure adequacy and advise Contractor of recommended restrictions.
- E. Contractor shall check all clearances, weight limitations and shall offer a rigging plan designed by a Registered Professional Engineer. All modifications to structures, including reinforcement thereof, shall be at Contractor's cost, time and responsibility.
- F. Rigging plan and methods shall be referred to RE/COTR for evaluation prior to actual work.
- G. Restore building to original condition upon completion of rigging work.

3.3 PIPE AND EQUIPMENT SUPPORTS

- A. Where hanger spacing does not correspond with beam spacing, use structural steel channels secured directly to beam 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 RE/COTR.
- B. Use of chain, wire or strap hangers; wood for blocking, stays and bracing; or, hangers suspended from piping above will not be permitted. Replace or thoroughly clean rusty products and paint with zinc primer.
- C. Use hanger rods that are straight and vertical. Turnbuckles for vertical adjustments may be omitted where limited space prevents use. Provide a minimum of 15 mm (1/2-inch) clearance between pipe or piping covering and adjacent work.

- D. HVAC Horizontal Pipe Support Spacing: Refer to MSS SP-69. Provide additional supports at valves, strainers, in-line pumps and other heavy components. Provide a support within one foot of each elbow.
- E. HVAC Vertical Pipe Supports:
 - 1. Up to 150 mm (6-inch pipe), 9 m (30 feet) long, bolt riser clamps to the pipe below couplings, or welded to the pipe and rests supports securely on the building structure.
 - 2. Vertical pipe larger than the foregoing, support on base elbows or tees, or substantial pipe legs extending to the building structure.
- F. Overhead Supports:
 - 1. The basic structural system of the building is designed to sustain the loads imposed by equipment and piping to be supported overhead.
 - 2. Provide steel structural members, in addition to those shown, of adequate capability to support the imposed loads, located in accordance with the final approved layout of equipment and piping.
 - 3. Tubing and capillary systems shall be supported in channel troughs.
- G. Floor Supports:
 - 1. Provide concrete bases, concrete anchor blocks and pedestals, and structural steel systems for support of equipment and piping. Anchor and dowel concrete bases and structural systems to resist forces under operating conditions without excessive displacement or structural failure.
 - 2. Do not locate or install bases and supports until equipment mounted thereon has been approved. Size bases to match equipment mounted thereon plus 50 mm (2 inch) excess on all edges. Refer to structural drawings. Bases shall be neatly finished and smoothed, shall have chamfered edges at the top, and shall be suitable for painting.
 - 3. All equipment shall be shimmed, leveled, firmly anchored, and grouted with epoxy grout. Anchor bolts shall be placed in sleeves, anchored to the bases. Fill the annular space between sleeves and bolts with a granular material to permit alignment and realignment.

3.4 CLEANING AND PAINTING

- A. Prior to final inspection and acceptance of the plant and facilities for beneficial use by the Owner, the plant facilities, equipment and systems shall be thoroughly cleaned and painted. Refer to Section 09 91 00, PAINTING.
- B. In addition, the following special conditions apply:
 - 1. Cleaning shall be thorough. Use solvents, cleaning materials and methods recommended by the manufacturers for the specific tasks. Remove all rust prior to painting and from surfaces to remain unpainted. Repair scratches, scuffs, and abrasions prior to applying prime and finish coats.
 - 2. Material And Equipment Not To Be Painted Includes:
 - a. Motors, controllers, control switches, and safety switches.
 - b. Control and interlock devices.
 - c. Regulators.
 - d. Pressure reducing valves.
 - e. Control valves and thermostatic elements.
 - f. Lubrication devices and grease fittings.

- g. Copper, brass, aluminum, stainless steel and bronze surfaces.
 - h. Valve stems and rotating shafts.
 - i. Pressure gauges and thermometers.
 - j. Glass.
 - k. Name plates.
- 3. Control and instrument panels shall be cleaned, damaged surfaces repaired, and shall be touched-up with matching paint obtained from panel manufacturer.
 - 4. Pumps, motors, steel and cast iron bases, and coupling guards shall be cleaned, and shall be touched-up with the same color as utilized by the pump manufacturer
 - 5. Temporary Facilities: Apply paint to surfaces that do not have existing finish coats.
 - 6. Paint shall withstand the following temperatures without peeling or discoloration:
 - a. Condensate -- 38 degrees C (100 degrees F) on insulation jacket surface and 120 degrees C (250 degrees F) on metal pipe surface.
 - b. Steam -- 52 degrees C (125 degrees F) on insulation jacket surface and 190 degrees C (375 degrees F) on metal pipe surface.
 - 7. Final result shall be smooth, even-colored, even-textured factory finish on all items. Completely repaint the entire piece of equipment if necessary to achieve this.

3.5 IDENTIFICATION SIGNS

- A. Provide laminated plastic signs, with engraved lettering not less than 5 mm (3/16-inch) high, designating functions, for all equipment, switches, motor controllers, relays, meters, control devices, including automatic control valves. Nomenclature and identification symbols shall correspond to that used in maintenance manual, and in diagrams specified elsewhere. Attach by chain, adhesive, or screws.
- B. Factory Built Equipment: Metal plate, securely attached, with name and address of manufacturer, serial number, model number, size, performance.
- C. Pipe Identification: Refer to Section 09 91 00, PAINTING.

3.6 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.

3.7 LUBRICATION

- A. Lubricate all devices requiring lubrication prior to initial operation. Field-check all devices for proper lubrication.
- B. Equip all devices with required lubrication fittings or devices. Provide a minimum of one liter (one quart) of oil and 0.5 kg (one pound) of grease of manufacturer's recommended grade and type for each different application; also provide 12 grease sticks for lubricated plug valves.

Deliver all materials to RE/COTR in unopened containers that are properly identified as to application.

- C. Provide a separate grease gun with attachments for applicable fittings for each type of grease applied.
- D. All lubrication points shall be accessible without disassembling equipment, except to remove access plates.

3.8 STARTUP AND TEMPORARY OPERATION

- A. Start up equipment as described in equipment specifications. Verify that vibration is within specified tolerance prior to extended operation. Temporary use of equipment is specified in Section 01 00 00, GENERAL REQUIREMENTS, Article, TEMPORARY USE OF MECHANICAL AND ELECTRICAL EQUIPMENT.

3.9 OPERATING AND PERFORMANCE TESTS

- A. Prior to the final inspection, perform required tests as specified in Section 01 00 00, GENERAL REQUIREMENTS, Article, TESTS, and submit the test reports and records to the RE/COTR.
- 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 for 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 work.

3.10 INSTRUCTIONS TO VA PERSONNEL

- A. Provide in accordance with Article, INSTRUCTIONS, of Section 01 00 00, GENERAL REQUIREMENTS.

3.11 WATERPROOFING, FLASHING AND COUNTERFLASHING

- A. Refer to Section 07 60 00 – FLASHING AND SHEET METAL.
- B. Unless specifically indicated otherwise on the drawings, each Contractor shall provide all counter flashing and waterproofing of all piping, ductwork and equipment provided by him, which pierce roofs, walls and other weather barrier surfaces. All work under this paragraph shall be coordinated with the General Contractor.
- C. All work shall be performed in a workmanlike manner to ensure weatherproof installation. Any leaks developed due to each Contractor's work shall be repaired at his expense, to the Architect's satisfaction.
- D. Pipes passing through slabs shall have the sleeve extended above floors as hereinbefore specified to retain any water and the space between the pipe and sleeve caulked waterproof fire stopping. The top and the bottom shall be sealed with monolastic caulking compound.

- E. All flashing required for ductwork and piping penetrations shall be provided by the General Contractor.

3.12 CONNECTIONS TO EQUIPMENT

- A. Contractor shall provide all duct and/or pipe connections, condensate traps, drains, overflows, relief valves and vents, power connections, etc., to make equipment operable, as provided under other Sections of the specifications, as shown on the Architectural and/or each Trade's drawings and herein specified, including final connections to equipment to result in a complete system, fully operational. Coordinate location of all equipment with Architect. Obtain installation diagrams and methods of installation of all equipment from manufacturers. Follow instructions strictly. If additional information is required, obtain same from Architect. If equipment is indicated on the Architectural drawings, it shall also be construed and understood by the Mechanical Contractor to be constructed as shown on the HVAC drawings and shall be fully serviced and connected at no extra cost to the Owner.

3.13 SMOKE DETECTION AND FIRE SAFETY SYSTEMS

- A. All duct or unit mounted smoke detectors shall be furnished and wired to the building fire alarm system by the Division 28 Contractor. All smoke detectors required in units and ducts and for smoke barrier dampers shall be installed in the field by the Division 23 Contractor.
- B. All smoke dampers shall be furnished and installed by the Division 23 Contractor with electric actuators field wired by the Division 28 Contractor.
- C. The Division 28 Contractor, when providing smoke detectors, shall include additional contacts, as required and coordinated with the Division 25 Contractor, to allow for other control functions, as specified hereinafter. Close coordination must be exercised to allow for the provision of contacts.
- D. All smoke detectors shall be installed as recommended by the smoke detection system manufacturer in sheet metal ducts or plenums to ensure that the sensing elements are effective and shall coordinate installation of smoke detectors with the Division 28 Contractor and detector manufacturer.
- E. The Division 23 Contractor shall provide access doors to make all such detection heads accessible, and shall provide bracing for smoke detection sampling tubes, as recommended by the detector manufacturer, to properly and securely support such tubes.
- F. If duct smoke detectors are required to be installed in ducts that are exposed to outside ambient conditions, they shall be installed in ventilated accessible weatherproof enclosures. See details on HVAC Drawings.

3.14 ELECTRICAL ROOM REQUIREMENTS

- A. The Division 23 Contractor shall not install any piping, ductwork or equipment in or through electrical rooms, transformer rooms, electrical closets, telephone rooms or elevator machine rooms, unless piping, ductwork or equipment is intended to serve these rooms. If any Contractor violates this requirement, he shall remove and/or relocate all items as required at his expense and to the satisfaction of the Architect.

3.15 CONTROL WIRING

- A. The Division 25 Contractor shall provide all control and interlock wiring for all systems provided under the HVAC and Division 25 Contracts.
- B. All control wiring shall be installed in conduit and in accordance with the respective equipment manufacturer's requirements, and all connections shall be provided by the Mechanical and/or the Division 25 Contractor. All conduit and wiring provided by these Contractors shall be installed in accordance with the requirements of Division 26 of the specifications.

--- END ---

SECTION 23 05 11.10

3D BUILDING INFORMATION MODELING

1.1 OVERVIEW

- A. Building Information Modeling (BIM) is the development and use of a 3-dimensional computer model to represent a virtual model of the facility and the process for constructing the facility. Once the model is developed, it can be used to simulate the construction process and to manage the operations of the facility. The Building Information Model can be created by combining many different 3D models from the designers and contractors into a composite model. From this composite model, views and data appropriate to various users' needs can be extracted and analyzed to generate information, to make decisions and to improve the process of delivering the building.

1.2 OUTCOME

- A. The purpose of BIM is to create a model that may be used for coordination of all trades throughout the construction process, with the final product being an as-built model of the Project which contains all of the major elements of construction that could be used by the Owner for future operation and maintenance of the building.

1.3 REQUIRED DISCLAIMER

- A. All users shall be required to sign a disclaimer as follows:

TERMS OF USE OF 3D COMPUTER MODEL FOR THE SLVHCS REPLACEMENT MEDICAL CENTER PROJECT ("Project")

This 3D Computer Model for the Project is provided by NBBJ (Architect) to user (individually, a "User", or collectively, "Users") at the User's request subject to the terms and conditions stated below (the "Terms of Use"):

The 3D Model is made available to User solely for his convenience and for informational purposes only. The User is not to rely upon the 3D Computer Model and the data and/or information contained therein in preparing any of the coordination documents for the Project. The User acknowledges that the 3D Computer Model is not a part of the Construction or Contract Documents for the Project and that the Architect makes no representations or warranties, express or implied, regarding the 3D Computer Model's, accuracy or completeness or the data and/or information contained therein.

By opening the files provided, the User agrees that these terms apply to the 3D Model in its entirety, together with all of its component parts and data. The User acknowledges that the requirements of these Terms of Use apply to all of User's principals, employees and agents.

The User agrees that the use of the 3D Computer Model is solely at the User's risk and that the User assumes full responsibility and liability in connection with the User's use of the 3D Computer Model and the information and/or data contained therein. The User agrees that the Architect has no responsibility for any deficiencies, inaccuracies, errors and/or omissions contained in the 3D Computer Model or the data and/or information contained therein. The Architect has no responsibility for any deficiencies or defects in the User's documents, work and/or services resulting from the User's use of the 3D Computer Model in lieu of the Construction and/or Contract Documents for the Project.

The User acknowledges and agrees a) that the use of the 3D Computer Model is not a substitute for professional judgment; b) that the use of the 3D Computer Model does not relieve the User from applying the appropriate standard of care and skill relevant to the use of the 3D Computer Model and its contents; c) that the 3D Computer Model is only to be used as a tool to assist the User in connection with the Project; d) that the User is solely responsible for verifying the accuracy of all results created with the use of the 3D Computer Model; and (e) the Architect is not responsible or liable for the means and methods of construction and the User's use of the 3D Computer Model shall in no way give rise to such responsible or liable by the Architect or its consultants.

THE ARCHITECT AND ITS CONSULTANTS SPECIFICALLY DISCLAIM ALL WARRANTIES WHETHER EXPRESSED, IMPLIED OR STATUTORY, INCLUDING, WITHOUT LIMITATION, ALL WARRANTIES OF MERCHANTABILITY, TITLE, FITNESS FOR A PARTICULAR PURPOSE, CONSTRUCTABILITY, NON-INFRINGEMENT, COMPATIBILITY, SECURITY OR ACCURACY AND USERS' USE OF THE 3D COMPUTER MODEL IS AT ITS OWN RISK. USER ASSUMES FULL RESPONSIBILITY AND RISK OF LOSS RESULTING FROM USE OR INABILITY TO USE THE 3D COMPUTER MODEL OR ITS CONTENT.

The User further agrees that the 3D Computer Model contains information that is confidential and proprietary to the Architect, and that the Architect retains the copyright and all other reserved rights in the work product reflected in the 3D Computer Model that was prepared by the Architect or its consultants for the Project. The Architect grants the User a non-exclusive, non-transferable royalty-free license to use the 3D Computer Model for informational purposes only in connection with the Project in strict accordance with these Terms of Use. The User agrees that the 3D Computer Model will be used solely and exclusively for the Project and that it will not use the 3D Computer Model and the data and/or information contained therein, in whole or in part, for any purpose or project other than the Project. The User further agrees that the 3D Computer Model will continue to be kept confidential by the User, and that it shall not be disclosed in any manner, transferred or exchanged to any third parties by the User without the express written consent of the Architect.

Upon completion of the User's involvement with the Project or at any time upon written request of the Architect, the User shall promptly deliver to the Architect the 3D Computer Model and any other material containing or reflecting any information or data in the 3D Computer Model (whether prepared by the Architect, the User or otherwise) and will not retain copies, extracts or other reproductions, tangible or intangible, in whole or in part of the 3D Computer Model. The User's non-disclosure and non-use obligations set forth herein shall survive the return, destruction or deletion of the 3D Computer Model. If the User becomes legally compelled, by subpoena or court order, to disclose the 3D Model, or any information contained therein, the User shall provide the Architect with prompt notice so that a protective order or other appropriate remedy may be sought by and at the expense of the Architect and/or compliance with the provisions of this Terms of Use may be waived.

User hereby agrees that the Architect shall be entitled to equitable relief, including injunction, in the event of any breach of the Terms of Use, including without limitation its obligations to maintain the confidentiality of the 3D Model, that the granting of such relief will not be opposed and that such relief shall not be the exclusive remedy for such breach. The Architect's failure to insist upon strict adherence to any term of these Terms of Use shall not be considered a waiver thereof or deprive the Architect of the right subsequently to insist upon strict adherence to that term or any other term of this Terms of Use.

The User hereby agrees, to the fullest extent permitted by law, that in no event shall the Architect be liable to User for any damages or losses of any kind including, but not limited to, damages for death or bodily injury to persons, injury to property, and direct, indirect, consequential, special, or incidental damages, resulting from any error, omission, inaccuracy, deficiency or defect in or problem with, the 3D Computer Model or the data and/or information contained therein. Without limiting the foregoing, the User acknowledges that the 3D Computer Model and the data and/or information contained therein may be inaccurate and/or incomplete and that the Architect will have no obligation to update or modify the 3D Computer Model or any of the data and/or information contained in it because the 3D Computer Model was prepared solely for informational purposes and is not part of the Construction or Contract Documents for the Project.

The User agrees that in the event the User, its officers, directors, shareholders, partners, agents, employees, consultants or independent contractors use the 3D Computer Model or the information and/or data contained therein, it shall, to the fullest extent permitted by law, defend, indemnify and hold the Architect and its officers, directors, shareholders, partners, principals, consultants, agents and employees harmless from and against any and all actions, damages, demands, claims, suits, losses, liability, judgments, recoveries, costs and expenses, including, but not limited to, reasonable attorney's fees which any of them may incur in connection with, arising from, resulting from or related to any use of the 3D Computer Model or the data and/or the information contained therein by the User or any third party who receives the 3D Computer Model from the User. Such claims include, without limitation, any claim which may arise due to deletions, omissions or variations of data due to mechanical or technical failure in connection with the transmission of the 3D Computer Model.

The User acknowledges and agrees that it is not in privity of contract with the Architect as of result of these Terms of Use with respect to any claims or causes of action related to or arising out of the Project. The User further agrees to obligate any contractor, consultant or other party who uses the 3D Computer Model to be bound by the terms and conditions contained herein. Any User's use of the 3D Computer Model and the information and/or data contained therein constitutes such User's acceptance of all the terms here specified.

ACCEPTED & AGREED:

Name: _____

Title: _____

Date: _____

1.4 SCOPE OF WORK

A. General Scope Requirements

1. In general, the BIM scope of work for the Project is to create a technically accurate and detailed 3D computer model of the architectural, structural, mechanical, plumbing and electrical systems.
2. The computer model (in plan view) shall extend to five feet beyond the exterior walls of the building. Vertically, the model shall extend from the lowest extent of the foundations up through and including the roof of the top-most floor. To the extent that the scope includes building systems, those systems will be included to the full horizontal and vertical extents of the model including underground utilities and roof mounted items.

3. The level of detail defined in the Specific Scope Requirements is the minimum level of detail required in the model. Greater detail than the minimum should be incorporated into the model where important details are necessary for communicating information about a system.
4. Each Trade Contractor shall provide shop drawings in both 2D and 3D model format.
5. The 3D model shall be located and oriented to the pre-determined world coordinates for the project to allow easy integration into the BIM for the project.
6. The 3D model shall include the project control grid. This grid should be visible when viewing the model in a true view along the X, Y or Z axis.
7. The 3D model shall be layered and constructed in a manner such that all elements of the model can be converted into a 2D dimensioned drawing for use in the field.
8. The 2d shop drawing scale should be 1'-0" = 3/8" unless specified otherwise or as required for full comprehensible and reviewable details.
9. Each drawing should include a key map referencing the location in the building.
10. In addition to the native file format, the Trade Contractor shall provide translation of the 3D model into a .DWG, CIS/2 or other agreed upon file format that can be viewed using NavisWorks Manager.
11. The following changes shall be promptly incorporated into the drawings and model, on a regular basis:
 - a. RFIs, Bulletins and Owner changes
 - b. Changes in the sequence of work
 - c. Field modifications
 - d. Shop drawing review comments
 - e. Changes requested by the Construction Manager
12. All revised 3d model or 2D drawing submittals shall have a written narrative to define changes from previous submittals. Typical drafting techniques such as 'clouds' or 'bubbles' are acceptable means of tracking changes on the 2D drawings. [Layer control shall be used to define changes in the 3D model. All revisions shall be shown in both 2D and 3D formats].
13. The working 3D model will be shared with the Trade Contractors and design team at least once every two weeks. This will be performed by posting the model to the project FTP site or PrologWeb. The Trade Contractor will post the native file format and an agreed upon file format as defined in Item 10 above.
14. Pre-detailing meeting:
 - a. Shall determine the lead trade.
 - b. The order that coordination work will be added to the model.
15. The 3D modeling and layering conventions will be established at a pre-detailing meeting to be attended by:
 - a. Concrete Contractor and detailer
 - b. Steel Fabricator and detailer
 - c. Mechanical Contractors and detailers
 - d. Electrical Contractors and detailers
 - e. Plumbing Contractors and detailers
 - f. Fire protection Contractors and detailers
 - g. Other trades.
16. Each Trade Contractor will submit its 3D modeling software and proposed file format(s) for approval prior to proceeding with detailing. The Trade Contractor will also provide a 3D mock-up of a specific portion of the project, to be agreed upon at a future time, in full detail in order to verify the compatibility of the file formats.

17. Each Trade Contractor shall provide viewer licenses only for its specific 3D software to the following:
 - a. Owner
 - b. Construction Manager
 - c. Architect
 - d. Engineer of Record
18. Each Trade Contractor and detailers shall have the capability to host and attend web meeting using Microsoft Live Meeting software.
19. Each Trade Contractor shall complete the drawings and model in a time frame capable of meeting the Project Schedule.
20. The Trade Contractors are advised that the model shall be shared among all trades and shall be the basis of coordination and fabrication. Costs incurred for post-coordination changes caused by unauthorized deviations from the model shall be borne by the Trade Contractor that initially deviated from the model. This determination is at the sole discretion of the Construction Manager.
21. The base architectural BIM will be created using AutoDesk's Revit Building.
22. The 3D modeling effort is intended to augment and assist in the MEP coordination process. Before first submission shop drawings, the elements shall be first pass coordinated in the 3D model. The model is intended to find conflicts before shop drawings are reviewed and approved.
23. In addition to the requirements set forth in the contract documents, final models shall be submitted reflecting true "as-built" conditions.

B. Plumbing Technical Scope Requirements – to be coordinated

1. All plumbing piping will be modeled. All plumbing equipment will be modeled to its overall height, width and depth. Pipes will be modeled to the outside diameter of the pipe or the pipe insulation, whichever is greater. Pipe slope will be incorporated in the model.
2. Pipe fittings and connections will not be modeled. All valves, clean outs and accessories will be modeled.
3. Each Trade Contractor to provide a list of minimum typical clearances for all model components and coordinate necessary clearances within the model. The 3D model is to include clearances for equipment – included as a modeled volume such that clash detection and coordination can be accommodated relating to necessary clearances.
4. Each Trade Contractor shall be prepared to attend scheduled coordination meetings to resolve conflicts within the model.
5. The 3D models submitted by the Trade Contractor for overall coordination are required to be checked and coordinated with the structure and the Trade Contractor's own work prior to submittal.
6. The 3D model is to include access areas for equipment – included as a modeled element such that clash detection and coordination can be accommodated relating to access.
7. Coordinated model data is to be distributed as scheduled and 1 day prior to coordination meetings.
8. Penetrations through building systems shall be identified in the 3D model by means of a modeled sleeve.
9. All items modeled shall have a level of intelligence associated with them, including, at a minimum, material type, size, insulation, etc.
10. All items located within mechanical rooms shall have a level of intelligence associated with them that includes, at a minimum, material type, size, insulation, manufacturer, product numbers, serial numbers, maintenance schedules, operation and maintenance data, etc.

C. Electrical Technical Scope Requirements – to be coordinated

1. All electrical equipment including switchgear, transformers and panelboards will be modeled to its overall size. All necessary clearances for electrical equipment will be modeled as a separate volume. All conduit 1-1/2" and larger shall be modeled.
2. All light fixtures will be modeled as an overall volume require for that fixture.
3. Each Trade Contractor shall provide a list of minimum typical clearances for all model components and coordinate necessary clearances within the model. The 3D model is to include clearances for equipment – included as a modeled volume such that clash detection and coordination can be accommodated relating to necessary clearances.
4. Each Trade Contractor shall be prepared to attend scheduled coordination meetings to resolve conflicts within the model.
5. The 3D models submitted by the Trade Contractor for overall coordination are required to be checked and coordinated with the structure and the Trade Contractor's own work prior to submittal.
6. The 3D model is to include access areas for equipment – included as a modeled element such that clash detection and coordination can be accommodated relating to access.
7. Coordinated model data is to be distributed as scheduled and 1 day prior to coordination meetings.
8. Penetrations through building systems shall be identified in the 3D model by means of a modeled sleeve.
9. All panelboards modeled shall have a level of intelligence associated with them that accurately identifies at a minimum the panel schedule.
10. All items located within electrical rooms and closets shall have a level of intelligence associated with them that includes, at a minimum, material type, size, manufacturer, product numbers, serial numbers, maintenance schedules, operation and maintenance data, etc.

D. Fire Protection Technical Scope Requirements – to be coordinated

1. All fire protection equipment including pipe, valves, heads, risers and drains will be modeled.
2. Each Trade Contractor to provide a list of minimum typical clearances for all model components and coordinate necessary clearances within the model. The 3D model is to include clearances for equipment – included as a modeled volume such that clash detection and coordination can be accommodated relating to necessary clearances.
3. This Trade Contractor shall be prepared to attend scheduled coordination meetings to resolve conflicts within the model.
4. The 3D models submitted by the Trade Contractor for overall coordination are required to be checked and coordinated with the structure and the Trade Contractor's own work prior to submittal.
5. Coordinated model data is to be distributed as scheduled and 1 day prior to coordination meetings.
6. Penetrations through building systems shall be identified in the 3D model by means of a modeled sleeve.
7. All items modeled shall have a level of intelligence associated with them that accurately identifies at a minimum the material type, rating, model number, etc.

E. Mechanical / Sheetmetal Technical Scope Requirements

1. All ducts and air handling equipment will be modeled. Ducts will be modeled to the outside face dimension. Equipment will be modeled to its overall height, width and depth. All piping associated with the mechanical system will be modeled. Pipes will be modeled to the outside diameter of the pipe or pipe insulation (whichever is greater).

2. Pipe hangers and hanger assemblies will be modeled for clash detection and coordination. Fittings and connections will not be modeled. The intent of this model is to show the ductwork and piping, etc. in a true representation of the actual condition at construction completion.
3. Pipe fittings and connections will not be modeled. All valves, clean outs and accessories will be modeled.
4. Each Trade Contractor to provide a list of minimum typical clearances for all model components and coordinate necessary clearances within the model. The 3D model is to include clearances for equipment – included as a modeled volume such that clash detection and coordination can be accommodated relating to necessary clearances.
5. Each Trade Contractor shall be prepared to attend scheduled coordination meetings to resolve conflicts within the model.
6. The 3D models submitted by the Trade Contractor for overall coordination are required to be checked and coordinated with the structure and the Trade Contractor's own work prior to submittal.
7. The 3D model is to include access areas for equipment – included as a modeled element such that clash detection and coordination can be accommodated relating to access.
8. Coordinated model data is to be distributed as scheduled and 1 day prior to coordination meetings.
9. Penetrations through building systems shall be identified in the 3D model by means of a modeled sleeve.
10. All items modeled shall have a level of intelligence associated with them including, at a minimum, the material type, size, insulation, etc.
11. Each Trade Contractor shall include in their base bid BIM/Coordination facilities on site. The Construction Manager shall provide a Coordination Trailer for the Construction Team's use throughout the duration of the project. The HVAC Trade Contractor must provide a CAD workstation capable of running the Trade Contractor's CAD software as well as the following BIM software:
 - a. NavisWorks Manager (current version)
 - b. AutoCAD Revit Architecture Suite (current version)
 - c. AutoCAD Revit MEP Suite (current version)
12. Each Trade Contractor shall turn over the above software complete with Licenses at Final Completion for the Owner's use.

--- END ---

SECTION 23 05 12
GENERAL MOTOR REQUIREMENTS FOR HVAC EQUIPMENT

PART 1 - GENERAL

1.1 DESCRIPTION

- A. This section specifies the furnishing, installation and connection of premium efficient motors for HVAC and steam generation equipment.

1.2 RELATED WORK

- A. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: General electrical requirements that is common to more than one Section of Division 26.
- B. Section 26 29 11, LOW-VOLTAGE MOTOR STARTERS: Starters, control and protection for motors.
- C. Section 26 24 19, MOTOR-CONTROL CENTERS: Multiple motor control assemblies, which include motor starters.
- D. Other sections specifying motor driven equipment in Division 23.
- E. Section 23 04 11, COMMON WORK RESULTS FOR HVAC AND STEAM GENERATION, General Mechanical requirements and items, which are common to more than one section of Division 23.
- F. Division 25, INTEGRATED AUTOMATION.

1.3 SUBMITTALS

- A. In accordance with Section, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS, submit the following:
- B. Shop Drawings:
 - 1. Sufficient information, clearly presented, shall be included to determine compliance with drawings and specifications.
 - 2. Include electrical ratings, dimensions, mounting details, materials, horsepower, RPM, enclosure, starting characteristics, torque characteristics, code letter, full load and locked rotor current, service factor, and lubrication method.
- C. Manuals:
 - 1. Submit simultaneously with the shop drawings, companion copies of complete maintenance and operating manuals, including technical data sheets and application data.

- D. Certification: Two weeks prior to final inspection, unless otherwise noted, submit four copies of the following certification to the Resident Engineer:

1. Certification that the motors have been properly applied, installed, adjusted, lubricated, and tested.

1.4 APPLICABLE PUBLICATIONS:

- A. Publications listed below (including amendments, addenda, revisions, supplements and errata) form a part of this specification to the extent referenced. Publications are referenced in the text by designation only.

- B. National Electrical Manufacturers Association (NEMA):

MG 1-98.....Motors and Generators
MG 2-01.....Safety Standard and Guide for Selection, Installation and Use of
Electric Motors and Generators

- C. National Fire Protection Association (NFPA):

70-02.....National Electrical Code (NEC)

- D. AFBMA: Anti-Friction Bearing Manufacturers Association.

1. 1-84 – Terminology for Anti Friction Ball and Roller Bearings and Parts.
2. 9-84 – Load Ratings and Fatigue Life for Ball Bearings.
3. 11-78 – Load Ratings and Fatigue Life for Roller Bearings.
4. 20-77 – Metric Ball and Roller Bearings Conforming to Basic Boundary Plans

- E. ANSI: American National Standards Institute.

1. 50-84 – Mechanical Vibration of Rotating and Reciprocating Machinery.

- F. ASTM: American Society for Testing and Materials.

1. A48-83 – Gray Iron Castings.
2. B117-85 – Method of Salt Spray (Fog) Testing.

- G. IEEE: Institute of Electrical and Electronic Engineers.

1. 1-86 – General Principles for Temperature Limits in the Rating of Electrical Equipment.
2. 85-73 – Test Procedures for Airborne Sound Measurements on Rotating Electric Machinery.
3. 112-84 – Standard Test Procedures for Polyphase Induction Motors and Generators.
4. 114-82 – Test Procedures for Single-Phase Induction Motors.
5. 117-74 – Test Procedures for Evaluation of Systems of Insulating Materials for Random-Wound AC Electric Machinery. Single-Phase Induction Motors.

1.5 SYSTEM DESCRIPTION

- A. Furnish and install all premium efficiency motors for all systems and equipment.

- B. Motor Controllers: Provide individual motor controllers not provided under Division 26. Coordinate with the Division 26 Contractor to determine the location, size and number of individual motor controllers to be provided under this Division.
- C. Mounting and installing of motors and drives.
- D. Installation of motor controllers supplied under this Division.
- E. Work shall be done in accordance with requirements of Division 26 "Electrical Work". Wiring shall be done under Divisions 26, 27 and 28.
- F. Disconnect switches; Provide combination motor controller and disconnect switch where required under Division 23 as specified in Division 26. If not specified under individual product sections, then disconnect switches shall be furnished and installed under Division 26.

1.6 QUALITY ASSURANCE

- A. Manufacturer regularly engaged in the design, testing and manufacturing of specified products and issuing complete catalog data on such products.
- B. Manufacturers must prove expertise in the design, testing and production of specified or similar to specified products for at least ten (10) years prior to date of bid.
- C. Manufacturer must provide written certification that the products provided meet or exceed the specification requirements. An executive officer of the company must sign the written certification.

1.7 PRODUCT DELIVERY, STORAGE AND HANDLING

- A. Delivery of materials shall be made to the project by the materials supplier in accordance with the instructions of the Contractor.
- B. The Contractor shall provide adequate storage space for the materials, shall be responsible for all items of materials after receipt from the supplier, and shall replace all materials lost or damaged after delivery and receipt.
- C. The Contractor shall furnish the materials supplier with receipts for all materials and accessory items received, and shall send copies of these receipts to the Architect.

PART 2 - PRODUCTS

2.1 GENERAL

- A. All control wiring shall be installed in conduits and in accordance with the respective equipment manufacturer requirements. All connections shall be provided by the HVAC Contractor. All conduit and wiring provided by the Mechanical Contractor shall be installed in accordance with the requirements of Division 26 of these Specifications.
- B. Motors shall be built in accordance with latest Standards of NEMA and as specified. Motors shall be specifically and expressly wound for voltage required.

- C. Motors shall be tested in accordance with ANSI 50 and conform thereto for insulation resistance and dielectric strength.
- D. Motors shall be provided with adequate starting and protective equipment as specified or required and with conduit terminal box of size adequate to accommodate conduits and wires.
- E. Capacity shall be sufficient to operate motors under job conditions of operation and load, without overload and shall be at least the horsepower size indicated or specified.
- F. All motors shall be suitable for continuous duty at rated horsepower, with temperature rise not to exceed 90°C above a 40° (with a 1.15 SF (before rise). All motors shall be capable of 15% overload without overheating. All motors shall be rated and certified for use with VFD's per NEMA MG1 section 31.
- G. Motors
 - 1. 3/4 to 75 MHP shall be provided with one of the following:
 - a. Shaft grounding rings (drive end)
 - b. Insulated sleeve bearings (both ends)
 - c. Insulated bearings (both ends)
- H. All motors shall be rated for inverter duty, and stamped as such. All motors shall have Class F insulation or higher temperatures.
 - 1. Manufactured to maximize Corona Inception Voltage (CIV) rating.
 - a. The minimum acceptable shall be 2500 Volts at 155°C.
 - 2. Windings shall be in-slot wound type
- I. Direct connected motors shall be furnished with adjustable base. Motors connected to driven equipment by belt or shaft shall be furnished with adjustable sliding bases, except for fractional motors which shall be furnished with slotted mounting holes.
- J. Motors shall have nameplates giving manufacturer's name, serial number, horsepower, speed and current characteristics.
- K. Motors smaller than 1/2 HP shall be capacitor, starter or split-phase type. Motors 1/2 HP and larger shall be squirrel cage, induction type. Motors 1 HP and larger shall have grease lubricated ball bearings and approved grease fittings. Motors provided shall have voltage, phase and hertz characteristics, as scheduled on the drawings.
- L. Except for electrical apparatus specifically called for to be provided under this Contract, all motor starters, disconnect switches, controllers and other electrical appurtenances required under the HVAC, Plumbing, Fire Protection, etc. work, shall be provided under Division 26. Study the Electrical drawings and coordinate requirements and quantities with the Electrical Contractor.
- M. All electrical apparatus and controls furnished as a part of the HVAC, Plumbing, Fire Protection, etc. work shall conform to applicable requirements under Electrical Section.
- N. Each Contractor shall provide the Electrical Contractor with all motor size and wiring requirements within (30) days from date of Contract to allow proper coordination of Trades by the General Contractor.

- O. Each Contractor shall verify with the Electrical Contractor available electrical characteristics before ordering any equipment or motors.
- P. Equipment which includes a number of correlated electrical control devices mounted in a single enclosure or on a common base with equipment, shall be supplied to manufacturer for installation completely wired internally with terminal strip ready for external wiring.
- Q. All motors shall meet NEMA vibration requirements and shall be less than 0.15 in./sec.

2.2 MOTORS

- A. For alternating current, fractional and integral horsepower motors, NEMA Publications MG 1 and MG 2 shall apply.
- B. Voltage ratings shall be as follows:
 - 1. Single phase:
 - a. Motors connected to 120-volt systems: 115 volts unless otherwise noted.
 - 2. Three phase:
 - a. Motors connected to 480 volt systems: 230/460 volts, unless otherwise noted.
- C. Number of phases shall be as follows:
 - 1. Motors, less than 373 W (1/2 HP): Single phase.
 - 2. Motors, 373 W (1/2 HP) and larger: 3 phase.
 - 3. Exceptions:
 - a. Motors for equipment assemblies, less than 746 W (one HP), may be single phase provided the manufacturer of the proposed assemblies cannot supply the assemblies with three phase motors.
- D. Motor type and application (1/2 hp and above):
 - 1. Squirrel-cage induction type, totally enclosed fan cooled, NEMA B design, class B insulation, up to 1 hp and Class F insulation above 1 hp 1.15 service factor, continuous duty unless otherwise noted on the contract drawings or specified.
- E. Motor shall be 1800 rpm single speed motors unless otherwise noted on the contract drawings.
- F. Motor type and application (less than ½ hp).
 - 1. Built in overload protection.
 - 2. Rewinding tap, permanent split capacitor type, unless otherwise noted on the contract drawings or specified.
 - 3. Suitable for service and location.
 - 4. Motor shall be 1800 rpm single speed motors, unless otherwise noted on the contract drawings.
- G. Horsepower ratings shall be adequate for operating the connected loads continuously in the prevailing ambient temperatures in areas where the motors are installed, without exceeding the NEMA standard temperature rises for the motor insulation.

- H. Motor designs, as indicated by the NEMA code letters, shall be coordinated with the connected loads to assure adequate starting and running torque.
- I. Motor Enclosures:
1. Shall be the NEMA types shown on the drawings for the motors.
 2. Where the types of motor enclosures are not shown on the drawings, they shall be the NEMA types, which are most suitable for the environmental conditions where the motors are being installed. Enclosure requirements for certain conditions include:
 - a. Motors located outdoors, indoors in wet or high humidity locations or in unfiltered airstreams shall be totally enclosed type.
 - b. Where motors are located in an NEC 511 classified area, provide TEFC explosion proof motor enclosures.
 - c. Where motors are located in a corrosive environment, provide TEFC enclosures with corrosion-resistant finish.
 3. Enclosures shall be primed and finish coated at the factory with manufacturer's prime coat and standard finish.
- J. Additional requirements for specific motors, as indicated in other sections, shall also apply.
- K. Motor Efficiency Ratings And Construction
1. Motors 1.0 hp and larger:: Suitable for 3 phase, 60 hertz, 480 volt, AC power source, premium-efficient type, unless otherwise noted on the contract drawings as specified.
 2. Guaranteed minimum power factor at full load and rated voltage and guaranteed minimum efficiency at full load and rated voltage when tested in accordance with IEEE Test Procedure 112A, Method B.
 3. Premium-efficient type motors shall conform to the following efficiencies:

Nominal Efficiencies For NEMA Premium Efficiency
Motors Rated at 600 Volts or Less

HP	Open Drip Proof			Totally Enclosed Fan-cooled		
	6 pole	4 pole	2 pole	6 pole	4 pole	2 pole
1	82.5	85.5	77.0	82.5	85.5	77.0
1.5	86.5	86.5	84.0	87.5	86.5	84.0
2	87.5	86.5	85.5	88.5	86.5	85.5
3	88.5	89.5	85.5	89.5	89.5	86.5
5	89.5	89.5	86.5	89.5	89.5	88.5
7.5	90.2	91.0	88.5	91.0	91.7	89.5
10	91.7	91.7	89.5	91.0	91.7	90.2
15	91.7	93.0	90.2	91.7	92.4	91.0
20	92.4	93.0	91.0	91.7	93.0	91.0
25	93.0	93.6	91.7	93.0	93.6	91.7
30	93.6	94.1	91.7	93.0	93.6	91.7
40	94.1	94.1	92.4	94.1	94.1	92.4
50	94.1	94.5	93.0	94.1	94.5	93.0
60	94.5	95.0	93.6	94.5	95.0	93.6
75	94.5	95.0	93.6	94.5	95.4	93.6
100	95.0	95.4	93.6	95.0	95.4	94.1
125	95.0	95.4	94.1	95.0	95.4	95.0
150	95.4	95.8	94.1	95.8	95.8	95.0
200	95.4	95.8	95.0	95.8	96.2	95.4

Nominal Efficiencies For NEMA Premium Efficiency
Motors Rated at 600 Volts or Less

HP	Open Drip Proof			Totally Enclosed Fan-cooled		
	6 pole	4 pole	2 pole	6 pole	4 pole	2 pole
250	95.4	95.8	95.0	95.8	96.2	95.8
300	95.4	95.8	95.4	95.8	96.2	95.8
350	95.4	95.8	95.4	95.8	96.2	95.8
400	95.8	95.8	95.8	95.8	96.2	95.8
450	96.2	96.2	95.8	95.8	96.2	95.8
500	96.2	96.2	95.8	95.8	96.2	95.8

4. Motors less than 1 hp shall be manufacturer's standard premium efficiency design.
 5. Motor nameplate shall be specially marked "energy efficient motor" or similar nomenclature.
 6. Motors built in accordance with current NEMA Standard MG-1 except as noted.
 - a. Motors NEMA Design B, NEMA T-frame sizes.
 - b. Insulation tested by manufacturer, Class F or better. Test per NEMA MG1-12.03.
 - c. Temperature rise limits in accordance with NEMA limits for insulation class, service factor and enclosure specified.
- L. Minimum Power Factor at Full Load and Rated Voltage: 90 percent at 1200 RPM, 1800 RPM and 3600 RPM.
- M. Materials and Construction:
1. Motors up to 5 hp
 - a. Steel motor frames, cast aluminum end brackets, steel terminal box, copper windings.
 2. Motors 5 hp and larger:
 - a. Cast iron motor frames, cast iron end brackets, cast iron terminal box, copper windings.
 3. TEFC Motors
 - a. Cast iron motor frames, cast iron end brackets, cast iron terminal box, copper windings, corrosion resistant fan internals, epoxy varnish coated for corrosion protection, cadmium plated hardware.
 - b. Severe duty motors:
 - 1) Cast iron construction (frame, end brackets and terminal box). External hardware, fan and fan cover coated or plated to prevent corrosion or corrosion-resistant material. Air gap surfaces coated with epoxy or zinc chromate. Shafts with rotating shaft mounted slingers or seals to prevent entry of contaminants at each end. Epoxy insulation system where used in high-moisture and corrosive atmospheres.
 4. Explosion proof motors:
 - a. UL listed for application or duty.
 - b. Motors shall conform to requirements defined in Article 500, 501, 502, 503 of the National Electric Code.

- c. Motor nameplate shall be specifically marked "explosion proof" or similar such nomenclature.
- 5. Sound-power levels no greater than recommendations of NEMA (MG1-12-49).
- N. Motors 1/2 hp and above, conform to following:
 - 1. Bearings: Antifriction type with bearing housings equipped with easily accessible plugged provisions for relubrication. Minimum L-10 life of 100,000 hours based on direct drive equipment. Bearing housings shall be equipped with grease openings for simultaneously adding new grease and purging the old grease. Provide corrosion resistant plugs or caps on grease openings.
 - 2. Belt-connected motors: NEMA foundation slide base and shaft as required for aligning pulleys. Minimum L-10 life based on belt drive shall be 40,000 hrs.
 - 3. Motor enclosure: Suitable for service and location.

2.3 MOTOR DISCONNECT

- A. Provide only devices of Specification Grade, UL listed and labeled, manufacturer's certification to meet applicable Federal Specifications, and to meet NEMA performance standards.
- B. Disconnects shall be "Heavy Duty Type".
- C. Single phase disconnect switches: Two pole toggle operated AC manual motor starting switch without overload protection for single phase motors.
- D. Three phase disconnect switches: 3 pole fusible or unfusible as required; 250 or 600 volt as required in NEMA 4 enclosures.
- E. The operating handle for three phase disconnect switches shall be of the box-mounted type that directly drives the switch mechanism.
- F. Three phase disconnect switches shall have a defeatable, front accessible, interlock to prevent the opening of the cover when the switch is in the "ON" position and prevent turning the switch "ON" when the door is open.
- G. Solid neutral: Provide as required.
- H. Provide ground lug for ground wire termination.
- I. All disconnects shall be lockable.
- J. Operating handle: Lockable in either open or closed position.
- K. All motor disconnects shall be horsepower rated.
- L. Feed through or double lugged: UL approved for the purpose.
- M. Installation:
 - 1. All switches shall have a nameplate indicating the circuit number feeding the switch. Nameplate shall be laminated black with white letters engraved.
 - 2. Install a motor disconnect switch with every motor.

2.4 MOTOR CONTROLLERS

A. Manual motor controller:

1. For single phase motors, provide H-O-A switches with thermal overload.
2. 2-speed: Fast-slow-off selector switch with overload protection for each speed, with pilot lights for slow and fast speed.

B. Magnetic motor controller:

1. Provide magnetic contactors with three overload relays, for motor running overload protection, per NEC.
2. 120 Volt holding coil.
3. Provide status pilot light in cover, red for energized. Pilot light shall be operated by an extra interlock (not placed across holding coil). Pilot light shall be long life (130 volt) type 6S6 incandescent lamps.
4. Provide reset button, and Hand-Off-Automatic switch in cover, field convertible to Off-Auto or Start/Stop pushbutton.
5. Provide one set of convertible auxiliary contacts in addition to standard auxiliary holding contacts supplied with each contactor.
6. Provide control transformer 120 volt secondary of sufficient capacity to handle operating coil and associated controls plus 75 volt amps.
7. Provide surface mounted starters in NEMA Type 1 enclosure for indoor applications and NEMA Type 4 enclosure for outdoor applications.
8. Contacts shall be solid-silver cadmium oxide alloy which will not require any filing, dressing or cleaning throughout the life of the control equipment. Bare copper or silver flashed contacts shall not be permitted.
9. Operating coils shall be pressure molded. When a coil fails under over-voltage condition, the motor controller shall drop out.
10. Overload relays shall be of the hand-reset, trip-free variety so that blocking the reset mechanism in the reset position will not prevent the starter from dropping out if the motor is overloaded. This specifically excludes those overload relays which change to automatic reset from hand-reset when the reset mechanism is blocked unless the automatic reset feature can be removed or voided. Accidentally depressing the reset button or mechanism shall not shut off the motor. Overload relays shall not be field convertible from hand to automatic reset type.
11. Disconnect switch shall be provided under Division 26 unless otherwise noted.
12. Where specified, motor hp rated disconnect switches shall be provided in NEMA 1 enclosure for indoor applications and NEMA 4 enclosures for outdoor applications.
13. Provide full coordination between settings or ratings of protective devices in accordance with the NEC.

C. Combination motor controller (only where indicated on the contract drawings or specified).

1. Provide molded case circuit breakers with rotary operating handle and lock-off facility.
2. Restrict opening of switch enclosure by the use of a defeater screw unless switch is in the OFF position.
3. Provide contactors with three overlay relays.
 - a. 120 Volt holding coil.
 - b. Provide status pilot light in cover, red for energized. Pilot light shall be operated by an extra interlock (not placed across holding coil) Pilot lights shall be long life (130 volt) type 6S6 incandescent lamps.

4. Provide reset button, and Hand-Off-Automatic switch in cover, field convertible to Off/Auto or Start/Stop pushbutton.
5. Provide one set of auxiliary contacts in addition to standard auxiliary hold contacts supplied with each contactor.
6. Provide control transformer 120 volt secondary of sufficient capacity to handle operating coil and associated controls plus additional 75 volt amps.
7. Time-delay relays shall be adjustable, 2 to 60 seconds and operate on 120 volts, 60 hertz. They shall have at least one normally open and one normally closed timed contact. The type of operation is as indicated or required.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install motors in accordance with manufacturer's recommendations, the NEC, NEMA, as shown on the drawings and/or as required by other sections of these specifications.
- B. Coordinate with appropriate trades.
 1. Motor and base mounting requirements.
 2. Motor electrical requirements.
- C. Motors shall be installed in accordance with all applicable codes.
- D. Division 23 Contractor shall assist the Division 25 Contractor in the calibration process of all motor current transformers as detailed in Division 25.

3.2 FIELD TESTS

- A. Megger all motors after installation, before start-up. All shall test free from grounds.

3.3 CONTROLLER

- A. Provide all controllers not indicated on the Division 26 documents.

--- END ---

SECTION 230514
VARIABLE FREQUENCY DRIVES

PART 1 – GENERAL

1.1 DESCRIPTION

- A. This section specifies the furnishing, installation and connection of the variable frequency drives for HVAC and steam generation equipment.
- B. Furnish and install variable frequency drives (VFDs) for equipment as scheduled on the drawings and specified herein. The term VFD shall refer to the entire assembly including but not limited to the by-pass.
- C. The VFD's shall comply with the latest applicable standards of ANSI, IEEE, NEMA, NEC, UL and City Test Lab. The controllers shall be rated as indicated. As a minimum, the full load output current of the drive shall be equal to the equivalent motor horsepower as listed by NEC Table 430-150.
- D. Drive horsepowers shall be minimum size as indicated. Coordinate size with driven equipment manufacturer.
- E. Provide UL listed, accessory reactors to be UL listed. Bypass panels shall be constructed of UL recognized components assembled in a UL listed enclosure in strict accordance with the NEC for electrical safety. In addition the assembly shall be UL listed.

1.2 RELATED WORK

- A. Examine all drawings and criteria sheets and all other Sections of the Specifications for requirements which affect work under this Section whether or not such work is specifically mentioned in this Section.
- B. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: General electrical requirements that are common to more than one Section of Division 26.
- C. Section 26 29 11, LOW-VOLTAGE MOTOR STARTERS: Starters, control and protection for motors.
- D. Section 26 24 19, MOTOR-CONTROL CENTERS: Multiple motor control assemblies, which include motor starters.
- E. Section 23 05 11, COMMON WORK RESULTS FOR HVAC, general mechanical requirements and items which are common to more than one section of Division 23.
- F. Section 01 91 13, COMMISSIONING: Requirements for commissioning, readiness checklists and training.
- G. Division 25, INTEGRATED AUTOMATION.

1.3 SUBMITTALS

- A. In accordance with Section, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS, submit the following:
- B. Shop Drawings:
 - 1. Sufficient information, clearly presented, shall be included to determine compliance with drawings and specifications.
 - 2. Include electrical ratings, dimensions, mounting details, materials, and product data as follows.
- C. Manuals:
 - 1. Submit simultaneously with the shop drawings, companion copies of complete maintenance and operating manuals, including technical data sheets and application data.
- D. Product Data: Provide product description and list of materials, including the following:
 - 1. Harmonic calculations
 - a. List of all drives.
 - b. Simplified one line diagram indicating linear as well as drives, transformers and PCC.
 - c. Technical description of the program used for the calculations.
 - d. Description of all inputs and outputs from the program.
 - 2. Complete drawings furnished and approved before proceeding with manufacture. Drawings shall consist of a specific bill of materials, connection diagrams and suitable outline drawings showing details necessary to locate conduit stub-ups and field wiring.
 - a. Details including all labeling.
 - b. Assembled panel short circuit rating and how it will be labeled.
 - c. Heat release of the drive.
 - 3. Description of field testing.
 - a. Proposed schedule of testing indications coordination with occupancy.
 - 4. Manufacturer's Instructions: Indicate installation procedures that ensure acceptable workmanship and installation standards will be achieved.

1.4 APPLICABLE PUBLICATIONS

- A. Applicable provisions of the following Codes and Trade Standard Publications shall apply to the work of this Section, and are hereby incorporated into, and made a part of the Contract Documents.
- B. Material standards shall be as specified or detailed hereinafter and as follows:
 - 1. IEEE: Institute of Electrical and Electronic Engineers
 - 2. NEMA: National electrical Manufacture's Association

- 3. MG 1-78: Motors and Generators
- 4. NEC: National Electrical Code
- 5. ANSI: American National Standards Institute
- 6. UL: Underwriter's Laboratories

1.5 QUALITY ASSURANCE

- A. Manufacturers must have more than ten (10) years of documents experience in the design, testing and manufacturing of specified or similar products.
- B. Manufacturer must provide written certification that the products provided meet or exceed the specification requirements. An executive officer of the company must sign the written certification.
- C. Commissioning of a system or systems specified in this section shall be part of the construction process. Documentation and testing of these systems; as well as training of the VAMC operation and maintenance personnel, is required in cooperation with the VA Resident Engineer and the Commissioning Authority. Project Close-out is dependent on successful completion of all commissioning procedures, documentation, and issue closure. Refer to Section 019113, COMMISSIONING, for detailed commissioning requirements.

PART 2 – PRODUCTS

2.1 VARIABLE FREQUENCY DRIVES

- A. General
 - 1. Provide a complete variable frequency drive (VFD) (in a single enclosure) of capacity, quantity and characteristics as described in this specification and as shown and scheduled on the drawings.
 - 2. All VFDs (6 & 18 pulse) shall be of the same manufacturer.
 - 3. Each drive and assembly (with or without bypasses) shall be U.L. listed and labeled.
 - a. Label shall include the AIC rating for the assembly (SSCR) which shall not be less than 65,000 AIC.
 - b. Any unit shipped without such label shall be removed from the job with NO EXCEPTIONS. This also includes six pulse drives with or without bypasses.
 - 4. Each drive shall be mounted with it's accessories in a single cabinet.
 - 5. Installation and start-up services for the equipment shall be covered by this specification.
 - 6. Input control signal shall be compatible with automatic controls and/or building automation control system. Submit written, signed off coordination with submittal.
 - 7. Complete drawings shall be furnished and approved before proceeding with manufacture. Drawings shall consist of a specific bill of materials, connection diagrams and suitable outline drawings showing details necessary to locate conduit stub-ups and field wiring.
 - 8. The VFD shall comply with the latest applicable standards of ANSI, IEEE and NEMA. The controllers shall be rated as shown in the drawings. As a minimum, the full load output current of the drive shall be equal to the equivalent motor horsepower as listed by NEC Table 430-150.
 - 9. Drive horsepowers shall be minimum size as indicated. Coordinate size with driven equipment manufacturer.

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10. The VFD manufacturer shall supply with submittal information, harmonic calculations made in accordance with IEEE 519-1992 Standards showing the specified THVD, line notching and the specified THCD limits are met. Calculations shall assume worst case system conditions. System 1-line, 480V transformer data, standby generator data, and primary fault current data required to make these calculations are provided in the system short circuit study and can be obtained from the Electrical Contractor. The submittal shall include, as a minimum, the following information:
- a. All input data and assumptions.
 - b. Explanation of method used to perform the analysis.
 - c. All calculations and computer printouts used in the analysis, including input documentation.
 - 1) List all drives and accessories.
 - 2) Explanation of all inputs
 - 3) Explanation of all outputs.
 - d. A system impedance diagram based on the Electrical one-line diagrams. It shall be the drive manufactures responsibility to obtain all information required.
 - e. All calculations shall be in accordance with IEEE 519 with all drives at 100% speed. The point of common coupling shall be the secondary connection of the transformer supplying that group of devices. These calculations shall be done with the transformer loaded to no more than 70% of its nominal capacity (without fans). These calculations shall also be done with all 18-pulse or greater drives running as well as the smaller drives running.
 - f. Each point of common coupling shall be defined as the secondary side of the transformer that feeds that group of drives. At the point of common coupling, the following numbers shall meet with the maximum load on the transformer no greater than 70% of its nominal capacity.
 - 1) **Total harmonic voltage distortion is less than 3%**
 - 2) **Total harmonic current distortion is less than 5% and harmonic table requirements $I_{SC} / I_L < 20$**
 - 3) **Note: 6-pulse drives will not be accepted on 30 HP drives or larger, even if this calculation is met.**
 - g. A detailed description of the tests, procedures and supporting calculations required to substantiate the installed systems compliance with the specified THD limits.
 - 1) The description shall include information on the proposed test equipment and test conditions.
 - 2) Include the name and qualifications of the firm which will conduct the field tests.
 - h. **Submittals without calculations will not be reviewed.**
11. Drives shall be capable of the full rated motor horsepower at all carrier frequencies of that drive.

B. Construction

1. VFDs 30 HP and Larger

- a. VFDs 30 HP and larger shall be 18-pulse (or greater) input. Provide data and calculations showing the drive harmonics do not exceed the following numbers at the power connection to the drive.

- 1) Total harmonic voltage distortion: Less than 3%
- 2) Total harmonic current distortion: Less than 5% and harmonic table requirements for $I_{SC}/I_L < 20$.

Note: These are the maximum harmonics that can be generated by each of these drives.

- b. The use of the following devices is permitted:

- 1) A.C. Line reactors
- 2) DC chokes
- 3) KMP Transformers
- 4) KMP + XFMR Filter Transformers

- c. The use of the following devices is not permitted:

- 1) Passive filters.
- 2) Broad band filters.

2. VFDs 25 HP and Less

- a. VFDs 25 HP and less shall be 6-pulse (or greater) input. Provide data and calculations showing the drive harmonics.
- b. 5% line reactors shall be provided on each drive as a minimum.
- c. The use of the following devices is not permitted:

- 1) Passive filters.
- 2) Broad band filters.

- d. The use of the following devices is permitted:

- 1) Changing additional drives to 18 pulse or greater.

3. Harmonic Table

ISC / I _L	Harmonic Order (Odd Harmonics)					THD
	H<11	11<h17	17<h23	23<h35	35<h	
<20	4.0	2.0	1.5	0.6	0.3	5.0
20-50	7.0	3.5	2.5	1.0	0.5	8.0
50-100	10.0	4.5	4.0	1.5	0.7	12.0
100-1000	12.0	5.5	5.0	2.0	1.0	15.0
>1000	15.0	7.0	6.0	2.5	1.4	20.0

4. 18 Pulse Transformer

a. Auto transformer

- 1) Voltage 480.
- 2) Input variation less than 3%.
- 3) Insulation Class 220°C
- 4) Temperature rise 150°C
- 5) With 7.5% AC input line reactors for proper current balance.
- 6) Output Voltage unbalance less than 2% for each bridge
- 7) Output current shall be 1/3 of rated input

b. Isolation Transformer.

- 1) Voltage 480.
- 2) Input variation less than 3%.
- 3) Output Voltage unbalance less than 2% for each bridge
- 4) Output current shall be 1/3 of rated input

5. All Drives

- a. The VFD shall be of the pulse width modulated (PWM) design converting the fixed utility voltage and frequency to a variable voltage and frequency output via a 2-step operation. VFDs utilizing a 3rd power section are not acceptable. Efficiency shall exceed 96% at 100% speed and load. Line side displacement power factor shall exceed (0.95) regardless of speed and load. The VFD shall be rated for 110% current for (1) minute for variable torque loads and 150% current for (1) minute for constant torque loads.
- b. VFDs located indoors shall be housed in a signal NEMA 1 metal enclosure (including 18-pulse transformer, filters, line reactor, and other required accessories).
- c. Drives located outside shall be provided with a single NEMA 3R enclosure and an independent heating and cooling system to maintain manufacturer's ambient operating conditions.
- d. Drives located other than outside (submit list of all drives individually indicating):
 - 1) Space drive is located.
 - 2) Space ventilation is adequate, space air conditioning is adequate or the size of the cooling provided in the drive.
 - 3) Space heating is adequate or the size of the heater provided in the drive.
- e. Standard operating conditions shall be:
 - 1) Incoming 3-phase 480 VAC power, +5% or -10%, 60 Hz.
 - 2) Humidity 0 to 95% (non-condensing and non-corrosive).
 - 3) Altitude 0'-0" to 3,300'-0" above sea level.
 - 4) Ambient temperature 0° to 40°C.
- f. VFDs shall include the following system interfaces:
 - 1) Speed reference interface with a differential amplifier or isolated input 0-10 VDC or 4-20 mADC signal.
 - 2) Run relay with an isolated set of Form C contacts.
 - 3) Minimum of 2 programmable contacts.
 - 4) Trip contacts (Form C).

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- 5) VFD will accept an external trip contact and indicate so on the display.
 - 6) Dedicated terminal blocks for interface with maintained remote start contacts.
 - 7) Output signal proportional to output frequency (0-10 VDC or 4-20 mADC).
 - 8) Output signal proportional to output current (0-10 VDC or 4-20 mADC).
 - 9) BACnet MS/TP communication interface with following points as a minimum:
 - a) VFD frequency (Hz)
 - b) Mode feedback VFD/Bypass (where applicable)
 - c) Motor RPM
 - d) General alarm
 - e) Amperage
 - f) Minimum speed
- g. The VFD shall include the following protective features:
- 1) Lockable Fused disconnect (or breaker) rated for 65,000 AIC.
 - 2) Electronic instantaneous overcurrent protection.
 - 3) DC bus undervoltage protection.
 - 4) DC bus overvoltage protection.
 - 5) Ability to withstand output line-to-line short circuits without component failure.
 - 6) Status indication via an LED display of the following protective functions:
 - a) DC Bus Undervoltage
 - b) Overcurrent
 - c) DC Bus Overvoltage
 - d) Controller Overtemperature
 - e) Overload
 - f) Overload Warning
 - g) Overfrequency and Phase Loss
 - h) A single light to indicate a VFD trip is not acceptable.
 - 7) Overload capability shall be 110% of the inverter rating for (1) minute.
 - 8) Selectable auto restart.
 - 9) VFD will catch a motor spinning in the forward or reverse direction upon starting.
 - 10) Upon loss of the input signal (4-20 mA), the drive will stop or go to preset speed.
- h. Standard adjustments shall include:
- 1) Minimum frequency (4-60 Hz)
 - 2) Maximum frequency (40-120 Hz)
 - 3) Minimum of three (3) preset speeds (4-120 Hz) initiated by contact closures
 - 4) Minimum of three (3) acceleration times (2-300 seconds)
 - 5) Minimum of three (3) deceleration times (2-300 seconds)
 - 6) Minimum speed dwell(stall speed) time (0-18 seconds)
 - 7) Minimum stall speed (fraction of rpm)
 - 8) Voltage boost (0-40V) for starting torque control
 - 9) Adjustable Carrier frequency 700-8,000 Hz for motor noise reduction or flexible switching technology. This adjustment shall be without derating the drive or motor.
 - 10) Current limit (70-120%)

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- 11) Critical frequency avoidance ([2] bands with 10 Hz adjustable widths)
 - i. Door mounted operator controls and status indication from the LED display shall include:
 - 1) Run/stop selection and LED indication (keypad or remote)
 - 2) Speed control selection and LED indication
 - 3) Forward/Reverse selection
 - 4) Manual speed adjustment
 - 5) Frequency meter
 - 6) Motor RPM
 - 7) Ammeter
 - 8) Output voltage
 - 9) Elapsed time meter
 - j. The keypad shall have an LED display. The reverse button and the programming functions may be locked out if desired.
 6. The following list of options shall be included:
 - a. Input lockable disconnect rated 65,000 AIC.
 - b. Thermal motor overcurrent relay.
 - c. Bypass which includes an output contactor electrically and mechanically interlocked with a bypass contactor, run relay including control logic, status lights and a thermal motor overcurrent relay. The complete bypass system and Inverter/Off/Bypass selector switch shall be packaged in a single VFD enclosure. The bypass shall include a starter.
 - d. Drives may be provided without bypass only when:
 - 1) The drawing states that the specific drive shall not have bypass.
 - 2) When the fan is part of a redundant configuration.
 - 3) When the pump is part of a redundant configuration.
 - e. Cooling tower fans shall always have a bypass.
 - f. Electronics shall allow VFD to follow discrete increase speed and discrete decrease speed contact closures from a photohelic or similar device.
 - g. 120V control transformer and circuitry.
 - h. Output line reactors or output filters when the drive location and the motor are more than 100 feet apart.
 - i. Interior heaters shall be provided to maintain the minimum drive temperature when the drive is off.
 - j. A Customer Interlock Terminal Strip – provide a separate terminal strip for connection of fire, smoke, freeze contacts and external start command. All external interlocks and start/stop contacts shall function with drive in hand, auto or bypass.
 - 1) Damper control circuit shall be operable in the hand, auto and bypass.
 7. Service
 - a. The VFD manufacturer shall provide a start-up service package for all VFDs provided. Service shall include inspector for final adjustment, operational checks, and a final report for record purposes.

The service package shall include a (1) year parts and labor warranty and 2 year parts warranty each from date of written acceptance and be performed by local factory trained service Engineers. The service center must be permanently located within (200) miles of the job site and able to provide 24-hour service.

8. Protection

- a. The VFD shall be protected against damage at all times. The drive shall be stored in a clean, dry environment with temperature and humidity within the range as specified by the drive manufacturer. Space heaters shall be energized controlled storage as recommended by the manufacturer. Storage space shall be environmentally controlled.

9. Factory Tests and Checks

- a. VFD power semiconductors and diodes shall be 100% inspected and tested, including load testing.
- b. Small signal semiconductors, resistors, capacitors and diodes shall be lot sampled. Testing shall include parameter, as well as functional characteristics.
- c. All printed circuit boards shall be tested under a temperature cycling (0°C to +65°C) 24-hour load test and then functionally tested via fault finder bench equipment prior to unit installation.
- d. All final assemblies shall be tested at full load with application of line-to-line and line-to-ground bolted faults. The VFD shall trip electronically without device failure.
- e. After all tests have been performed, each VFD shall undergo a 30 minute burn-in test. The drive shall be burned-in at 100% inductive or motor load for 30 minutes without an unscheduled shutdown.

- 10. A 4-hour training course for Owner's personnel shall be presented by representatives of the manufacturer at the jobsite.

PART 3 – EXECUTION

3.1 VFD INSTALLATION

- A. Install in accordance with manufacturer recommendations, Contract Drawings, and reviewed submittals.
- B. Install to meet the Local and State Electrical Code and so as to ensure easy accessibility for service, removal, or replacement of all components.
- C. Provide supplemental steel, support, rods and hangers necessary to hang or mount VFDs.
- D. Receive and inspect VFDs to ensure they are without defect. Defective or damaged VFDs shall be returned to the manufacturer.
- E. Protect equipment to prevent damage from water, dirt, or accident. Protection shall include, but not be limited to, temporary plastic wrap to maintain equipment in original factory condition.
- F. Wiring installation and handling shall be in accordance with manufacturer's recommendations.
- G. Provide field testing (as described in Paragraph F, of this above Section).

3.2 FIELD TESTS AND CHECKS

- A. Testing, checkout and start-up of the VFD equipment shall be performed under the technical direction of the manufacturer's service Engineer and witnessed by the Commissioning Agent. Under no circumstances are any portions of the drive system to be energized without authorization from the manufacturer's representative.
- B. The Contractor shall provide independent harmonic testing by an independent testing company. Provide readings with printouts of the harmonic current at each harmonic band as well as the total voltage distortion. The following readings shall be provided:
 - 1. At each point of common coupling:
 - a. With all drives running with load
 - b. With all drives off
 - 2. At the power connection to each drive:
 - a. With the drive running loaded
 - b. With drive off
 - 3. All the above data shall be submitted to the Architect for review. If these tests show that the drives are not in compliance with the Specifications at the power connection to each drive only, the drive manufacturer shall make all changes required to comply with the Specifications at no cost to the Owner. If required, this could mean replacing the drives that are not in compliance.
 - 4. A copy of all tests and checks performed in the field, complete with meter readings and recordings, where applicable, shall be submitted to the Owner for this record.

3.3 FUNCTIONAL PERFORMANCE AND INTEGRATED SYSTEMS TESTING

- A. Functional Performance and Integrated Systems Testing (FP & IST) is part of the commissioning process. FP & IST shall be performed by the Contractor, and witnessed and documented by the Commissioning Authority. Refer to Section 019113, COMMISSIONING, for FP & IST requirements.

3.4 TRAINING

- A. Training of the VAMC operation and maintenance personnel shall be required in cooperation with the VA Resident Engineer. Provide competent, factory-authorized personnel to instruct operation and maintenance personnel concerning the location, operation, and troubleshooting of the installed systems. The instruction shall be scheduled in coordination with the VA Resident Engineer after submission and approval of formal training plans. Refer to Section 017900, DEMONSTRATION AND TESTING, and Section 019113, COMMISSIONING, for Contractor training requirements.

--- END ---

SECTION 23 05 41
NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Furnish and install all necessary vibration isolation materials to meet design standards.
- B. All trapeze supported Items weighing 10 Lbs per foot or greater shall be braced. This weight shall include all pipes and conduits filled with water.
- C. Secure all permits and local/state approval for the installation of all components included under this Section.
- D. The work in this Section shall include the following:
 - 1. Vibration isolation elements for equipment.
 - 2. Equipment isolation bases.
 - 3. Piping flexible connectors.
- E. Coordinate closely with Hangers and Supports, Pipe Expansion and Structural documents.

1.2 RELATED WORK

- A. Section 03 30 00, CAST-IN-PLACE CONCRETE: Requirements for concrete inertia bases.
- B. Section 23 05 11, COMMON WORK RESULTS FOR HVAC: General mechanical requirements and items, which are common to more than one section of Division 23.
- C. Section 23 22 13, STEAM AND CONDENSATE HEATING PIPING: Requirements for flexible pipe connectors to reciprocating and rotating mechanical equipment.
- D. Section 23 73 00, CUSTOM INDOOR CENTRAL-STATION AIR-HANDLING UNITS and Section 23 73 13, PACKAGED INDOOR CENTRAL-STATION AIR-HANDLING UNITS: Requirements for optional Air Handling Unit internal vibration isolation.
- E. Section 23 31 00, HVAC DUCTS, CASINGS AND SILENCERS: requirements for flexible duct connectors, sound attenuators and sound absorbing duct lining.
- F. Section 23 05 93, TESTING, ADJUSTING, and BALANCING FOR HVAC: requirements for sound and vibration tests.
- G. Section 23 37 00, AIR OUTLETS and INLETS: noise requirements for G-grilles.
- H. Section 23 21 23, HYDRONIC PUMPS: vibration isolation requirements for pumps.
- I. Section 23 34 00, HVAC FANS: sound and vibration isolation requirements for fans.

- J. Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS: Requirements for commissioning, readiness checklists and training.

1.3 QUALITY ASSURANCE

- A. Refer to article, QUALITY ASSURANCE in specification Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
- B. Noise Criteria
1. Noise levels in all 8 octave bands due to equipment and duct systems shall not exceed the following Noise Criteria (NC):

ROOM TYPE	NC
Audio Speech Pathology / Audio Suites / Photo Studio / AV Recording	30
Auditoriums, Theaters	35
Autopsy Suites	35
Bathrooms / Toilet Rooms	45
Chapel	35
Classrooms, Conference Rooms	35
Corridors (Public)	40
Dining Rooms, Food Services, Serving	40
Exam Rooms, Consultation Rooms	35
Gymnasiums	50
Kitchens, Laundries	50
Laboratories (with fume hoods)	55
Library	35
Lobbies, Vestibules, Concourse	45
Locker Rooms	45
Offices, Large Open	40
Offices, Small Private	35
Operating Rooms	40
Patient Rooms (Beds), Isolation Rooms	35
Pharmacy	40
Recreation Rooms	45
SPD (Decontamination and Clean Preparation)	45
Therapeutic Pools	45
Treatment Rooms, Observation Rooms	35
Therapy Rooms	35
Waiting Areas	40
Warehouse, Shops	50
X-Ray and General Work Rooms	40

2. For equipment which has no sound power ratings scheduled on the plans, the Contractor shall select equipment such that the space type noise criteria, local ordinance noise levels, and OSHA requirements are not exceeded. Selection procedure shall be in accordance with the 2009 ASHRAE Fundamentals Handbook, Chapter 8, Sound and Vibration.
 3. An allowance, not to exceed 5db, may be added to the measured value to compensate for the variation of the room attenuating effect between room test condition prior to occupancy and design condition after occupancy which may include the addition of sound absorbing material, such as, furniture. This allowance may not be taken after occupancy. The room attenuating effect is defined as the difference between sound power level emitted to room and sound pressure level in room.
 4. In absence of specified measurement requirements, measure equipment noise levels three feet from equipment and at an elevation of maximum noise generation.
- C. Allowable Vibration Tolerances for Rotating, Non-reciprocating Equipment: Not to exceed a self-excited vibration maximum velocity of 5 mm per second (0.20 inch per second) RMS, filter in, when measured with a vibration meter on bearing caps of machine in vertical, horizontal and axial directions or measured at equipment mounting feet if bearings are concealed. Measurements for internally isolated fans and motors may be made at the mounting feet.

1.4 SUBMITTALS

- A. Submit in accordance with specification Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.
- B. Manufacturer's Literature and Data:
 1. Vibration isolators:
 - a. Floor mountings
 - b. Hangers
 - c. Snubbers
 - d. Thrust restraints
 2. Bases
- C. Isolator manufacturer shall furnish with submittal load calculations for selection of isolators, including supplemental bases, based on lowest operating speed of equipment supported.

1.5 APPLICABLE PUBLICATIONS

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.
- B. American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE):
2009..... Fundamentals Handbook, Chapter 8, Sound and Vibration
- C. American Society for Testing and Materials (ASTM):
A123/A123M-02..... Standard Specification for Zinc (Hot-Dip Galvanized) Coatings
on Iron and Steel Products
A307-04..... Standard Specification for Carbon Steel Bolts and Studs, 60,000
PSI Tensile Strength
D2240-05..... Standard Test Method for Rubber Property - Durometer
Hardness

- D. Manufacturers Standardization (MSS):
SP-58-02 Pipe Hangers and Supports-Materials, Design and Manufacture
- E. Occupational Safety and Health Administration (OSHA):
29 CFR 1910.95 Occupational Noise Exposure

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS

- A. Type of isolator, base, and minimum static deflection shall be as required for each specific equipment application as recommended by isolator or equipment manufacturer but subject to minimum requirements indicated herein and in the schedule on the drawings.
- B. Elastometric Isolators shall comply with ASTM D2240 and be oil resistant neoprene with a maximum stiffness of 60 durometer and have a straight-line deflection curve.
- C. Exposure to weather: Isolators, including springs, exposed to weather shall be hot dip galvanized after fabrication. Hot-dip zinc coating shall not be less than 609 grams per square meter (two ounces per square foot) by weight complying with ASTM A123. In addition provide limit stops to resist wind velocity. Comply with the design wind velocity of 130 mph.
- D. Uniform Loading: Select and locate isolators to produce uniform loading and deflection even when equipment weight is not evenly distributed.
- E. Color code isolators by type and size for easy identification of capacity.

2.2 VIBRATION ISOLATORS

- A. Floor Mountings:
 - 1. Double Deflection Neoprene (Type N): Shall include neoprene covered steel support plated (top and bottom), friction pads, and necessary bolt holes.
 - 2. Spring Isolators (Type S): Shall be free-standing, laterally stable and include acoustical friction pads and leveling bolts. Isolators shall have a minimum ratio of spring diameter-to-operating spring height of 1.0 and an additional travel to solid equal to 50 percent of rated deflection.
 - 3. Spring Isolators with Vertical Limit Stops (Type SP): Similar to spring isolators noted above, except include a vertical limit stop to limit upward travel if weight is removed and also to reduce movement and spring extension due to wind loads. Provide clearance around restraining bolts to prevent mechanical short circuiting. Isolators shall have a minimum seismic rating of one G.
 - 4. Pads (Type D), Washers (Type W), and Bushings (Type L): Pads shall be felt, cork, neoprene waffle, neoprene and cork sandwich, neoprene and fiberglass, neoprene and steel waffle, or reinforced duck and neoprene. Washers and bushings shall be reinforced duck and neoprene. Size pads for a maximum load of 345 kPa (50 pounds per square inch).

- B. Hangers: Shall be combination neoprene and springs unless otherwise noted and shall allow for expansion of pipe.
1. Combination Neoprene and Spring (Type H): Vibration hanger shall contain a spring and double deflection neoprene element in series. Spring shall have a diameter not less than 0.8 of compressed operating spring height. Spring shall have a minimum additional travel of 50 percent between design height and solid height. Spring shall permit a 15 degree angular misalignment without rubbing on hanger box.
 2. Spring Position Hanger (Type HP): Similar to combination neoprene and spring hanger except hanger shall hold piping at a fixed elevation during installation and include a secondary adjustment feature to transfer load to spring while maintaining same position.
 3. Neoprene (Type HN): Vibration hanger shall contain a double deflection type neoprene isolation element. Hanger rod shall be separated from contact with hanger bracket by a neoprene grommet.
 4. Spring (Type HS): Vibration hanger shall contain a coiled steel spring in series with a neoprene grommet. Spring shall have a diameter not less than 0.8 of compressed operating spring height. Spring shall have a minimum additional travel of 50 percent between design height and solid height. Spring shall permit a 15 degree angular misalignment without rubbing on hanger box.
 5. Hanger supports for piping 50 mm (2 inches) and larger shall have a pointer and scale deflection indicator.
- C. Thrust Restraints (Type THR): Restraints shall provide a spring element contained in a steel frame with neoprene pads at each end attachment. Restraints shall have factory preset thrust and be field adjustable to allow a maximum movement of 6 mm (1/4 inch) when the fan starts and stops. Restraint assemblies shall include rods, angle brackets and other hardware for field installation.

2.3 BASES

- A. Rails (Type R): Design rails with isolator brackets to reduce mounting height of equipment and cradle machines having legs or bases that do not require a complete supplementary base. To assure adequate stiffness, height of members shall be a minimum of 1/12 of longest base dimension but not less than 100 mm (4 inches). Where rails are used with neoprene mounts for small fans or close coupled pumps, extend rails to compensate overhang of housing.
- B. Integral Structural Steel Base (Type B): Design base with isolator brackets to reduce mounting height of equipment which require a complete supplementary rigid base. To assure adequate stiffness, height of members shall be a minimum of 1/12 of longest base dimension, but not less than 100 mm (four inches).
- C. Inertia Base (Type I): Base shall be a reinforced concrete inertia base. Pour concrete into a welded steel channel frame, incorporating prelocated equipment anchor bolts and pipe sleeves. Level the concrete to provide a smooth uniform bearing surface for equipment mounting. Provide grout under uneven supports. Channel depth shall be a minimum of 1/12 of longest dimension of base but not less than 150 mm (six inches). Form shall include 13-mm (1/2-inch) reinforcing bars welded in place on minimum of 203 mm (eight inch) centers running both ways in a layer 40 mm (1-1/2 inches) above bottom. Use height saving brackets in all mounting locations. Weight of inertia base shall be equal to or greater than weight of equipment supported to provide a maximum peak-to-peak displacement of 2 mm (1/16 inch).

- D. Curb Mounted Isolation Base (Type CB): Fabricate from aluminum to fit on top of standard curb with overlap to allow water run-off and have wind and water seals which shall not interfere with spring action. Provide resilient snubbers with 6 mm (1/4 inch) clearance for wind resistance. Top and bottom bearing surfaces shall have sponge type weather seals. Integral spring isolators shall comply with Spring Isolator (Type S) requirements.

2.4 SOUND ATTENUATING UNITS

- A. Refer to specification Section 23 31 00, HVAC DUCTS, CASINGS AND SILENCERS.

2.5 NOISE BARRIER WRAP FOR DUCTWORK

- A. Noise barrier duct wrap shall be constructed of 0.10 inch (3mm) thick, mass loaded, flexible vinyl sheet bonded to a thin layer of aluminum foil on one side. The barrier shall have a nominal density of 1.0 psf (4.88 kg/sqM).
- B. Surface burning characteristics per ASTM E84 shall not exceed the following:
1. Flame Spread Index – 10
 2. Smoke Developed Index – 40
- C. Thermal conductivity ("K" value) shall not exceed 0.29 btu-inch/hr.ft.²F. Rated service temperature range shall be -40°F to 220°F.
- D. Sound transmission loss (TL) of noise barrier material shall be minimum as listed below when tested as a free hanging barrier.

Frequency Hz	125	250	500	1000	2000
TL (dB)	13	17	21	28	33

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Vibration Isolation:
1. No metal-to-metal contact will be permitted between fixed and floating parts.
 2. Connections to Equipment: Allow for deflections equal to or greater than equipment deflections. Electrical, drain, piping connections, and other items made to rotating or reciprocating equipment (pumps, compressors, etc.) which rests on vibration isolators, shall be isolated from building structure for first three hangers or supports.
 3. Common Foundation: Mount each electric motor on same foundation as driven machine. Hold driving motor and driven machine in positive rigid alignment with provision for adjusting motor alignment and belt tension. Bases shall be level throughout length and width. Provide shims to facilitate pipe connections, leveling, and bolting.
 4. Provide heat shields where elastomers are subject to temperatures over 38 degrees C (100 degrees F).
 5. Extend bases for pipe elbow supports at discharge and suction connections at pumps. Pipe elbow supports shall not short circuit pump vibration to structure.

6. Non-rotating equipment such as heat exchangers and convertors shall be mounted on isolation units having the same static deflection as the isolation hangers or support of the pipe connected to the equipment.

B. Spring Riser Support System

1. All vertical riser subjected to thermal expansion and/or contraction as noted herein or on the documents, shall be supported by spring isolators and central anchors designed to insure loading within design limits at structural support points. The riser design must include the initial load, initial deflection, change in deflection, final load and change in load at all spring support locations. In order to minimize load changes, the initial spring deflection must be at least 4 times the thermal movement. The submittal must also include anchor loads when installed, cold filled, and at operating temperature. Include calculated pipe stress at end conditions and branch off locations as well as installation instruction. The submittals must be stamped and signed by a licensed Professional Engineer in the employ of the vibration vendor for at least five years.
2. Neutral resilient anchors close to the center of the run shall direct movement up and down. The anchors shall be capable of holding an upward force equal to the water weight when the system is drained. If one level cannot accommodate this force, anchors can be located on 2 or 3 adjacent floors. Resilient guides shall be spaced and sized properly depending on the pipe diameter.
3. The Contractor shall provide and design all brackets at riser spring and anchor locations where standard clamps lack capacity or do not fit. The Contractor must install and adjust all isolators under the supervision of the designing isolation vendor or his representative.

- C. Inspection and Adjustments: Check for vibration and noise transmission through connections, piping, ductwork, foundations, and walls. Adjust, repair, or replace isolators as required to reduce vibration and noise transmissions to specified levels.

- D. Noise barrier duct wrap shall be installed in accordance with manufacturer's recommendations and as follows:

1. Install noise barrier on ductwork in locations and lengths as indicated on the drawings. In addition, supply and return air ductwork leaving service bay spaces above patient bedrooms in Buildings 1 and 6 will require minimum 25 feet of noise barrier wrap from service bay wall.
2. Overlap noise barrier wrap a minimum of 2 inches at seams.
3. Install duct insulation (as required by Section 23 07 11, HVAC INSULATION) over noise barrier wrap.

3.2 ADJUSTING

- A. Adjust vibration isolators after piping systems are filled and equipment is at operating weight.
- B. Adjust limit stops on restrained spring isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.
- C. Attach thrust limits at centerline of thrust and adjust to a maximum of 1/4inch (6-mm) movement during start and stop.
- D. Adjust active height of spring isolators.

3.3 VIBRATION TESTING

- A. Perform vibration tests on all pumps and fans, with motors 5 HP and larger. Refer to Section 23 05 93, TESTING, ADJUSTING AND BALANCING for HVAC.

3.4 FUNCTIONAL PERFORMANCE AND INTEGRATED SYSTEMS TESTING

- A. Functional Performance and Integrated Systems Testing (FP & IST) is part of the commissioning process. FP & IST shall be performed by the Contractor, and witnessed and documented by the Commissioning Authority. Refer to Section 019113, COMMISSIONING, for FP & IST requirements.

--- END ---

SELECTION GUIDE FOR VIBRATION ISOLATORS

EQUIPMENT		ON GRADE			20FT FLOOR SPAN			30FT FLOOR SPAN		
		BASE TYPE	ISOL TYPE	MIN DEFL	BASE TYPE	ISOL TYPE	MIN DEFL	BASE TYPE	ISOL TYPE	MIN DEFL
PUMPS										
CLOSE COUPLED	UP TO 1-1/2 HP	---	---	---	---	D,L,W	---	---	D,L,W	---
	2 HP & OVER	---	---	---	I	S	1.0	I	S	1.5
BASE MOUNTED	UP TO 10 HP	---	---	---	---	D,L,W	---	---	D,L,W	---
	15 HP THRU 40 HP	I	S	1.0	I	S	1.0	I	S	1.7
	50 HP & OVER	I	S	1.0	I	S	1.0	I	S	1.7
ROOF MOUNTED FANS										
ABOVE OCCUPIED AREAS:										
5 HP & OVER		---	---	---	CB	S	1.0	CB	S	1.0
CENTRIFUGAL FANS										
UP TO 50 HP:										
UP TO 200 RPM		B	N	0.3	B	S	2.5	B	S	2.5
201 - 300 RPM		B	N	0.3	B	S	1.7	B	S	2.5
301 - 500 RPM		B	N	0.3	B	S	1.7	B	S	1.7
501 RPM & OVER		B	N	0.3	B	S	1.0	B	S	1.0
60 HP & OVER:										
UP TO 300 RPM		B	S	1.7	I	S	2.5	I	S	3.5
301 - 500 RPM		B	S	1.7	I	S	1.7	I	S	2.5
501 RPM & OVER		B	S	1.0	I	S	1.7	I	S	1.7
AIR HANDLING UNIT PACKAGES, FAN COIL UNITS										
SUSPENDED:										
UP THRU 5 HP		---	---	---	---	H	1.0	---	H	1.0
7-1/2 HP & OVER:										
UP TO 500 RPM		---	---	---	---	H, THR	1.7	---	H, THR	1.7
501 RPM & OVER		---	---	---	---	H, THR	1.0	---	H, THR	1.0

EQUIPMENT	ON GRADE			20FT FLOOR SPAN			30FT FLOOR SPAN		
	BASE TYPE	ISOL TYPE	MIN DEFL	BASE TYPE	ISOL TYPE	MIN DEFL	BASE TYPE	ISOL TYPE	MIN DEFL
FLOOR MOUNTED:									
UP THRU 5 HP	---	D	---	---	S	1.0	---	S	1.0
7-1/2 HP & OVER:									
UP TO 500 RPM	---	D	---	R	S, THR	2.5	R	S, THR	2.5
501 RPM & OVER	---	D	---	---	S	1.5	---	S, THR	1.5
IN-LINE CENTRIFUGAL AND VANE AXIAL FANS, FLOOR MOUNTED: (ARR 9)									
UP THRU 50 HP:									
UP TO 300 RPM	---	D	---	R	S	3.5	R	S	3.5
301 - 500 RPM	---	D	---	R	S	1.7	R	S	1.7
501 - & OVER	---	D	---	---	S	1.0	---	S	1.0
60 HP AND OVER:									
301 - 500 RPM	R	S	1.5	R	S	1.7	R	S	2.5
501 RPM & OVER	R	S	1.0	R	S	1.7	R	S	1.7

NOTES:

1. For suspended floors lighter than 100mm (4 inch) thick concrete, select deflection requirements from next higher floor span.
2. Direct bolt fire pumps to concrete base. Provide pads (D) for domestic water booster pump package.
3. For floor mounted in-line centrifugal blowers (ARR 1): use "B" type in lieu of "R" type base.
4. Suspended: Use "H" isolators of same deflection as floor mounted.

SECTION 23 05 93
TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Testing, adjusting, and balancing (TAB) of heating, ventilating and air conditioning (HVAC) systems. TAB includes the following:
1. Planning systematic TAB procedures.
 2. Design Review Report.
 3. Systems Inspection report.
 4. Duct Air Leakage test report.
 5. Systems Readiness Report.
 6. Balancing air and water distribution systems; adjustment of total system to provide design performance; and testing performance of equipment and automatic controls.
 7. Vibration and sound measurements.
 8. Recording and reporting results.
- B. Definitions:
1. Basic TAB used in this Section: Chapter 37, "Testing, Adjusting and Balancing" of ASHRAE Handbook, "HVAC Applications".
 2. TAB: Testing, Adjusting and Balancing; the process of checking and adjusting HVAC systems to meet design objectives.
 3. AABC: Associated Air Balance Council.
 4. NEBB: National Environmental Balancing Bureau.
 5. Hydronic Systems: Includes chilled water, condenser water, heating hot water and glycol-water systems.
 6. Air Systems: Includes all outside air, supply air, return air, exhaust air and relief air systems.
 7. Flow rate tolerance: The allowable percentage variation, minus to plus, of actual flow rate from values (design) in the contract documents.

1.2 RELATED WORK

- A. Section 23 05 11, COMMON WORK RESULTS FOR HVAC: General Mechanical Requirements.
- B. Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT: Noise and Vibration Requirements.
- C. Section 23 07 11, HVAC INSULATION: Piping and Equipment Insulation.
- D. Section 23 36 00, AIR TERMINAL UNITS: Terminal Units Performance.
- E. Section 23 31 00, HVAC DUCTS, CASINGS AND SILENCERS: Duct Leakage.

- F. Section 23 73 00, CUSTOM INDOOR CENTRAL STATION AIR HANDLING UNITS; and Section 23 73 13, PACKAGED INDOOR CENTRAL-STATION AIR-HANDLING UNITS: Unit Factory and Field Tests.
- G. Division 25, INTEGRATED AUTOMATION: Controls and Instrumentation Settings.

1.3 QUALITY ASSURANCE

- A. Refer to Articles, Quality Assurance and Submittals, in Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
- B. Qualifications:
 - 1. TAB Agency: The TAB agency shall be a subcontractor of the General Contractor and shall report to and be paid by the General Contractor.
 - 2. The TAB agency shall be either a certified member of AABC or certified by the NEBB to perform TAB service for HVAC, water balancing and vibrations and sound testing of equipment. The certification shall be maintained for the entire duration of duties specified herein. If, for any reason, the agency loses subject certification during this period, the General Contractor shall immediately notify the Resident Engineer and submit another TAB firm for approval. Any agency that has been the subject of disciplinary action by either the AABC or the NEBB within the five years preceding Contract Award shall not be eligible to perform any work related to the TAB. All work performed in this Section and in other related Sections by the TAB agency shall be considered invalid if the TAB agency loses its certification prior to Contract completion, and the successor agency's review shows unsatisfactory work performed by the predecessor agency.
 - 3. TAB Specialist: The TAB specialist shall be either a member of AABC or an experienced technician of the Agency certified by NEBB. The certification shall be maintained for the entire duration of duties specified herein. If, for any reason, the Specialist loses subject certification during this period, the General Contractor shall immediately notify the Resident Engineer and submit another TAB Specialist for approval. Any individual that has been the subject of disciplinary action by either the AABC or the NEBB within the five years preceding Contract Award shall not be eligible to perform any duties related to the HVAC systems, including TAB. All work specified in this Section and in other related Sections performed by the TAB specialist shall be considered invalid if the TAB Specialist loses its certification prior to Contract completion and must be performed by an approved successor.
 - 4. TAB Specialist shall be identified by the General Contractor within 60 days after the notice to proceed. The TAB specialist will be coordinating, scheduling and reporting all TAB work and related activities and will provide necessary information as required by the Resident Engineer. The responsibilities would specifically include:
 - a. Shall directly supervise all TAB work.
 - b. Shall sign the TAB reports that bear the seal of the TAB standard. The reports shall be accompanied by report forms and schematic drawings required by the TAB standard, AABC or NEBB.
 - c. Would follow all TAB work through its satisfactory completion.
 - d. Shall provide final markings of settings of all HVAC adjustment devices.
 - e. Permanently mark location of duct test ports.
 - 5. All TAB technicians performing actual TAB work shall be experienced and must have done satisfactory work on a minimum of 3 projects comparable in size and complexity to this project. Qualifications must be certified by the TAB agency in writing.

- C. Test Equipment Criteria: The instrumentation shall meet the accuracy/calibration requirements established by AABC National Standards or by NEBB Procedural Standards for Testing, Adjusting and Balancing of Environmental Systems and instrument manufacturer. Provide calibration history of the instruments to be used for test and balance purpose.
- D. Tab Criteria:
1. One or more of the applicable AABC, NEBB or SMACNA publications, supplemented by ASHRAE Handbook "HVAC Applications" Chapter 36, and requirements stated herein shall be the basis for planning, procedures, and reports.
 2. Flow rate tolerance: Following tolerances are allowed. For tolerances not mentioned herein follow ASHRAE Handbook "HVAC Applications", Chapter 36, as a guideline. Air Filter resistance during tests, artificially imposed if necessary, shall be at least 90 percent of final values for pre-filters and after-filters.
 - a. Air handling unit and all other fans, cubic meters/min (cubic feet per minute): Minus 0 percent to plus 10 percent.
 - b. Air terminal units (maximum values): Minus 2 percent to plus 10 percent.
 - c. Exhaust hoods/cabinets: 0 percent to plus 10 percent.
 - d. Minimum outside air: 0 percent to plus 10 percent.
 - e. Individual room air outlets and inlets, and air flow rates not mentioned above: Minus 2 percent to plus 10 percent except if the air to a space is 100 CFM or less the tolerance would be 0 to plus 5 percent.
 - f. Heating hot water pumps and hot water coils: Minus 5 percent to plus 5 percent.
 - g. Chilled water and condenser water pumps: 0 percent to plus 5 percent.
 - h. Chilled water coils: 0 percent to plus 5 percent.
 3. Systems shall be adjusted for energy efficient operation as described in PART 3.
 4. Typical TAB procedures and results shall be demonstrated to the Resident Engineer for one air distribution system (including all fans, three terminal units, three rooms) and one hydronic system (pumps and three coils) as follows:
 - a. When field TAB work begins.
 - b. During each partial final inspection and the final inspection for the project if requested by VA.

1.4 SUBMITTALS

- A. Submit in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.
- B. Submit names and qualifications of TAB agency and TAB specialists within 60 days after the notice to proceed. Submit information on three recently completed projects and a list of proposed test equipment.
- C. For use by the Resident Engineer staff, submit one complete set of applicable AABC or NEBB publications that will be the basis of TAB work.
- D. Submit Following for Review and Approval:
1. Design Review Report within 90 days for conventional design projects after the system layout on air and water side is completed by the Contractor.
 2. Systems inspection report on equipment and installation for conformance with design.
 3. Duct Air Leakage Test Report.

4. Systems Readiness Report.
 5. Intermediate and Final TAB reports covering flow balance and adjustments, performance tests, vibration tests and sound tests.
 6. Include in final reports uncorrected installation deficiencies noted during TAB and applicable explanatory comments on test results that differ from design requirements.
- E. Prior to request for Final or Partial Final inspection, submit completed Test and Balance report for the area.

1.5 APPLICABLE PUBLICATIONS

- A. The following publications form a part of this specification to the extent indicated by the reference thereto. In text the publications are referenced to by the acronym of the organization.
- B. American Society of Heating, Refrigerating and Air Conditioning Engineers, Inc. (ASHRAE):
2007Applications ASHRAE Handbook, Chapter 37, Testing, Adjusting, and Balancing and Chapter 47, Sound and Vibration Control
- C. Associated Air Balance Council (AABC):
2002.....AABC National Standards for Total System Balance
- C. National Environmental Balancing Bureau (NEBB):
7th Edition 2005.....Procedural Standards for Testing, Adjusting, Balancing of Environmental Systems
1st Edition 1994.....Procedural Standards for the Measurement and Assessment of Sound and Vibration
2nd Edition 1999Procedural Standards for Building Systems Commissioning
- D. Sheet Metal and Air Conditioning Contractors National Association (SMACNA):
3rd Edition 2002.....HVAC SYSTEMS-Testing, Adjusting and Balancing

PART 2 - PRODUCTS

2.1 PLUGS

- A. Provide plastic plugs to seal holes drilled in ductwork for test purposes.

2.2 INSULATION REPAIR MATERIAL

- A. See Section 23 07 11, HVAC INSULATION. Provide for repair of insulation removed or damaged for TAB work.

PART 3 - EXECUTION

3.1 GENERAL

- A. Refer to TAB Criteria in Article, Quality Assurance.

- B. Obtain applicable contract documents and copies of approved submittals for HVAC equipment and automatic control systems.

3.2 DESIGN REVIEW REPORT

- A. The TAB Specialist shall review the Contract Plans and specifications and advise the Resident Engineer of any design deficiencies that would prevent the HVAC systems from effectively operating in accordance with the sequence of operation specified or prevent the effective and accurate TAB of the system. The TAB Specialist shall provide a report individually listing each deficiency and the corresponding proposed corrective action necessary for proper system operation.

3.3 SYSTEMS INSPECTION REPORT

- A. Inspect equipment and installation for conformance with design.
- B. The inspection and report is to be done after air distribution equipment is on site and duct installation has begun, but well in advance of performance testing and balancing work. The purpose of the inspection is to identify and report deviations from design and ensure that systems will be ready for TAB at the appropriate time.
- C. Reports: Follow check list format developed by AABC, NEBB or SMACNA, supplemented by narrative comments, with emphasis on air handling units and fans. Check for conformance with submittals. Verify that diffuser and register sizes are correct. Check air terminal unit installation including their duct sizes and routing.

3.4 DUCT AIR LEAKAGE TEST REPORT

- A. See paragraphs "Duct leakage Tests and Repairs" in Section 23 31 00, HVAC DUCTS, CASINGS AND SILENCERS for TAB agency's role and responsibilities in witnessing, recording and reporting of deficiencies.

3.5 SYSTEM READINESS REPORT

- A. Inspect each System to ensure that it is complete including installation and operation of controls.
- B. Verify that all items such as ductwork piping, ports, terminals, connectors, etc., that is required for TAB is installed. Provide a report to the Resident Engineer.

3.6 TAB REPORTS

- A. Submit an intermediate report for 50 percent of systems and equipment tested and balanced to establish satisfactory test results.
- B. The TAB contractor shall provide raw data immediately in writing to the Resident Engineer if there is a problem in achieving intended results before submitting a formal report.

- C. If over 20 percent of readings in the intermediate report fall outside the acceptable range, the TAB report shall be considered invalid and all contract TAB work shall be repeated and re-submitted for approval.
- D. Do not proceed with the remaining systems until intermediate report is approved by the Resident Engineer.

3.7 TAB PROCEDURES

- A. TAB shall be performed in accordance with the requirement of the Standard under which TAB agency is certified by either AABC or NEBB.
- B. General: During TAB all related system components shall be in full operation. Fan and pump rotation, motor loads and equipment vibration shall be checked and corrected as necessary before proceeding with TAB. Set controls and/or block off parts of distribution systems to simulate design operation of variable volume air or water systems for test and balance work.
- C. Coordinate TAB procedures with any phased construction completion requirements for the project. Provide TAB reports for each phase of the project prior to partial final inspections of each phase of the project.
- D. Allow sufficient time in construction schedule for TAB and submission of all reports for an organized and timely correction of deficiencies.
- E. Air Balance and Equipment Test: Include air handling units, fans, terminal units, fan coil units, room diffusers/outlets/inlets, computer room AC units, and laboratory fume hoods and cabinets.
 - 1. Artificially load air filters by partial blanking to produce air pressure drop of at least 90 percent of the design final pressure drop.
 - 2. Adjust fan speeds to provide design air flow. V-belt drives, including fixed pitch pulley requirements, are specified in Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
 - 3. Test and balance systems in all specified modes of operation, including variable volume, economizer, and fire emergency modes. Verify that dampers and other controls function properly.
 - 4. Variable air volume (VAV) systems:
 - a. Coordinate TAB, including system volumetric controls, with Division 25, INTEGRATED AUTOMATION.
 - b. Section 23 36 00, AIR TERMINAL UNITS, specifies that maximum and minimum flow rates for air terminal units (ATU) be factory set. Check and readjust ATU flow rates if necessary. Balance air distribution from ATU on full cooling maximum scheduled cubic meters per minute (cubic feet per minute). Reset room thermostats and check ATU operation from maximum to minimum cooling, to the heating mode, and back to cooling. Record and report the heating coil leaving air temperature when the ATU is in the maximum heating mode.
 - 5. Record final measurements for air handling equipment performance data sheets.
- F. Water Balance and Equipment Test: Include circulating pumps, heat exchangers, coils, evaporators and condensers:
 - 1. Adjust flow rates for equipment. Set coils and evaporator to values on equipment submittals, if different from values on contract drawings.

2. Variable Volume Systems: Coordinate TAB with Division 25 – INTEGRATED AUTOMATION. Balance systems at design water flow and then verify that variable flow controls function properly.
3. Record final measurements for hydronic equipment on performance data sheets. Include entering and leaving water temperatures for heating and cooling coils, and for heat exchangers. Include entering and leaving air temperatures (DB/WB for cooling coils) for air handling units and reheat coils. Make air and water temperature measurements at the same time.

3.8 VIBRATION TESTING

- A. Furnish instruments and perform vibration measurements as specified in Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT.
- B. Field vibration balancing is specified in Section 23 05 11, COMMON WORK RESULTS FOR HVAC. Provide measurements for all rotating HVAC equipment of 3700 watts (5 horsepower) and larger, including cooling towers, pumps, fans and motors.
- C. Field vibration testing of custom air handling units is specified in Section 23 73 00, CUSTOM INDOOR CENTRAL STATION AIR HANDLING UNITS.
- D. Record initial measurements for each unit of equipment on test forms and submit a report to the Resident Engineer. Where vibration readings exceed the allowable tolerance Contractor shall be directed to correct the problem. The TAB agency shall verify that the corrections are done and submit a final report to the Resident Engineer.

3.9 SOUND TESTING

- A. Perform and record required sound measurements in accordance with Paragraph, QUALITY ASSURANCE in Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT.
 1. Take readings in rooms, approximately three (3) percent of all rooms. The Resident Engineer may designate the specific rooms to be tested.
- B. Take measurements with a calibrated sound level meter and octave band analyzer of the accuracy required by AABC or NEBB.
- C. Sound reference levels, formulas and coefficients shall be according to ASHRAE Handbook, "HVAC Applications", Chapter 47, SOUND AND VIBRATION CONTROL.
- D. Determine compliance with specifications as follows:
 1. When sound pressure levels are specified, including the NC Criteria in Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT:
 - a. Reduce the background noise as much as possible by shutting off unrelated audible equipment.
 - b. Measure octave band sound pressure levels with specified equipment "off."
 - c. Measure octave band sound pressure levels with specified equipment "on."
 - d. Use the DIFFERENCE in corresponding readings to determine the sound pressure due to equipment.

DIFFERENCE:	0	1	2	3	4	5 to 9	10 or More
FACTOR:	10	7	4	3	2	1	0

- e. Sound pressure level due to equipment equals sound pressure level with equipment "on" minus FACTOR.
 - f. Plot octave bands of sound pressure level due to equipment for typical rooms on a graph which also shows noise criteria (NC) curves.
2. When sound power levels are specified:
 - a. Perform steps 1.a. thru 1.d., as above.
 - b. For indoor equipment: Determine room attenuating effect, i.e., difference between sound power level and sound pressure level. Determined sound power level will be the sum of sound pressure level due to equipment plus the room attenuating effect.
 - c. For outdoor equipment: Use directivity factor and distance from noise source to determine distance factor, i.e., difference between sound power level and sound pressure level. Measured sound power level will be the sum of sound pressure level due to equipment plus the distance factor. Use 13 meters (40 feet) for sound level location.
 3. Where sound pressure levels are specified in terms of dB(A), as in Section 23 65 00, COOLING TOWERS, measure sound levels using the "A" scale of meter. Single value readings will be used instead of octave band analysis.
- E. Where measured sound levels exceed specified level, the installing contractor or equipment manufacturer shall take remedial action approved by the Resident Engineer and the necessary sound tests shall be repeated.

3.10 MARKING OF SETTINGS

- A. Following approval of Tab final Report, the setting of all HVAC adjustment devices including valves, splitters and dampers shall be permanently marked by the TAB Specialist so that adjustment can be restored if disturbed at any time. Style and colors used for markings shall be coordinated with the Resident Engineer.

3.11 IDENTIFICATION OF TEST PORTS

- A. The TAB Specialist shall permanently and legibly identify the location points of duct test ports. If the ductwork has exterior insulation, the identification shall be made on the exterior side of the insulation. All penetrations through ductwork and ductwork insulation shall be sealed to prevent air leaks and maintain integrity of vapor barrier.

--- END ---

SECTION 23 07 11
HVAC INSULATION

PART 1 - GENERAL

1.1 DESCRIPTION

A. Field applied insulation for thermal efficiency and condensation control for

1. HVAC piping, ductwork and equipment.

B. Definitions

1. ASJ: All service jacket, white finish facing or jacket.
2. Air conditioned space: Space having air temperature and/or humidity controlled by mechanical equipment.
3. Cold: Equipment, ductwork or piping handling media at design temperature of 16 degrees C (60 degrees F) or below.
4. Concealed: Ductwork and piping above ceilings and in chases and pipe spaces.
5. Exposed: Piping, ductwork, and equipment exposed to view in finished areas including mechanical equipment rooms or exposed to outdoor weather. Spaces where air handling units are located are considered to be mechanical rooms. Shafts, chases, crawl spaces and pipe basements are not considered finished areas.
6. FSK: Foil-scrim-kraft facing.
7. Hot: HVAC Ductwork handling air at design temperature above 16 degrees C (60 degrees F); HVAC equipment or piping handling media above 41 degrees C (105 degrees F); piping media and equipment 32 to 230 degrees C (90 to 450 degrees F)
8. Density: kg/m^3 - kilograms per cubic meter (Pcf - pounds per cubic foot).
9. Runouts: Branch pipe connections up to 25-mm (one-inch) nominal size to fan coil units or reheat coils for terminal units.
10. Thermal conductance: Heat flow rate through materials.
 - a. Flat surface: Watt per square meter (BTU per hour per square foot).
 - b. Pipe or Cylinder: Watt per square meter (BTU per hour per linear foot).
11. Thermal Conductivity (k): Watt per meter, per degree C (BTU per inch thickness, per hour, per square foot, per degree F temperature difference).
12. HPS: High pressure steam (415 kPa [60 psig] and above).
13. HPR: High pressure steam condensate return.
14. MPS: Medium pressure steam (110 kPa [16 psig] thru 414 kPa [59 psig]).
15. MPR: Medium pressure steam condensate return.
16. LPS: Low pressure steam (103 kPa [15 psig] and below).
17. LPR: Low pressure steam condensate gravity return.
18. PC: Pumped condensate.
19. HWH: Hot water heating supply.
20. HWHR: Hot water heating return.
21. CPD: Condensate pump discharge.
22. R: Pump recirculation.
23. CH: Chilled water supply.
24. CHR: Chilled water return.
25. CWR: Condenser water return.
26. CWS: Condenser water supply.

- 27. CW: Cold water.
- 28. SW: Soft water.
- 29. HW: Hot water.
- 30. PVDC: Polyvinylidene chloride vapor retarder jacketing, white.

1.2 RELATED WORK

- A. Section 07 84 00, FIRESTOPPING: Mineral fiber and bond breaker behind sealant.
- B. Section 23 05 11, COMMON WORK RESULTS FOR HVAC: General mechanical requirements and items, which are common to more than one section of Division 23.
- C. Section 23 21 13, HYDRONIC PIPING and Section 23 22 13, STEAM AND CONDENSATE HEATING PIPING: Piping and equipment.
- D. Section 23 31 00, HVAC DUCTS, CASINGS AND SILENCERS: Ductwork, plenum and fittings.

1.3 QUALITY ASSURANCE

- A. Refer to article QUALITY ASSURANCE, in Section 23 05 11, COMMON WORK RESULTS FOR HVAC AND STEAM GENERATION.
- B. Criteria:

- 1. Comply with NFPA 90A, particularly paragraphs 4.3.3.1 through 4.3.3.6, 4.3.10.2.6, and 5.4.6.4, parts of which are quoted as follows:

4.3.3.1 Pipe insulation and coverings, duct coverings, vapor retarder facings, adhesives, fasteners, tapes, and supplementary materials added to air ducts, plenums, panels, and duct silencers used in duct systems, unless otherwise provided for in 4.3.3.1.2 or 4.3.3.1.3, shall have, in the form in which they are used, a maximum flame spread index of 25 without evidence of continued progressive combustion and a maximum smoke developed index of 50 when tested in accordance with NFPA 255, *Standard Method of Test of Surface Burning Characteristics of Building Materials*.

4.3.3.1.1 Where these products are to be applied with adhesives, they shall be tested with such adhesives applied, or the adhesives used shall have a maximum flame spread index of 25 and a maximum smoke developed index of 50 when in the final dry state.

4.3.3.1.2 The flame spread and smoke developed index requirements of 4.3.3.1.1 shall not apply to air duct weatherproof coverings where they are located entirely outside of a building, do not penetrate a wall or roof, and do not create an exposure hazard.

4.3.3.2 Closure systems for use with rigid and flexible air ducts tested in accordance with UL 181, Standard for Safety Factory-Made Air Ducts and Air Connectors, shall have been tested, listed, and used in accordance with the conditions of their listings, in accordance with one of the following:

- a. UL 181A, Standard for Safety Closure Systems for Use with Rigid Air Ducts and Air Connectors
- b. UL 181B, Standard for Safety Closure Systems for Use with Flexible Air Ducts and Air Connectors

4.3.3.3 Air duct, panel, and plenum coverings, and pipe insulation and coverings shall not flame, glow, smolder, or smoke when tested in accordance with a similar test for pipe covering, ASTM C 411, Standard Test Method for Hot-Surface Performance of High-Temperature Thermal Insulation, at the temperature to which they are exposed in service.

4.3.3.3.1 In no case shall the test temperature be below 121°C (250°F).

4.3.3.4 Air duct coverings shall not extend through walls or floors that are required to be fire stopped or required to have a fire resistance rating, unless such coverings meet the requirements of 5.4.6.4.

4.3.3.6 Air duct coverings shall not be installed so as to conceal or prevent the use of any service opening.

4.3.10.2.6 Materials exposed to the airflow shall be noncombustible or limited combustible and have a maximum smoke developed index of 50 or comply with the following.

4.3.10.2.6.6 Supplementary materials for air distribution systems shall be permitted when complying with the provisions of 4.3.3.

4.3.10.2.6.7 Smoke detectors shall not be required to meet the provisions of this section.

5.4.6.4 Where air ducts pass through walls, floors, or partitions that are required to have a fire resistance rating and where fire dampers are not required, the opening in the construction around the air duct shall be as follows:

- a. Not exceeding a 25.4 mm (1 in.) average clearance on all sides
 - b. Filled solid with an approved material capable of preventing the passage of flame and hot gases sufficient to ignite cotton waste when subjected to the time-temperature fire conditions required for fire barrier penetration as specified in NFPA 251, *Standard Methods of Tests of Fire Endurance of Building Construction and Materials*
2. Test methods: ASTM E84, UL 723, or NFPA 255.
 3. Specified k factors are at 24 degrees C (75 degrees F) mean temperature unless stated otherwise. Where optional thermal 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.
 4. All materials shall be compatible and suitable for service temperature, and shall not contribute to corrosion or otherwise attack surface to which applied in either the wet or dry state.
- C. Every package or standard container of insulation or accessories delivered to the job site for use must have a manufacturer's stamp or label giving the name of the manufacturer and description of the material.

1.5 SUBMITTALS

- A. Submit in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.

B. Shop Drawings:

1. All information, clearly presented, shall be included to determine compliance with drawings and specifications and ASTM, federal and military specifications.
 - a. Insulation materials: Specify each type used and state surface burning characteristics.
 - b. Insulation facings and jackets: Each type used. Make it clear that white finish will be furnished for exposed ductwork, casings and equipment.
 - c. Insulation accessory materials: Each type used.
 - d. Manufacturer's installation and fitting fabrication instructions for flexible unicellular insulation.
 - e. Make reference to applicable specification paragraph numbers for coordination.
 - f. Calculate minimum thickness insulation for each application with actual K value, if larger than specified, to meet minimum equivalent thickness insulation and ASHRAE Standard 90.1 2007.

C. Samples:

1. Each type of insulation: Minimum size 100 mm (4 inches) square for board/block/ blanket; 150 mm (6 inches) long, full diameter for round types.
2. Each type of facing and jacket: Minimum size 100 mm (4 inches square).
3. Each accessory material: Minimum 120 ML (4 ounce) liquid container or 120 gram (4 ounce) dry weight for adhesives / cement / mastic.

1.6 STORAGE AND HANDLING OF MATERIAL

- A. Store materials in clean and dry environment, pipe covering jackets shall be clean and unmarred. Place adhesives in original containers. Maintain ambient temperatures and conditions as required by printed instructions of manufacturers of adhesives, mastics and finishing cements.

1.7 APPLICABLE PUBLICATIONS

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by basic designation only.

B. Military Specifications (Mil. Spec.):

MIL-A-3316C (2)-90.....Adhesives, Fire-Resistant, Thermal Insulation
MIL-A-24179A (1)-87.....Adhesive, Flexible Unicellular-Plastic Thermal Insulation
MIL-C-19565C (1)-88Coating Compounds, Thermal Insulation, Fire-and Water-Resistant, Vapor-Barrier
MIL-C-20079H-87Cloth, Glass; Tape, Textile Glass; and Thread, Glass and Wire-Reinforced Glass

C. American Society for Testing and Materials (ASTM):

A167-99.....Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip

B209-04	Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate
C411-97	Standard test method for Hot-Surface Performance of High-Temperature Thermal Insulation
C449-00	Standard Specification for Mineral Fiber Hydraulic-Setting Thermal Insulating and Finishing Cement
C533-04	Standard Specification for Calcium Silicate Block and Pipe Thermal Insulation
C534-05	Standard Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form
C547-06	Standard Specification for Mineral Fiber pipe Insulation
C552-03	Standard Specification for Cellular Glass Thermal Insulation
C553-02	Standard Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications
C585-90	Standard Practice for Inner and Outer Diameters of Rigid Thermal Insulation for Nominal Sizes of Pipe and Tubing (NPS System) R (1998)
C612-04	Standard Specification for Mineral Fiber Block and Board Thermal Insulation
C1126-04	Standard Specification for Faced or Unfaced Rigid Cellular Phenolic Thermal Insulation
C1136-06	Standard Specification for Flexible, Low Permeance Vapor Retarders for Thermal Insulation
D1668-97a (2006)	Standard Specification for Glass Fabrics (Woven and Treated) for Roofing and Waterproofing
E84-06	Standard Test Method for Surface Burning Characteristics of Building Materials
E119-05a	Standard Test Method for Fire Tests of Building Construction and Materials
E136-04	Standard Test Methods for Behavior of Materials in a Vertical Tube Furnace at 750 degrees C (1380 F)

D. National Fire Protection Association (NFPA):

90A-02	Installation of Air Conditioning and Ventilating Systems
101-06	Life Safety Code

E. Manufacturer's Standardization Society of the Valve and Fitting Industry (MSS):

SP58-2002	Pipe Hangers and Supports Materials, Design, and Manufacture
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PART 2 - PRODUCTS

2.1 MINERAL FIBER OR FIBER GLASS

- A. ASTM C612 (Board, Block), Class 1 or 2, density 48 kg/m³ (3 pcf), k = 0.037 (0.26) at 24 degrees C (75 degrees F), external insulation for temperatures up to 204 degrees C (400 degrees F) with foil scrim (FSK) facing.
- B. ASTM C553 (Blanket, Flexible) Type I, Class B-5, Density 16 kg/m³ (1 pcf), k = 0.04 (0.27) at 24 degrees C (75 degrees F), for use at temperatures up to 121 degrees C (250 degrees F) with foil scrim (FSK) facing.

- C. ASTM C547 (Pipe Fitting Insulation and Preformed Pipe Insulation), Class 1, $k = 0.037$ (0.26) at 24 degrees C (75 degrees F), for use at temperatures up to 230 degrees C (450 degrees F) with an all service vapor retarder jacket with polyvinyl chloride pre-molded fitting covering.

2.2 MINERAL WOOL OR REFRACTORY FIBER

- A. Comply with Standard ASTM C612, Class 3, 450 degrees C (850 degrees F).

2.3 RIGID CELLULAR PHENOLIC FOAM

- A. Preformed (molded) pipe insulation, ASTM C1126, type III, grade 1, $k = 0.021$ (0.15) at 10 degrees C (50 degrees F), for use at temperatures up to 121 degrees C (250 degrees F) with all service vapor retarder jacket with polyvinyl chloride premolded fitting covering.
- B. Equipment and Duct Insulation, ASTM C 1126, type II, grade 1, $k = 0.021$ (0.15) at 10 degrees C (50 degrees F), for use at temperatures up to 121 degrees C (250 degrees F) with rigid cellular phenolic insulation and covering, and all service vapor retarder jacket.

2.4 CELLULAR GLASS CLOSED-CELL

- A. Comply with Standard ASTM C177, C518, density 120 kg/m^3 (7.5 pcf) nominal, $k = 0.033$ (0.29) at 24 degrees C (75 degrees F).
- B. Pipe insulation for use at temperatures up to 200 degrees C (400 degrees F) with all service vapor retarder jacket.

2.5 POLYISOCYANURATE CLOSED-CELL RIGID

- A. Preformed (fabricated) pipe insulation, ASTM C591, type IV, $K=0.027$ (0.19) at 24 degrees C (75 degrees F), flame spread not over 25, smoke developed not over 50, for use at temperatures up to 149 degree C (300 degree F) with factory applied PVDC or all service vapor retarder jacket with polyvinyl chloride premolded fitting covers.
- B. Equipment and duct insulation, ASTM C 591,type IV, $K=0.027$ (0.19) at 24 degrees C (75 degrees F), for use at temperatures up to 149 degrees C (300 degrees F) with PVDC or all service jacket vapor retarder jacket.

2.6 FLEXIBLE ELASTOMERIC CELLULAR THERMAL

- A. ASTM C177, C518, $k = 0.039$ (0.27) at 24 degrees C (75 degrees F), flame spread not over 25, smoke developed not over 50, for temperatures from minus 4 degrees C (40 degrees F) to 93 degrees C (200 degrees F). No jacket required.

2.7 DUCT WRAP FOR KITCHEN HOOD GREASE DUCTS

- A. Light weight, high temperature mineral fiber or ceramic fiber insulating material with low thermal conductivity K value of 0.060 W/m^2 degrees C ($0.417 \text{ Btu in/hr ft}^2$ degrees F) at mean temperature of 260 degrees C (500 degrees F).

- B. Material shall be fully encapsulated by UL classified aluminum foil and tested to ASTM E84 standard.
- C. Material shall be UL tested for internal grease fire to 1093 degrees C (2,000 degrees F) with zero clearance and for through-penetration firestop.
- D. Material shall be UL classified for // 1 hour // 2 hour // fire rating for grease duct enclosure, and meet NFPA 96 requirements for direct applied insulating material to grease ducts with zero clearance.
- E. Material flame spread and smoke developed ratings shall not be higher than 5, as per ASTM E 84/UL 723 Flammability Test.

2.8 CALCIUM SILICATE

- A. Preformed pipe Insulation: ASTM C533, Type I with indicator denoting asbestos-free material.
- B. Pre-molded Pipe Fitting Insulation: ASTM C533, Type I with indicator denoting asbestos-free material.
- C. Equipment Insulation: ASTM C533, Type I
- D. Characteristics:

Insulation Characteristics		
ITEMS	TYPE I	
Temperature, maximum degrees C (degrees F)	649 (1200)	
Density (dry), Kg/m ³ (lb/ ft3)	232 (14.5)	
Thermal conductivity: Min W/ m K (Btu in/h ft ² degrees F) @ mean temperature of 93 degrees C (200 degrees F)	0.059 (0.41)	
Surface burning characteristics: Flame spread Index, Maximum	0	
Smoke Density index, Maximum	0	

2.9 INSULATION FACINGS AND JACKETS

- A. Vapor Retarder, higher strength with low water permeance ≤ 0.02 or less perm rating, Beach puncture 50 units for insulation facing on exposed ductwork, casings and equipment, and for pipe insulation jackets. Facings and jackets shall be all service type (ASJ) or PVDC Vapor Retarder jacketing.
- B. ASJ jacket shall be white kraft bonded to 0.025 mm (1 mil) thick aluminum foil, fiberglass reinforced, with pressure sensitive adhesive closure. Comply with ASTM C1136. Beach puncture 5 units, Suitable for painting without sizing. Jackets shall have minimum 40 mm (1-1/2 inch) lap on longitudinal joints and minimum 100 mm (4 inch) butt strip on end joints. Butt strip material shall be same as the jacket. Lap and butt strips shall be self-sealing type with factory-applied pressure sensitive adhesive.

- C. Vapor Retarder medium strength with low water vapor permeance of 0.02 or less perm rating), Beach puncture 25 units: Foil-Scrim-Kraft (FSK) or PVDC vapor retarder jacketing type for concealed ductwork and equipment.
- D. Field applied vapor barrier jackets shall be provided, in addition to the specified facings and jackets, on all exterior piping and ductwork as well as on interior piping and ductwork exposed to outdoor air (i.e.; in ventilated attics, piping in ventilated (not air conditioned) spaces, etc.) in high humidity areas conveying fluids below ambient temperature. The vapor barrier jacket shall consist of a multi-layer laminated cladding with a maximum water vapor permeance of 0.001 perms. The minimum puncture resistance shall be 35 cm-kg (30 inch-pounds) for interior locations and 92 cm-kg (80 inch-pounds) for exterior or exposed locations or where the insulation is subject to damage.
- E. Glass Cloth Jackets: Presized, minimum 0.18 kg per square meter (7.8 ounces per square yard), 2000 kPa (300 psig) bursting strength with integral vapor retarder where required or specified. Weather proof if utilized for outside service.
- F. Factory composite materials may be used provided that they have been tested and certified by the manufacturer.
- G. Pipe fitting insulation covering (jackets): Fitting covering shall be premolded to match shape of fitting and shall be polyvinyl chloride (PVC) conforming to Fed Spec L-P-335, composition A, Type II Grade GU, and Type III, minimum thickness 0.7 mm (0.03 inches). Provide color matching vapor retarder pressure sensitive tape.
- H. Aluminum Jacket-Piping systems: ASTM B209, 3003 alloy, H-14 temper, 0.6 mm (0.023 inch) minimum thickness with locking longitudinal joints. Jackets for elbows, tees and other fittings shall be factory-fabricated to match shape of fitting and of 0.6 mm (0.024) inch minimum thickness aluminum. Fittings shall be of same construction as straight run jackets but need not be of the same alloy. Factory-fabricated stainless steel bands shall be installed on all circumferential joints. Bands shall be 20 mm (0.75 inch) wide on 450 mm (18 inch) centers. System shall be weatherproof where utilized for outside service.
- I. Aluminum jacket: ASTM B209, 3003 alloy, H-14 temper, 0.5 mm (0.020 inches) thick with 32 mm (1-1/4 inch) corrugations or 0.8 mm (0.032 inches) thick with no corrugations. System shall be weatherproof where used for outside service.

2.10 REMOVABLE INSULATION JACKETS

- A. Insulation and Jacket:
 - 1. Non-Asbestos Glass mat, type E needled fiber.
 - 2. Temperature maximum of 450°F, Maximum water vapor transmission of 0.00 perm and maximum moisture absorption of 0.2 percent by volume.
 - 3. Jacket Material: Silicon/fiberglass and LFP 2109 pure PTFE.
 - 4. Construction: One piece jacket body with three-ply braided pure Teflon or Kevlar thread and insulation sewn as part of jacket. Belt fastened.

2.11 PIPE COVERING PROTECTION SADDLES

- A. Cold pipe support: Premolded pipe insulation 180 degrees (half-shells) on bottom half of pipe at supports. Material shall be cellular glass or high density insulation of the same thickness as adjacent insulation. Density of insulation shall be a minimum of 48 kg/m³ (3.0 pcf).

Nominal Pipe Size and Accessories Material (Insert Blocks)	
Nominal Pipe Size mm (inches)	Insert Blocks mm (inches)
Up through 125 (5)	150 (6) long
150 (6)	150 (6) long
200 (8), 250 (10), 300 (12)	225 (9) long

- B. Warm or hot pipe supports: Premolded pipe insulation (180 degree half-shells) on bottom half of pipe at supports. Material shall be calcium silicate. Insulation at supports shall have same thickness as adjacent insulation. Density of insulation shall be a minimum of 48 kg/m^3 (3.0 pcf).

2.12 ADHESIVE, MASTIC, CEMENT

- A. Mil. Spec. MIL-A-3316, Class 1: Jacket and lap adhesive and protective finish coating for insulation.
- B. Mil. Spec. MIL-A-3316, Class 2: Adhesive for laps and for adhering insulation to metal surfaces.
- C. Mil. Spec. MIL-A-24179, Type II Class 1: Adhesive for installing flexible unicellular insulation and for laps and general use.
- D. Mil. Spec. MIL-C-19565, Type I: Protective finish for outdoor use.
- E. Mil. Spec. MIL-C-19565, Type I or Type II: Vapor barrier compound for indoor use.
- F. ASTM C449: Mineral fiber hydraulic-setting thermal insulating and finishing cement.
- G. Other: Insulation manufacturers' published recommendations.

2.13 MECHANICAL FASTENERS

- A. 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.
- B. Staples: Outward clinching monel or stainless steel.
- C. Wire: 1.3 mm thick (18 gage) soft annealed galvanized or 1.9 mm (14 gage) copper clad steel or nickel copper alloy.
- D. Bands: 20 mm (3/4 inch) nominal width, brass, galvanized steel, aluminum or stainless steel.

2.14 REINFORCEMENT AND FINISHES

- A. Glass fabric, open weave: ASTM D1668, Type III (resin treated) and Type I (asphalt treated).

- B. Glass fiber fitting tape: Mil. Spec MIL-C-20079, Type II, Class 1.
- C. Tape for Flexible Elastomeric Cellular Insulation: As recommended by the insulation manufacturer.
- D. Hexagonal wire netting: 25 mm (one inch) mesh, 0.85 mm thick (22 gage) galvanized steel.
- E. Corner beads: 50 mm (2 inch) by 50 mm (2 inch), 0.55 mm thick (26 gage) galvanized steel; or, 25 mm (1 inch) by 25 mm (1 inch), 0.47 mm thick (28 gage) aluminum angle adhered to 50 mm (2 inch) by 50 mm (2 inch) Kraft paper.
- F. PVC fitting cover: Fed. Spec L-P-535, Composition A, 11-86 Type II, Grade GU, with Form B Mineral Fiber insert, for media temperature 4 degrees C (40 degrees F) to 121 degrees C (250 degrees F). Below 4 degrees C (40 degrees F) and above 121 degrees C (250 degrees F). Provide double layer insert. Provide color matching vapor barrier pressure sensitive tape.

2.15 FIRESTOPPING MATERIAL

- A. Other than pipe and duct insulation, refer to Section 07 84 00 FIRESTOPPING.

2.16 FLAME AND SMOKE

- A. Unless shown otherwise all assembled systems shall meet flame spread 25 and smoke developed 50 rating as developed under ASTM, NFPA and UL standards and specifications. See paragraph 1.4 "Quality Assurance".

PART 3 - EXECUTION

3.1 GENERAL REQUIREMENTS

- A. Required pressure tests of duct and piping joints and connections shall be completed and the work approved by the Resident Engineer prior to application of insulation. Surface shall be clean and dry with all foreign materials, such as dirt, oil, loose scale and rust removed.
- B. Except for specific exceptions, insulate entire specified equipment, piping (pipe, fittings, valves, accessories), and duct systems. Insulate each pipe and duct individually. Do not use scrap pieces of insulation where a full length section will fit.
- C. 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 retarders shall be continuous and uninterrupted throughout systems with operating temperature 16 degrees C (60 degrees 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 150 mm (6 inches).
- D. Install vapor stops at all insulation terminations on either side of valves, pumps and equipment and particularly in straight lengths of pipe insulation.


- E. Construct insulation on parts of equipment such as heat exchangers that must be opened periodically for maintenance or repair, so insulation can be removed and replaced without damage. Install insulation with bolted 1 mm thick (20 gage) galvanized steel or aluminum covers as complete units, or in sections, with all necessary supports, and split to coincide with flange/split of the equipment.
- F. All chilled water system piping, components and accessories are to be insulated in a manner so as to provide a complete, uninterrupted vapor barrier.
- G. Insulation on hot piping and equipment shall be terminated square at items not to be insulated, access openings and nameplates. Cover all exposed raw insulation with white sealer or jacket material.
- H. Protect all insulations outside of buildings with aluminum jacket using lock joint or other approved system for a continuous weather tight system. Access doors and other items requiring maintenance or access shall be removable and sealable.
- I. HVAC work not to be insulated
 - 1. Exhaust air ducts and plenums, and ventilation exhaust air shafts.
 - 2. Equipment: Expansion tanks, flash tanks, hot water pumps, steam condensate pumps.
 - 3. In hot piping: Unions, flexible connectors, control valves, safety relief valves, vacuum breakers, thermostatic vent valves, steam traps 20 mm (3/4 inch) and smaller. Insulate piping to within approximately 75 mm (3 inches) of uninsulated items.
- J. Apply insulation materials subject to the manufacturer's recommended temperature limits. Apply adhesives, mastic and coatings at the manufacturer's recommended minimum coverage.
- K. Elbows, flanges and other fittings shall be insulated with the same material as is used on the pipe straights. The elbow/ fitting insulation shall be field-fabricated, mitered or factory prefabricated to the necessary size and shape to fit on the elbow/ fitting. Use of polyurethane spray-foam to fill a PVC elbow jacket is prohibited on cold applications.
- L. Firestop Pipe and Duct insulation:
 - 1. Provide firestopping insulation at fire and smoke barriers through penetrations. Fire stopping insulation shall be UL listed as defines in Section 07 84 00, FIRESTOPPING.
 - 2. Pipe and duct penetrations requiring fire stop insulation including, but not limited to the following:
 - a. Pipe risers through floors
 - b. Pipe or duct chase walls and floors
 - c. Smoke partitions
 - d. Fire partitions
- M. Freeze protection of outdoor piping (over heat tracing tape): shall be insulated using double the thickness scheduled insulation. Provide metal jackets for all pipes. Provide for cold water make-up to chilled water piping as described in Section 23 21 13, HYDRONIC PIPING (electrical heat tracing systems).
- N. Provide jackets over insulation as follows:
 - 1. Aluminum jacket for all insulated piping and ducts exposed to outdoor weather.
 - 2. PVC jacket for all piping exposed in building, within 2400 mm (8 feet) of the floor. Provide aluminum angle ring escutcheons at wall, ceiling or floor penetrations.

3. A 50 mm (2 inch) overlap is required at longitudinal and circumferential joints.

3.2 INSULATION INSTALLATION

A. Mineral Fiber Board:

1. Faced board: Apply board on pins spaced not more than 300 mm (12 inches) on center each way, and not less than 75 mm (3 inches) from each edge of board. In addition to pins, apply insulation bonding adhesive to entire underside of horizontal metal surfaces. Butt insulation edges tightly and seal all joints with laps and butt strips. After applying speed clips cut pins off flush and apply vapor seal patches over clips.
2. Plain board:
 - a. Insulation shall be scored, beveled or mitered to provide tight joints and be secured to equipment with bands spaced 225 mm (9 inches) on center for irregular surfaces or with pins and clips on flat surfaces. Use corner beads to protect edges of insulation.
 - b. For hot equipment: Stretch 25 mm (1 inch) mesh wire, with edges wire laced together, over insulation and finish with insulating and finishing cement applied in one coat, 6 mm (1/4 inch) thick, trowel led to a smooth finish.
 - c. For cold equipment: Apply meshed glass fabric in a tack coat 1.5 to 1.7 square meter per liter (60 to 70 square feet per gallon) of vapor mastic and finish with mastic at 0.3 to 0.4 square meter per liter (12 to 15 square feet per gallon) over the entire fabric surface.
 - d. Chilled water pumps: Insulate with removable and replaceable 1 mm thick (20 gage) aluminum or galvanized steel covers lined with insulation. Seal closure joints/flanges of covers with gasket material. Fill void space in enclosure with flexible mineral fiber insulation.
3. Exposed, unlined supply and return ductwork located in mechanical spaces and service bays within 8 feet of floor: 25 mm (1 inch) thick insulation faced with ASJ.
4. Exposed, unlined supply and return ductwork exposed to outdoor weather: 50 mm (2 inch) thick insulation faced with a reinforcing membrane and two coats of vapor barrier mastic or multi-layer vapor barrier with a maximum water vapor permeability of 0.001 perms.
5. Louver blank-off panels: 50 mm (2 inch) thick insulation faced with ASJ.
6. Outside and exhaust/relief air plenums: 50 mm (2-inch) thick insulation faced with ASJ.
7. Cold equipment: 40 mm (1-1/2 inch) thick insulation faced with ASJ.
 - a. Chilled water pumps, water filter, chemical feeder pot or tank.
 - b. Pneumatic, cold storage water and surge tanks.
8. Hot equipment: 40 mm (1-1/2 inch) thick insulation faced with ASJ.
 - a. Convertors, air separators, steam condensate pump receivers.
 - b. Reheat coil casing and separation chambers on steam humidifiers located above ceilings.
 - c. Domestic water heaters and hot water storage tanks (not factory insulated).
 - d. Booster water heaters for dietetics dish and pot washers and for washdown grease-extracting hoods.



RFI:08754 -
DIX_EWP09B_OA
Plenum Insulation
Facing can also be
FSK

B. Flexible Mineral Fiber Blanket:

1. Adhere insulation to metal with 75 mm (3 inch) wide strips of insulation bonding adhesive at 200 mm (8 inches) on center all around duct. Additionally secure insulation to bottom of ducts exceeding 600 mm (24 inches) in width with pins welded or adhered on 450 mm (18 inch) 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 retarder penetrations with mastic. Sagging duct insulation will not be acceptable. Install firestop duct insulation where required.
2. Supply air ductwork to be insulated includes main and branch ducts from AHU discharge to room supply outlets, and the bodies of ceiling outlets to prevent condensation. Insulate sound attenuator units, coil casings and damper frames. To prevent condensation insulate trapeze type supports and angle iron hangers for flat oval ducts that are in direct contact with metal duct.
3. Supply air ductwork.
 - a. Above ceilings at a roof level: 50 mm (2 inch) thick insulation faced with FSK.
 - b. Above ceilings for other than roof level: 40 mm (1 ½ inch) thick insulation faced with FSK.
 - c. Located in mechanical spaces/service bays and more than 8 feet above floor: 40 mm (1-1/2 inch) thick insulation faced with FSK.
 - d. Located in MRI rooms (within shielding): 40 mm (1-1/2 inch) thick insulation faced with vinyl type vapor barrier.
4. Return air duct:
 - a. Located in mechanical spaces/service bays and more than 8 feet above floor: 40 mm (1-1/2 inch) thick insulation faced with FSK.
 - b. Return air ductwork in other locations need not be insulated.
5. Outside air duct: 40 mm (1-1/2 inch) thick insulation faced with FSK.
6. Exhaust air branch duct from autopsy refrigerator to main duct: 40 mm (1-1/2 inch) thick insulation faced with FSK.

C. Molded Mineral Fiber Pipe and Tubing Covering:

1. Fit insulation to pipe or duct, 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 retarder penetrations on cold piping with a generous application of vapor barrier mastic. Provide inserts and install with metal insulation shields at outside pipe supports. Install freeze protection insulation over heating cable.
2. Contractor's options for fitting, flange and valve insulation:
 - a. Insulating and finishing cement for sizes less than 100 mm (4 inches) operating at surface temperature of 16 degrees C (61 degrees F) or more.
 - b. Factory premolded, one piece PVC covers with mineral fiber, (Form B), inserts. Provide two insert layers for pipe temperatures below 4 degrees C (40 degrees F), or above 121 degrees C (250 degrees F). Secure first layer of insulation with twine. Seal seam edges with vapor barrier mastic and secure with fitting tape.
 - c. Factory molded, ASTM C547 or field mitered sections, joined with adhesive or wired in place. For hot piping finish with a smoothing coat of finishing cement. For cold fittings, 16 degrees C (60 degrees F) or less, vapor seal with a layer of glass fitting tape imbedded between two 2 mm (1/16 inch) coats of vapor barrier mastic.

- d. Fitting tape shall extend over the adjacent pipe insulation and overlap on itself at least 50 mm (2 inches).
 - 3. Nominal thickness in millimeters and inches specified in the schedule at the end of this section.
- D. Rigid Cellular Phenolic Foam:
- 1. Rigid closed cell phenolic insulation may be provided for piping, ductwork and equipment for temperatures up to 121 degrees C (250 degrees F).
 - 2. Note the NFPA 90A burning characteristics requirements of 25/50 in paragraph 1.3.B
 - 3. Provide secure attachment facilities such as welding pins.
 - 4. Apply insulation with joints tightly drawn together
 - 5. Apply adhesives, coverings, neatly finished at fittings, and valves.
 - 6. Final installation shall be smooth, tight, neatly finished at all edges.
 - 7. Minimum thickness in millimeters (inches) specified in the schedule at the end of this section.
 - 8. Exposed, unlined supply and return ductwork exposed to outdoor weather: 50 mm (2 inch) thick insulation faced with a multi-layer vapor barrier with a maximum water vapor permeance of 0.00 perms.
 - 9. Condensation control insulation: Minimum 25 mm (1.0 inch) thick for all pipe sizes.
 - a. HVAC: Cooling coil condensation piping to waste piping fixture or drain inlet. Omit insulation on plastic piping in mechanical rooms.
- E. Cellular Glass Insulation:
- 1. Pipe and tubing, covering nominal thickness in millimeters and inches as specified in the schedule at the end of this section.
 - 2. Underground Piping Other than or in lieu of that Specified in Section 23 21 13, HYDRONIC PIPING and Section 33 63 00, STEAM ENERGY DISTRIBUTION: Type II, factory jacketed with a 3 mm laminate jacketing consisting of 3000 mm x 3000 mm (10 ft x 10 ft) asphalt impregnated glass fabric, bituminous mastic and outside protective plastic film.
 - a. 75 mm (3 inches) thick for hot water piping.
 - b. As scheduled at the end of this section for chilled water piping.
 - c. Underground piping: Apply insulation with joints tightly butted. Seal longitudinal self-sealing lap. Use field fabricated or factory made fittings. Seal butt joints and fitting with jacketing as recommended by the insulation manufacturer. Use 100 mm (4 inch) wide strips to seal butt joints.
 - d. Provide expansion chambers for pipe loops, anchors and wall penetrations as recommended by the insulation manufacturer.
 - e. Underground insulation shall be inspected and approved by the Resident Engineer as follows:
 - 1) Insulation in place before coating.
 - 2) After coating.
 - f. Sand bed and backfill: Minimum 75 mm (3 inches) all around insulated pipe or tank, applied after coating has dried.
 - 3. Cold equipment: 50 mm (2 inch) thick insulation faced with ASJ for chilled water pumps, water filters, chemical feeder pots or tanks, expansion tanks, air separators and air purgers.

4. Exposed, unlined supply and return ductwork exposed to outdoor weather: 50 mm (2 inch) thick insulation faced with a reinforcing membrane and two coats of vapor barrier mastic or multi-layer vapor barrier with a water vapor permeability of 0.00 perms.

F. Polyisocyanurate Closed-Cell Rigid Insulation:

1. Polyisocyanurate closed-cell rigid insulation (PIR) may be provided for exterior piping, equipment and ductwork for temperature up to 149 degree C (300 degree F).
2. Install insulation, vapor barrier and jacketing per manufacturer's recommendations. Particular attention should be paid to recommendations for joint staggering, adhesive application, external hanger design, expansion/contraction joint design and spacing and vapor barrier integrity.
3. Install insulation with all joints tightly butted (except expansion) joints in hot applications).
4. If insulation thickness exceeds 63 mm (2.5 inches), install as a double layer system with longitudinal (lap) and butt joint staggering as recommended by manufacturer.
5. For cold applications, vapor barrier shall be installed in a continuous manner. No staples, rivets, screws or any other attachment device capable of penetrating the vapor barrier shall be used to attach the vapor barrier or jacketing. No wire ties capable of penetrating the vapor barrier shall be used to hold the insulation in place. Banding shall be used to attach PVC or metal jacketing.
6. Elbows, flanges and other fittings shall be insulated with the same material as is used on the pipe straights. The elbow/ fitting insulation shall be field-fabricated, mitered or factory prefabricated to the necessary size and shape to fit on the elbow/ fitting. Use of polyurethane spray-foam to fill PVC elbow jacket is prohibited on cold applications.
7. For cold applications, the vapor barrier on elbows/fittings shall be either mastic-fabric-mastic or 2 mil thick PVDC vapor barrier adhesive tape.
8. All PVC and metal jacketing shall be installed so as to naturally shed water. Joints shall point down and shall be sealed with either adhesive or caulking (except for periodic slip joints).
9. Underground piping: Follow instructions for above ground piping but the vapor retarder jacketing shall be 6 mil thick PVDC or minimum 30 mil thick rubberized bituminous membrane. Sand bed and backfill shall be a minimum of 150 mm (6 inches) all around insulated pipe.
10. Exposed, unlined supply and return ductwork exposed to outdoor weather: 50 mm (2 inch) thick insulation faced with a multi-layer vapor barrier with a water vapor permeance of 0.00 perms.
11. Note the NFPA 90A burning characteristic requirements of 25/50 in paragraph 1.3B. Refer to paragraph 3.1 for items not to be insulated.
12. Minimum thickness in millimeter (inches) specified in the schedule at the end of this section.

G. Flexible Elastomeric Cellular Thermal Insulation:

1. Apply insulation and fabricate fittings in accordance with the manufacturer's installation instructions and finish with two coats of weather resistant finish as recommended by the insulation manufacturer.
2. Pipe and tubing insulation:
 - a. Use proper size material. Do not stretch or strain insulation.
 - b. To avoid undue compression of insulation, provide cork stoppers or wood inserts at supports as recommended by the insulation manufacturer. Insulation shields are specified under Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

- c. Where possible, slip insulation over the pipe or tubing prior to connection, and seal the butt joints with adhesive. Where the slip-on technique is not possible, slit the insulation and apply it to the pipe sealing the seam and joints with contact adhesive. Optional tape sealing, as recommended by the manufacturer, may be employed. Make changes from mineral fiber insulation in a straight run of pipe, not at a fitting. Seal joint with tape.
 3. Apply sheet insulation to flat or large curved surfaces with 100 percent adhesive coverage. For fittings and large pipe, apply adhesive to seams only.
 4. Pipe insulation: nominal thickness in millimeters (inches as specified in the schedule at the end of this section.
 5. Use Class S (Sheet), 20 mm (3/4 inch) thick for the following:
 - a. Chilled water pumps
 - b. Bottom and sides of metal basins for winterized cooling towers (where basin water is heated).
 - c. Chillers, insulate any cold chiller surfaces subject to condensation which has not been factory insulated.
 - d. Piping inside refrigerators and freezers: Provide heat tape under insulation.
 6. Exposed, unlined supply and return ductwork exposed to outdoor weather: 50 mm (2 inch) thick insulation faced with a multi-layer vapor barrier with a water vapor permeance of 0.00 perms.
- H. Duct Wrap for Kitchen Hood Grease Ducts:
1. The insulation thickness, layers and installation method shall be as per recommendations of the manufacturer to maintain the fire integrity and performance rating.
 2. Provide stainless steel jacket for all exterior and exposed interior ductwork.
- I. Calcium Silicate:
1. Minimum thickness in millimeter (inches) specified in the schedule at the end of this section for piping other than in boiler plant.
 2. Kitchen Exhaust Duct work: Type II, class D, 65 mm (2.5 inches) nominal thickness. Wire insulation in place with 12 gauge galvanized wire.
 3. MRI Quench Vent Insulation: Type I, class D, 150 mm (6 inch) nominal thickness.

3.3 PIPE INSULATION SCHEDULE

- A. Provide insulation for piping systems as scheduled below:

Insulation Thickness Millimeters (Inches)					
Operating Temperature Range/Service	Insulation Material	Nominal Pipe Size Millimeters (Inches)			
		Less than 25 (1)	25 – 32 (1 – 1¼)	38 – 75 (1½ - 3)	100 (4) and Above
122-177 degrees C (251-350 degrees F)	(Above ground piping only)	75 (3)	100 (4)	113 (4.5)	113 (4.5)
93-260 degrees C (200-500 degrees F)		100 (4)	125 (5)	150 (6)	150 (6)

Insulation Thickness Millimeters (Inches)					
Operating Temperature Range/Service	Insulation Material	Nominal Pipe Size Millimeters (Inches)			
		Less than 25 (1)	25 – 32 (1 – 1¼)	38 – 75 (1½ - 3)	100 (4) and Above
100-121 degrees C (212-250 degrees F) (HPR, MPR, LPS, vent piping from PRV Safety Valves, Condensate receivers and flash tanks)	Mineral Fiber (Above ground piping only)	62 (2.5)	62 (2.5)	75 (3.0)	75 (3.0)
100-121 degrees C (212-250 degrees F) (HPR, MPR, LPS, vent piping from PRV Safety Valves, Condensate receivers and flash tanks)	Rigid Cellular Phenolic Foam	50 (2.0)	50 (2.0)	75 (3.0)	75 (3.0)
38-94 degrees C (100-200 degrees F) (LPR, PC, HWH, HWHR)	Mineral Fiber (Above ground piping only)	38 (1.5)	38 (1.5)	50 (2.0)	50 (2.0)
38-99 degrees C (100-211 degrees F) (LPR, PC, HWH, HWHR)	Rigid Cellular Phenolic Foam	38 (1.5)	38 (1.5)	50 (2.0)	50 (2.0)
39-99 degrees C (100-211 degrees F) (LPR, PC, HWH, HWHR)	Polyiso-cyanurate Closed-Cell Rigid (Exterior Locations only)	38 (1.5)	38 (1.5)	----	----
38-94 degrees C (100-200 degrees F) (LPR, PC, HWH, HWHR)	Flexible Elastomeric Cellular Thermal (Above ground piping only)	38 (1.5)	38 (1.5)	----	----
4-16 degrees C (40-60 degrees F) (CH, CHR and RS for DX refrigeration)	Rigid Cellular Phenolic Foam	38 (1.5)	38 (1.5)	38 (1.5)	38 (1.5)
4-16 degrees C (40-60 degrees F) (CH and CHR within chiller room and pipe chase and underground)	Cellular Glass Closed-Cell	50 (2.0)	50 (2.0)	75 (3.0)	75 (3.0)
4-16 degrees C (40-60 degrees F) (CH, CHR and RS for DX refrigeration)	Cellular Glass Closed-Cell	38 (1.5)	38 (1.5)	38 (1.5)	38 (1.5)
4-16 degrees C (40-60 degrees F) (CH, CHR (where underground)	Polyiso-cyanurate Closed-Cell Rigid	38 (1.5)	38 (1.5)	50 (2.0)	50 (2.0)
4-16 degrees C (40-60 degrees F) (CH, CHR and RS for DX	Polyiso-cyanurate Closed-Cell Rigid (Exterior Locations	38 (1.5)	38 (1.5)	38 (1.5)	38 (1.5)

Insulation Thickness Millimeters (Inches)					
		Nominal Pipe Size Millimeters (Inches)			
Operating Temperature Range/Service	Insulation Material	Less than 25 (1)	25 – 32 (1 – 1¼)	38 – 75 (1½ - 3)	100 (4) and Above
refrigeration)	only)				
(40-60 degrees F) (CH, CHR, and RS for DX refrigeration)	Flexible Elastomeric Cellular Thermal (Above ground piping only)	38 (1.5)	38 (1.5)	38 (1.5)	38 (1.5)
Coil Condensate Drains (except plastic pipe in mechanical rooms)	Rigid Cellular Phenolic Foam	25 (1)	25 (1)	25 (1)	25 (1)

--- END ---

SECTION 23 21 13
HYDRONIC PIPING

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Water piping to connect HVAC equipment, including the following:
 - 1. Chilled water, condenser water, heating hot water and drain piping.
 - 2. Extension of domestic water make-up piping.

1.2 RELATED WORK

- A. Section 01 00 00, GENERAL REQUIREMENTS.
- B. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.
- C. Section 23 05 11, COMMON WORK RESULTS FOR HVAC: General mechanical requirements and items, which are common to more than one section of Division 23.
- D. Section 23 21 23, HYDRONIC PUMPS: Pumps.
- E. Section 23 07 11, HVAC INSULATION: Piping insulation.
- F. Section 23 25 00, HVAC WATER TREATMENT: Water treatment for open and closed systems.
- G. Section 23 82 00, CONVECTION HEATING AND COOLING UNITS: VAV and CV units, fan coil units, and radiant ceiling panels.
- H. Division 25, INTEGRATED AUTOMATION.
- I. Section 01 03 42, ALTERNATES: Alternate ~~9-039.32~~ to allow standard weight steel pipe (in lieu of Schedule 40) above 10" pipe size.

1.3 QUALITY ASSURANCE

- A. Section 23 05 11, COMMON WORK RESULTS FOR HVAC, which includes welding qualifications.
- B. Submit prior to welding of steel piping a certificate of Welder's certification. The certificate shall be current and not more than one year old.
- C. To assure uniformity and compatibility of piping components in grooved piping systems, all grooved products utilized shall be supplied by a single manufacturer. Grooving tools shall be supplied by the same manufacturer as the grooved components.

- D. Manufacturers Training Service: The Contractor shall obtain the services of an independent trained representative of the pre-insulated chilled water pipe system manufacturer to instruct contractor's work force in installation procedures for all pre-insulated, prefabricated systems.
- E. Grooved coupling manufacturer's factory trained field representative shall provide on-site training to contractor's field personnel in the proper use of grooving tools and installation of grooved piping products. Factory-trained representative shall periodically review the product installation. Contractor shall remove or replace any improperly installed products.

1.4 SUBMITTALS

- A. Submit in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.
- B. Manufacturer's Literature and Data:
 - 1. Pipe and equipment supports. Submit calculations for variable spring and constant support hangers.
 - 2. Pipe and tubing, with specification, class or type, and schedule.
 - 3. Pipe fittings, including miscellaneous adapters and special fittings.
 - 4. Flanges, gaskets and bolting.
 - 5. Grooved Joint Couplings
 - 6. Valves of all types.
 - 7. Strainers.
 - 8. Flexible connectors for water service.
 - 9. Pipe alignment guides.
 - 10. Expansion joints.
 - 11. Expansion compensators.
 - 12. All specified hydronic system components.
 - 13. Water flow measuring devices.
 - 14. Gages.
 - 15. Thermometers and test wells.
 - 16. Electric heat tracing systems.
- C. Manufacturer's certified data report, Form No. U-1, for ASME pressure vessels:
 - 1. Heat exchangers.
 - 2. Air separators.
 - 3. Expansion tanks.
 - 4. Flash tanks.
- D. Submit prior to welding of steel piping a certificate of Welder's certification. The certificate shall be current and not more than one year old.
- E. Coordination Drawings: Refer to Article, SUBMITTALS of Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
- F. As-Built Piping Diagrams: Provide drawing as follows for chilled water, condenser water, and heating hot water system and other piping systems and equipment. .
 - 1. One wall-mounted stick file with complete set of prints. Mount stick file in the chiller plant or control room along with control diagram stick file.
 - 2. One complete set of reproducible drawings.

3. One complete set of drawings in electronic format (AutoCAD, PDF, or other approved format).

1.5 APPLICABLE PUBLICATIONS

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.

- B. American Society of Mechanical Engineers (ASME):

B1.20.1-83	Pipe Threads, General Purpose (Inch)
B16.1-98	Cast Iron Pipe Flanges and Flanged Fittings
B16.3-98	Malleable Iron Threaded Fittings
B16.4-98	Gray Iron Threaded Fittings
B16.5-03	Pipe Flanges and Flanged Fittings
B16.9-03	Factory-Made Wrought Butt Welding Fittings
B16.11-05	Forged Fittings, Socket-Welding and Threaded
B16.14-91	Ferrous Pipe Plugs, Bushings, and Locknuts with Pipe Threads
B16.22-01	Wrought Copper and Copper Alloy Solder-Joint Pressure Fittings
B16.23-02	Cast Copper Alloy Solder Joint Drainage Fittings
B16.24-01	Cast Copper Alloy Pipe Flanges and Flanged Fittings, Class 150, 300, 400, 600, 900, 1500 and 2500
B16.39-98	Malleable Iron Threaded Pipe Unions, Classes 150, 250, and 300
B16.42-98	Ductile Iron Pipe Flanges and Flanged Fittings: Classes 150 and 300
B31.1-01	Power Piping
B31.9-04	Building Services Piping
B40.100-05	Pressure Gauges and Gauge Attachments

- C. American National Standards Institute, Inc. (ANSI):

B16.1 00	Cast Iron Pipe Flanges and Flanged Fittings, Class 25, 125 and 250
B16.3 00	Malleable Iron Threaded Fittings Classes 150 and 300
B16.5 03	Pipe Flanges and Flanged Fittings NPS ½ through NPS 24
B16.9 03	Factory Made Wrought Butt Welding Fittings
B16.11 01	Forged Fittings, Socket Welding and Threaded
B16.14 91	Ferrous Pipe Plugs, Bushings and Locknuts with Pipe Threads
B16.18-01	Cast Copper Alloy Solder joint Pressure fittings
B16.22 00	Wrought Copper and Bronze Solder Joint Pressure Fittings
B16.24 01	Cast Copper Alloy Pipe Fittings and Flanged Fittings: Class 150, 300, 400, 600, 900, 1500 and 2500
B31.1 01	Power Piping

- D. American Society for Testing and Materials (ASTM):

A47/A47M-99 (2004)	Ferritic Malleable Iron Castings
A53/A53M-06	Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
A106/A106M-06	Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service
A126-04	Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings

A181/A181M-01.....	Standard Specification for Carbon Steel Forgings, for General-Purpose Piping
A183-03.....	Standard Specification for Carbon Steel Track Bolts and Nuts
A216/A216M-04.....	Standard Specification for Steel Castings, Carbon, Suitable for Fusion Welding, for High Temperature Service
A234/A234M 04.....	Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service
A307-04.....	Standard Specification for Carbon Steel Bolts and Studs, 60,000 PSI Tensile Strength
A536-84 (2004).....	Standard Specification for Ductile Iron Castings
A 615/A 615M-04.....	Deformed and Plain Carbon Steel Bars for Concrete Reinforcement
A653/A 653M-04.....	Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy Coated (Galvannealed) By the Hot-Dip Process
B32-04.....	Standard Specification for Solder Metal
B61-02.....	Standard Specification for Steam or Valve Bronze Castings
B62-02.....	Standard Specification for Composition Bronze or Ounce Metal Castings
B88-03.....	Standard Specification for Seamless Copper Water Tube
B209 04.....	Aluminum and Aluminum Alloy Sheet and Plate
C177 97.....	Standard Test Method for Steady State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded Hot Plate Apparatus
C478-03.....	Precast Reinforced Concrete Manhole Sections
C533 03.....	Calcium Silicate Block and Pipe Thermal Insulation
C552 03.....	Cellular Glass Thermal Insulation
D 3350-02.....	Polyethylene Plastics Pipe and Fittings Materials
C591-01.....	Unfaced Preformed Rigid Cellular Polyisocyanurate Thermal Insulation
D1784 03.....	Rigid Poly (Vinyl Chloride) (PVC) Compounds and Chlorinated Poly (Vinyl Chloride) (CPVC) Compounds
D1785 03.....	Poly (Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80 and 120
D2241 04.....	Poly (Vinyl Chloride) (PVC) Pressure Rated Pipe (SDR Series)
D2464 99.....	Threaded Poly (Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80.
D3139 98.....	Joints for Plastic Pressure Pipes Using Flexible Elastomeric Seals
F439-06.....	Standard Specification for Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80
F441/F441M-02.....	Standard Specification for Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe, Schedules 40 and 80
F477-02.....	Elastomeric Seals Gaskets) for Joining Plastic Pipe

E. American Water Works Association (AWWA):

C110/03.....	Ductile Iron and Grey Iron Fittings for Water
C203 00.....	Coal Tar Protective Coatings and Linings for Steel Water Pipe Lines Enamel and Tape Hot Applied
C606 06.....	Grooved and Shouldered Joints

F. American Welding Society (AWS):

A5.8/A5.8M-04.....	Specification for Filler Metals for Brazing and Braze Welding
B2.1-02.....	Standard Welding Procedure Specification

- G. Copper Development Association, Inc. (CDA):
 - 1. CDA A4015-95 Copper Tube Handbook
- H. Expansion Joint Manufacturer's Association, Inc. (EJMA):
 - EMJA-2003 Expansion Joint Manufacturer's Association Standards, Eighth Edition
- I. Manufacturers Standardization Society (MSS) of the Valve and Fitting Industry, Inc.:
 - SP-67-02a Butterfly Valves
 - SP-70-06 Gray Iron Gate Valves, Flanged and Threaded Ends
 - SP-71-05 Gray Iron Swing Check Valves, Flanged and Threaded Ends
 - SP-72-99 Ball Valves with Flanged or Butt-Welding Ends for General Service
 - SP-78-05 Cast Iron Plug Valves, Flanged and Threaded Ends
 - SP-80-03 Bronze Gate, Globe, Angle and Check Valves
 - SP-85-02 Cast Iron Globe and Angle Valves, Flanged and Threaded Ends
- J. National Sanitation Foundation (NSF):
 - 14 03 Plastic Piping System Components and Related Materials
- K. Tubular Exchanger Manufacturers Association: TEMA 8th Edition, 2000
- L. Sheet Metal and Air Conditioning Contractors National Association (SMACNA): HVAC Duct Construction Standards, 2nd Edition 1997

PART 2 - PRODUCTS

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

- A. Provide in accordance with Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

2.2 PIPE AND TUBING

- A. Chilled Water (above ground), Condenser Water (above ground), Heating Hot Water and Vent Piping:
 - 1. Steel: ASTM A53 Grade B, seamless or ERW, Schedule 40.
 - a. Alternate 9.0332
 - 1) Steel piping 12" pipe size and above: ASTM A53 Grade B, seamless or ERW, standard weight.
 - 2. Copper water tube option: ASTM B88, Type K or L, hard drawn. Soft drawn tubing, 20 mm (3/4 inch) and larger, may be used for runouts to floor mounted fan coil units.
 - 3. Chilled water piping underground and optional piping in utility tunnels, pipe basements and crawl spaces: Factory prefabricated (preinsulated chilled water piping).

- B. Extension of Domestic Water Make-up Piping: ASTM B88, Type K or L, hard drawn copper tubing.
- C. Cooling Coil Condensate Drain Piping:
 - 1. From air handling units: Schedule 40 PVC.
 - 2. From fan coil or other terminal units: Schedule 40 PVC.
- D. Chemical Feed Piping for Condenser Water Treatment: Chlorinated polyvinyl chloride (CPVC), Schedule 80, ASTM F441.
- E. Pipe supports, including insulation shields, for above ground piping: Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

2.3 FITTINGS FOR STEEL PIPE

- A. 65 mm (2-1/2 inches) and Larger: Welded or flanged joints. Mechanical couplings and fittings are optional for water piping only.
 - 1. Butt welding fittings: ASME B16.9 with same wall thickness as connecting piping. Elbows shall be long radius type, unless otherwise noted.
 - 2. Welding flanges and bolting: ASME B16.5:
 - a. Water service: Weld neck or slip-on, plain face, with 6 mm (1/8 inch) thick full face neoprene gasket suitable for 104 degrees C (220 degrees F).
 - 1) Contractor's option: Convuluted, cold formed 150 pound steel flanges, with Teflon gaskets, may be used for water service.
 - b. Flange bolting: Carbon steel machine bolts or studs and nuts, ASTM A307, Grade B.
- B. 50 mm (2 inches) and Smaller: Screwed or welded. Mechanical couplings are optional for water and glycol-water piping only.
 - 1. Butt welding: ASME B16.9 with same wall thickness as connecting piping.
 - 2. Forged steel, socket welding or threaded: ASME B16.11.
 - 3. Screwed: 150 pound malleable iron, ASME B16.3. 125 pound cast iron, ASME B16.4, may be used in lieu of malleable iron. Bushing reduction of a single pipe size, or use of close nipples, is not acceptable.
 - 4. Unions: ASME B16.39.
 - 5. Water hose connection adapter: Brass, pipe thread to 20 mm (3/4 inch) garden hose thread, with hose cap nut.
- C. Welded Branch and Tap Connections: Forged steel weldolets, or branchlets and threadolets may be used for branch connections up to one pipe size smaller than the main. Forged steel half-couplings, ASME B16.11 may be used for drain, vent and gage connections.

- D. Mechanical Pipe Couplings and Fittings: May be used in accessible locations, with cut or roll grooved pipe, in water service up to 110 degrees C (230 degrees F), in lieu of welded, screwed or flanged connections.
1. Mechanical pipe couplings and fittings shall not be used within vertical shafts, above inaccessible and limited accessible ceilings, or in any areas where access for inspection and service is not readily available.
 2. Grooved mechanical couplings: Ductile iron, ASTM A536, fabricated in two parts, securely held together by two or more track-head, square, or oval-neck bolts, ASTM A183 and A449.
 - a. Rigid Type (Up to 12"): Housings shall be cast with offsetting, angle-pattern bolt pads to provide system rigidity and support and hanging in accordance with ASME B31.1 and B31.9, with a maximum pressure rating up to 5170 kPa (750 psi) and no bolt torque requirement.
 - b. Rigid Type (14" and Larger): Two piece housing design with flat bolt pads for metal-to-metal contact meeting the support and hanging requirements of ASME B31.1 and B31.9, with a maximum pressure rating of 2070 kPa (300 psi). Required torque shall be in accordance with the manufacturer's recommendations.
 - c. Flexible Type (2-1/2" and Larger): Two piece housing design with the same torque requirements and pressure ratings as the rigid couplings. Use in locations where vibration attenuation and stress relief are required.
 3. Gaskets: Rubber product recommended by the coupling manufacturer for the intended service. EPDM gaskets for 8" and smaller shall be rated for -30F to 230F.
 4. Grooved end fittings: ductile iron, ASTM A536; or steel, ASTM A53 or A106, designed to accept grooved mechanical couplings of the same manufacturer. Tap-in type branch connections are acceptable.
 5. Option for Stainless Steel Piping: In lieu of steel piping for sizes 50 mm and smaller, crimped joint fittings manufactured of precision, cold drawn, austenitic stainless steel fittings with elastomer O-ring seals may be used. Fittings shall be rated to 300 psi.

2.4 FITTINGS FOR COPPER TUBING

A. Solder Joint:

1. Joints shall be made up in accordance with recommended practices of the materials applied. Apply 95/5 tin and antimony on all copper piping.
2. Mechanically formed tee connection in water and drain piping: Form mechanically extracted collars in a continuous operation by drilling pilot hole and drawing out tube surface to form collar, having a height of not less than three times the thickness of tube wall. Adjustable collaring device shall insure proper tolerance and complete uniformity of the joint. Notch and dimple joining branch tube in a single process to provide free flow where the branch tube penetrates the fitting.

B. Bronze Flanges and Flanged Fittings: ASME B16.24.

- C. Mechanical Pipe Couplings and Fittings: May be used in accessible locations, with roll grooved copper tube, in water and glycol-water service up to 110 degrees C (230 degrees F) in lieu of soldered or flanged connections.
1. Mechanical pipe couplings and fittings shall not be used within vertical shafts, above inaccessible and limited accessible ceilings, or in any areas where access for inspection and service is not readily available.
 2. Grooved mechanical couplings: Copper-tube dimensions, ductile iron, ASTM A536, fabricated in two parts cast with offsetting, angle-pattern bolt pads, coated with copper-colored enamel, securely held together by two or more track-head, square, or oval-neck bolts, ASTM A183 and A449.
 3. Gaskets: Rubber product recommended by the coupling manufacturer for the intended service. EPDM gaskets shall be rated for -30F to 250F.
 4. Grooved end fittings: Wrought copper, ASME B16.22; or bronze casting, ASME B16.18, designed to accept copper-tube dimensioned grooved mechanical couplings (flaring of tube and fitting ends to IPS dimensions is not acceptable). Tap-in type branch connections are acceptable.

2.5 PRESSURE-SEALED PIPE CONNECTIONS FOR COPPER TUBING

A. General

1. Provide as optional pressure fitting connections for chilled water and hot water copper pipes from 3/4" up to 2-1/2".
2. Pressure-sealed copper press fitting pipes shall be installed using the proper tool, actuator, jaws and rings as instructed by press fitting manufacturer.

B. Materials

1. Tubing Standard: Copper tubing shall conform to ASTM B 75 or ASTM B88.
2. Fitting Standard: Copper fittings shall conform to ASME B16.18, ASME B16.22 or ASME B16.26.
3. Press Fitting: Copper and copper alloy press fittings shall conform to material requirements of ASME B16.22 and performance criteria of IAPMO PS 117. Sealing elements for press fittings shall be EPDM. Sealing elements shall be factory installed or an alternative supplied by fitting manufacturer.
4. Hanger Standard: Hangers and supports shall conform to MSS-SP-58.

2.6 FITTINGS FOR PLASTIC PIPING

- A. Schedule 80, socket type for solvent welding.
- B. Polypropylene drain piping: Flame retardant, drainage pattern.
- C. Chemical feed piping for condenser water treatment: Chlorinated polyvinyl chloride (CPVC), Schedule 80, ASTM F439.

2.7 DIELECTRIC FITTINGS

- A. Provide where copper tubing and ferrous metal pipe are joined.

- B. 50 mm (2 inches) and Smaller: Threaded dielectric union, ASME B16.39.
- C. 65 mm (2 1/2 inches) and Larger: Flange union with dielectric gasket and bolt sleeves, ASME B16.42.
- D. Temperature Rating, 99 degrees C (210 degrees F).
- E. 15 mm (1/2 inch) through 200 mm (8 inches): Waterway fitting with grooved or threaded ends and thermoplastic lining, rated to 110 degrees C (230 degrees F).

2.8 SCREWED JOINTS

- A. Pipe Thread: ANSI B1.20.
- B. Lubricant or Sealant: Oil and graphite or other compound approved for the intended service.

2.9 VALVES

- A. Asbestos packing is not acceptable.
- B. All valves of the same type shall be products of a single manufacturer. Provide gate and globe valves with packing that can be replaced with the valve under full working pressure.
- C. Provide chain operators for valves 100 mm (4 inches) and larger when the centerline is located 2400 mm (8 feet) or more above the floor or operating platform.
- D. Gate Valves:
 - 1. 50 mm (2 inches) and smaller: MSS-SP80, Bronze, 1034 kPa (150 lb.), wedge disc, rising stem, union bonnet.
 - 2. 65 mm (2 1/2 inches) and larger: Flanged, outside screw and yoke.
 - a. MSS-SP 70, iron body, bronze mounted, 861 kPa (125 psig) wedge disc.
- E. Globe, Angle and Swing Check Valves:
 - 1. 50 mm (2 inches) and smaller: MSS-SP 80, bronze, 1034 kPa (150 lb.) Globe and angle valves shall be union bonnet with metal plug type disc.
 - 2. 65 mm (2 1/2 inches) and larger: 861 kPa (125 psig), flanged, iron body, bronze trim, MSS-SP-85 for globe valves and MSS-SP-71 for check valves.
 - 3. 50 mm to 100 mm (2 inches to 4 inches): 2070 kPa (300 psig), grooved, ductile iron body, type 316 stainless steel clapper for horizontal installation only. Meets or exceeds MSS-SP-71 for check valves.
- F. Non-Slam or Silent Check Valve: Spring loaded double disc swing check or internally guided flat disc lift type check for bubble tight shut-off. Provide where check valves are shown in chilled water and hot water piping. Check valves incorporating a balancing feature may be used.
 - 1. Body: Cast iron, ASTM A126, Class B, or steel, ASTM A216, Class WCB, or ductile iron, ASTM 536, flanged, grooved, or wafer type.
 - 2. Seat, disc and spring: 18-8 stainless steel, or bronze, ASTM B62, or ductile iron disc, welded-in, or plated nickel seat. Seats may be elastomer material.

- G. Butterfly Valves: May be used in lieu of gate valves in water service except for direct buried pipe. Provide stem extension to allow 50 mm (2 inches) of pipe insulation without interfering with valve operation.
1. MSS-SP 67, flange lug type (for end of line service) rated 1205 kPa (175 psig) working pressure at 93 degrees C (200 degrees F).
 - a. Body: Cast iron, ASTM A126, Class B. Malleable iron, ASTM A47 electro-plated, or ductile iron, ASTM A536, Grade 65-45-12electro-plated.
 - b. Trim: Bronze, aluminum bronze, or 300 series stainless steel disc, bronze bearings, 316 stainless steel shaft and manufacturer's recommended resilient seat. Resilient seat shall be field replaceable, and fully line the body to completely isolate the body from the product. A phosphate coated steel shaft or stem is acceptable, if the stem is completely isolated from the product.
 - c. Actuators: Field interchangeable. Valves for balancing service shall have adjustable memory stop to limit open position.
 - 1) Valves 150 mm (6 inches) and smaller: Lever actuator with minimum of seven locking positions, except where chain wheel is required.
 - 2) Valves 200 mm (8 inches) and larger: Enclosed worm gear with handwheel, and where required, chain-wheel operator.
 2. Meets or exceeds MSS SP-67, grooved end type suitable for bubble tight shutoff, dead-end, and bi-directional service at 2065 kPa (300 psig) full rated pressure up to 110 degrees C (230 degrees F).
 - a. Body: Ductile iron, ASTM A536, Grade 65-45-12, black enamel or PPS coated.
 - b. Trim: Electroless nickel-plated ductile iron or PPS coated ductile iron offset disc, 416 or 17-4 PH stainless steel two-piece stem, EPDM, resilient seat (rated for 230 degrees F), or PPS coated surface.
 - c. Actuators: Lever handle, gear operator with handwheel, or power actuator with electrical activation.
- H. Ball Valves: Brass or bronze or ductile iron body with chrome-plated ball with standard or full port and Teflon seat at 4140 kPa (600 psig) working pressure rating. Screwed, grooved end or solder connections. Provide stem extension to allow operation without interfering with pipe insulation.
- I. Water Flow Balancing Valves: For flow regulation and shut-off. Valves shall be line size rather than reduced to control valve size and be one of the following types.
1. Butterfly valve as specified herein with memory stop.
 2. Eccentric plug valve: Iron body, bronze, elastomer-coated or nickel-plated iron plug, stainless steel or bronze bearings, adjustable memory stop, operating lever, rated 861 kPa (125 psig) and 110 degrees C (230 degrees F).
- J. Circuit Balancing Valves: Y-pattern, globe style, providing flow measurement, flow balancing, shutoff feature, and drain connection. Valves shall have multiple-turn digital readout handwheel for balancing, hidden memory feature to provide a tamper-proof setting, and connections for a portable differential pressure meter. Provide read-out kit of same manufacturer including: Flow meter, read-out probes, hoses, flow charts or calculator and carrying case.

- K. Automatic Balancing Control Valves: Factory calibrated to maintain constant flow (plus or minus five percent) over system pressure fluctuations of at least 10 times the minimum required for control. Provide standard pressure taps and four sets of capacity charts. Valves shall be line size and be one of the following designs:
1. Gray iron (ASTM A126) or brass body rated 1205 kPa (175 psig) at 93 degrees C (200 degrees F), with stainless steel piston and spring.
 2. Brass or ferrous body designed for 2067 kPa (300 psig) service at 121 degrees C (250 degrees F), with corrosion resistant, tamper proof, self-cleaning piston/spring assembly that is easily removable for inspection or replacement.
 3. Combination assemblies containing ball type shut-off valves, unions, flow regulators, strainers with blowdown valves and pressure temperature ports shall be acceptable.
 4. Provide a read-out kit of same manufacturer including: Flow meter, probes, hoses, flow charts and carrying case.
- L. Pressure Control Valves: Electronic actuated pressure control valve to provide consistent but resettable back-pressure on chilled water service to each building. Pressure control valve shall consist of a main globe valve and factory-installed integral pressure control assembly with pilot operated regulator. Pressure control valve shall receive remote set-point command from BAS and provide return valve position indication back to the BAS.
1. Main Valve: 150 Class, flanged, ductile iron body, bronze trim, ANSI B16.42.
 2. Pressure Control Assembly:
 - a. The Electronic Actuated Pressure Reducing Pilot Control shall have an integral hydraulic pilot and electronic controller to provide interface between remote telemetry and valve set-point control. It will compare a remote analog command signal with an internal position sensor signal and adjust the hydraulic pilot control spring mechanism to a new set-point position. Remote analog signal input shall be isolated and reverse polarity protected and resettable. 4-20mA actuator position feedback output shall be provided. A second command control input shall be from dry contact switch closure for clockwise or counter clockwise actuator rotation.
 - b. If power fails, the control pilot valve shall continue main valve to control to last set-point command. If the Remote Set-Point signal is lost, the actuator shall be selectable to go to either the 4mA, Last, or 20mA command set-point. No mechanical adjustments shall be necessary to the actuator.
 - c. Factory piped pilot shall include strainer, isolation valves, and pressure gauges.

2.9 WATER FLOW MEASURING DEVICES

- A. Minimum overall accuracy plus or minus three percent over a range of 70 to 110 percent of design flow. Select devices for not less than 110 percent of design flow rate.
- B. Venturi Type: Bronze, steel, or cast iron with bronze throat, with valved pressure sensing taps upstream and at the throat.
- C. Wafer Type Circuit Sensor: Cast iron wafer-type flow meter equipped with readout valves to facilitate the connecting of a differential pressure meter. Each readout valve shall be fitted with an integral check valve designed to minimize system fluid loss during the monitoring process.
- D. Self-Averaging Annular Sensor Type: Brass or stainless steel metering tube, shutoff valves and quick-coupling pressure connections. Metering tube shall be rotatable so all sensing ports may be pointed down-stream when unit is not in use.

- E. Flow Measurement/Balance Valves: A system comprised of two valves of bronze and stainless steel metallurgy designed for 1205 kPa (175 psig) pressure at 121 degrees C (250 degrees F), with thermal insulation sleeve.
1. Measurement and shut-off valve: An on/off ball valve with integral high regain venturi and dual quick connect valves with integral check valves and color coded safety caps for pressure/temperature readout.
 2. A butterfly balancing valve as specified herein, with memory stop and quick connect valve for pressure/temperature readout.
- F. Energy Meters: Division 25, INTEGRATED AUTOMATION.
- G. Flow Measuring Device Identification:
1. Metal tag attached by chain to the device.
 2. Include meter or equipment number, manufacturer's name, meter model, flow rate factor and design flow rate in l/m (gpm).
- H. Portable Water Flow Indicating Meters:
1. Minimum 150 mm (6 inch) diameter dial, forged brass body, beryllium-copper bellows, designed for 1205 kPa (175 psig) working pressure at 121 degrees C (250 degrees F).
 2. Bleed and equalizing valves.
 3. Vent and drain hose and two 3000 mm (10 feet) lengths of hose with quick disconnect connections.
 4. Factory fabricated carrying case with hose compartment and a bound set of capacity curves showing flow rate versus pressure differential.
 5. Provide one portable meter for each range of differential pressure required for the installed flow devices.
- I. Permanently Mounted Water Flow Indicating Meters: Minimum 150 mm (6 inch) diameter, or 450 mm (18 inch) long scale, for 120 percent of design flow rate, direct reading in lps (gpm), with three valve manifold and two shut-off valves.

2.10 STRAINERS

- A. Basket or Y Type. Tee type is acceptable for water service.
1. Screens: Bronze, monel metal or 18-8 or type 304 stainless steel, free area not less than 2-1/2 times pipe area, with perforations as follows: 1.1 mm (0.045 inch) or 1.6 mm (0.062 inch) diameter perforations.
 2. 100 mm (4 inches) and larger: 3.2 mm (0.125 inch) and 4 mm (0.156 inch) diameter perforations.
- B. Suction Diffusers: Specified in Section 23 21 23, HYDRONIC PUMPS.

2.11 FLEXIBLE CONNECTORS FOR WATER SERVICE

- A. Flanged Spool Connector:
1. Single arch or multiple arch type. Tube and cover shall be constructed of chlorobutyl elastomer with full faced integral flanges to provide a tight seal without gaskets.

Connectors shall be internally reinforced with high strength synthetic fibers impregnated with rubber or synthetic compounds as recommended by connector manufacturer, and steel reinforcing rings.

2. Working pressures and temperatures shall be as follows:
 - a. Connector sizes 50 mm to 100 mm (2 inches to 4 inches), 1137 kPa (165psig) at 121 degrees C (250 degrees F).
 - b. Connector sizes 125 mm to 300 mm (5 inches to 12 inches), 965 kPa (140 psig) at 121 degrees C (250 degrees F).
3. Provide ductile iron retaining rings and control units.

B. Mechanical Pipe Couplings: Use in lieu of flexible connectors for vibration isolation at equipment connections. A minimum of three (3) flexible couplings, for each connector, shall be placed in close proximity to the source of vibration.

1. See other fittings specified under Part 2, PRODUCTS.

2.12 EXPANSION JOINTS

A. General

1. Furnish and install all necessary offsets, joints, expansion loops, compensators, anchors and guides so that no stress is placed on the piping systems or equipment due to thermal expansion.
2. Make proper provision for expansion and contraction in all parts of piping systems wherever possible by means of pipe bends, pipe offsets, swing connections or changes in direction of piping. Where piping network cannot be employed to absorb expansion and contraction in the piping systems, provide expansion joint compensators.
3. Expansion compensator elements shall be as specified herein and shall be selected by the manufacturer to withstand system pressure and temperature conditions and to absorb thermal expansion of the piping. Use of expansion compensators in non-accessible locations shall not be permitted.
4. Where piping network cannot be employed to absorb expansion and contraction in the piping systems, provide expansion joint compensators. Securely anchor all piping utilizing expansion loops and joints to the building structure with steel angles, properly braced and welded to the pipe.

B. Factory built devices, inserted in the pipe lines, designed to absorb axial cyclical pipe movement which results from thermal expansion and contraction. This includes factory-built or field-fabricated guides located along the pipe lines to restrain lateral pipe motion and direct the axial pipe movement into the expansion joints.

C. Manufacturing Quality Assurance: Conform to Expansion Joints Manufacturers Association Standards.

D. Bellows - Internally Pressurized Type:

1. Multiple corrugations of Type 304 or Type A240-321 stainless steel.
2. Internal stainless steel sleeve entire length of bellows.
3. External cast iron equalizing rings for services exceeding 340 kPa (50 psig).
4. Welded ends.
5. Design shall conform to standards of EJMA and ASME B31.1.

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6. External tie rods designed to withstand pressure thrust force upon anchor failure if one or both anchors for the joint are at change in direction of pipeline.
 7. Integral external cover.
- E. Bellows - Externally Pressurized Type:
1. Multiple corrugations of Type 304 stainless steel.
 2. Internal and external guide integral with joint.
 3. Design for external pressurization of bellows to eliminate squirm.
 4. Welded ends.
 5. Conform to the standards of EJMA and ASME B31.1.
 6. Threaded connection at bottom, 25 mm (one inch) minimum, for drain or drip point.
 7. Integral external cover and internal sleeve.
- F. Grooved End Expansion Joints – In-line device, designed to absorb axial pipe movement up to 80 mm (3 inches) resulting from expansion and contraction. Expansion joints shall be a combination of grooved end short nipples and flexible couplings or slip-type with grooved end telescoping slip pipe section.
- G. Expansion Compensators:
1. Corrugated bellows, externally pressurized, stainless steel or bronze.
 2. Internal guides and anti-torque devices.
 3. Threaded ends.
 4. External shroud.
 5. Conform to standards of EJMA.
- H. Expansion Joint Identification: Provide stamped brass or stainless steel nameplate on each expansion joint listing the manufacturer, the allowable movement, flow direction, design pressure and temperature, date of manufacture, and identifying the expansion joint by the identification number on the contract drawings.
- I. Guides: Provide factory-built guides along the pipe line to permit axial movement only and to restrain lateral and angular movement. Guides must be designed to withstand a minimum of 15 percent of the axial force which will be imposed on the expansion joints and anchors. Field-built guides may be used if detailed on the contract drawings.
- J. Inline Seismic Expansion Joint
1. The seismic expansion joint shall be fully enclosed in-line construction. Designs requiring elbows or a change in direction are not acceptable. The pressure/temperature rating shall be 150 psig at 400°F. Rated axial and lateral (all planes) motions shall be plus or minus 6", 12", 18" or 24" as required. The assembly shall consist of a Ball Joint at each end for lateral offset and a multi-ply externally pressurized expansion joint for axial motion. Bellows design shall be in accordance with the Standards of the Expansion Joint Manufacturer's Association, Inc. using ASME Section II, Part D allowable stresses. Internal vented guiding shall be included. All pipe including the expansion joint housing shall be ASTM A53 Gr. B standard weight.
- K. Spring Riser Supports
1. Refer to Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT.

L. Engineering Services

1. The Contractor shall provide a thermal stress analysis on all piping to confirm allowable stresses are below 80%.
2. The Contractor shall retain a registered Professional Engineer licensed to practice in the project state to review all loads imposed on the building structure and piping system to assure that no points are overstressed.
3. The maximum allowable stress shall be 15,000 psi for cold water, hot water, condensate, and steam and the maximum allowable stress shall be 2500 psi for generator exhaust piping if pipe material is low carbon steel A53 B or A106 B (Marks' Standard Handbook for Mechanical Engineers, Tenth Edition).
4. The Contractor shall submit shop drawings with calculations (with P.E. stamp) detailing the proposed anchor locations for review.
5. All anchor details and forces shall be submitted to the project structural engineer for review prior to any installation.

2.12 FLEXIBLE BALL JOINTS

- A. Design and Fabrication: One piece component construction, fabricated from steel with welded ends, designed for a working steam pressure of 1720 kPa (250 psig) and a temperature of 232 degrees C (450 degrees F). Each joint shall provide for 360 degrees rotation in addition to a minimum angular flexible movement of 30 degrees for sizes 6 mm (1/4 inch) to 150 mm (6 inch) inclusive, and 15 degrees for sizes 65 mm (2-1/2 inches) to 750 mm (30 inches). Joints through 350 mm (14 inches) shall have forged pressure retaining members; while size 400 mm (16 inches) through 760 mm (30 inches) shall be of one piece construction.
- B. Material:
 1. Cast or forged steel pressure containing parts and bolting in accordance with Section II of the ASME Boiler Code or ASME B31.1. Retainer may be ductile iron ASTM A536, Grade 65-45-12, or ASME Section II SA 515, Grade 70.
 2. Gaskets: Steam pressure molded composition design for a temperature range of from minus 10 degrees C (50 degrees F) to plus 274 degrees C (525 degrees F).
- C. Certificates: Submit qualifications of ball joints in accordance with the following test data:
 1. Low pressure leakage test: 41 kPa (6psig) saturated steam for 60 days.
 2. Flex cycling: 800 Flex cycles at 3445 kPa (500 psig) saturated steam.
 3. Thermal cycling: 100 saturated steam pressure cycles from atmospheric pressure to operating pressure and back to atmospheric pressure.
 4. Environmental shock tests: Forward certificate from a recognized test laboratory, that ball joints of the type submitted has passed shock testing in accordance with Mil. Spec MIL-S-901.
 5. Vibration: 170 hours on each of three mutually perpendicular axis at 25 to 125 Hz; 1.3 mm to 2.5 mm (0.05 inch to 0.1 inch) double amplitude on a single ball joint and 3 ball joint off set.

2.13 HYDRONIC SYSTEM COMPONENTS

- A. Converter: Shell and tube type, U-bend removable tube bundle, steam in shell, water in tubes, equipped with support cradles.
1. Maximum tube velocity: 2.3 m/s (7.5 feet per second).
 2. Tube fouling factor: TEMA Standards, but not less than 0.001.
 3. Materials:
 - a. Shell: Steel.
 - b. Tube sheet and tube supports: Steel or brass.
 - c. Tubes: 20 mm (3/4 inch) OD copper.
 - d. Head or bonnet: Cast iron or steel.
 4. Construction: In accordance with ASME Pressure Vessel Code for 861 kPa (125 psig) working pressure for shell and tubes. Provide manufacturer's certified data report, Form No. U-1.
- B. Optional Heat Transfer Package: In lieu of field erected individual components, the Contractor may provide a factory or shop assembled package of converters, pumps, and other components supported on a welded steel frame.
- C. Air Purger: Cast iron or fabricated steel, 861 kPa (125 psig) water working pressure, for in-line installation.
- D. Tangential Air Separator: ASME Pressure Vessel Code construction for 861 kPa (125 psig) working pressure, flanged tangential inlet and outlet connection, internal perforated stainless steel air collector tube designed to direct released air into expansion tank, bottom blowdown connection. Provide Form No. U-1. If scheduled on the drawings, provide a removable stainless steel strainer element having 5 mm (3/16 inch) perforations and free area of not less than five times the cross-sectional area of connecting piping.
- E. Diaphragm Type Pre-Pressurized Expansion Tank: ASME Pressure Vessel Code construction for 861 kPa (125 psig) working pressure, welded steel shell, rust-proof coated, with a flexible elastomeric diaphragm suitable for a maximum operating temperature of 116 degrees C (240 degrees F). Provide Form No. U-1. Tank shall be equipped with system connection, drain connection, standard air fill valve and be factory pre-charged to a minimum of 83 kPa (12 psig).
- F. Pressure Reducing Valve (Water): Diaphragm or bellows operated, spring loaded type, with minimum adjustable range of 28 kPa (4 psig) above and below set point. Bronze, brass or iron body and bronze, brass or stainless steel trim, rated 861 kPa (125 psig) working pressure at 107 degrees C (225 degrees F).
- G. Pressure Relief Valve: Bronze or iron body and bronze or stainless steel trim, with testing lever. Comply with ASME Code for Pressure Vessels, Section 8, and bear ASME stamp.
- H. Automatic Air Vent Valves (where shown): Cast iron or semi-steel body, 1034 kPa (150 psig) working pressure, stainless steel float, valve, valve seat and mechanism, minimum 15 mm (1/2 inch) water connection and 6 mm (1/4 inch) air outlet. Pipe air outlet to drain.

2.14 WATER FILTERS AND POT CHEMICAL FEEDERS

- A. Refer to Section 23 25 00, HVAC WATER TREATMENT, Article 2.2, CHEMICAL TREATMENT FOR CLOSED LOOP SYSTEMS.

2.15 GAGES, PRESSURE AND COMPOUND

- A. ASME B40.100, Accuracy Grade 1A, (pressure, vacuum, or compound for air, oil or water), initial mid-scale accuracy 1 percent of scale (Qualify grade), metal or phenolic case, 115 mm (4-1/2 inches) in diameter, 6 mm (1/4 inch) NPT bottom connection, white dial with black graduations and pointer, clear glass or acrylic plastic window, suitable for board mounting. Provide red "set hand" to indicate normal working pressure.
- B. Provide brass lever handle union cock. Provide brass/bronze pressure snubber for gages in water service.
- C. Range of Gages: Provide range equal to at least 130 percent of normal operating range.
 - 1. For condenser water suction (compound): Minus 100 kPa (30 inches Hg) to plus 700 kPa (100 psig).

2.16 PRESSURE/TEMPERATURE TEST PROVISIONS

- A. Pete's Plug: 6 mm (1/4 inch) MPT by 75 mm (3 inches) long, brass body and cap, with retained safety cap, norel self-closing valve cores, permanently installed in piping where shown, or in lieu of pressure gage test connections shown on the drawings.
- B. Provide one each of the following test items to the Resident Engineer:
 - 1. 6 mm (1/4 inch) FPT by 3 mm (1/8 inch) diameter stainless steel pressure gage adapter probe for extra long test plug. PETE'S 500 XL is an example.
 - 2. 90 mm (3-1/2 inch) diameter, one percent accuracy, compound gage from 100 kPa (30 inches) Hg to 700 kPa (100 psig) range.
 - 3. 0 - 104 degrees C (220 degrees F) pocket thermometer one-half degree accuracy, 25 mm (one inch) dial, 125 mm (5 inch) long stainless steel stem, plastic case.

2.17 THERMOMETERS

- A. Mercury or organic liquid filled type, red or blue column, clear plastic window, with 150 mm (6 inch) brass stem, straight, fixed or adjustable angle as required for each in reading.
- B. Case: Chrome plated brass or aluminum with enamel finish.
- C. Scale: Not less than 225 mm (9 inches), range as described below, two degree graduations.
- D. Separable Socket (Well): Brass, extension neck type to clear pipe insulation.

- E. Scale ranges may be slightly greater than shown to meet manufacturer's standard. Required ranges in degrees C (F):

Chilled Water 0 to 38 degrees C (32-100 degrees F)	Hot Water and Condenser Water -1 to 116 degrees C (30 to 240 degrees F).
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2.18 FIRESTOPPING MATERIAL

- A. Refer to Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

2.19 ELECTRICAL HEAT TRACING SYSTEMS

- A. Systems shall meet requirements of the National Electrical Code (NEC), Section 427.
- B. Provide tracing for outdoor winterized piping as follows:
1. Condenser water piping for cooling towers.
 2. Make-up water.
- C. Heating Cable: Flexible, parallel circuit construction consisting of a continuous self-limiting resistance, conductive inner core material between two parallel copper bus wires, designed for cut-to-length at the job site and for wrapping around valves and complex fittings. Self-regulation shall prevent overheating and burnouts even where the cable overlaps itself.
1. Provide end seals at ends of circuits. Wire at the ends of the circuits is not to be tied together.
 2. Provide sufficient cable, as recommended by the manufacturer, to keep the pipe surface at 2.2 degrees C (36 degrees F) minimum during winter outdoor design temperature, but not less than the following:
 - a. 75 mm (3 inch) pipe and smaller with 25 mm (1 inch) thick insulation: 4 watts per foot of pipe.
 - b. 100 mm 300 mm (foot) pipe and larger 38 mm (1-1/2 inch) thick insulation: 8 watts per 300 mm (foot) of pipe.
- D. Local Digital Controller with built-in GFPD
1. The System shall be field-mounted and shall have FM or CSA approval for Class1, Division 2, Groups A, B, C, D when using a solid-state switching device.
 2. The system shall provide the user with the option of line-sensing control with a user-selectable dead band, ambient sensing proportional ambient sensing (PASC) and power limiting control modes.
 3. Electric code-approved ground-fault detection equipment shall be integral to the controller.
 4. Enclosure type shall be NEMA4X fiberglass reinforced plastic (FRP) for corrosion resistance and protection from moisture.
 5. The controller will be used in conjunction with resistance temperature detector (RTD) sensors wire to the controller using 18 AWG, 3 wire cable.

E. Electrical Heating Tracing Accessories:

1. Power supply connection fitting and stainless steel mounting brackets. Provide stainless steel worm gear clamp to fasten bracket to pipe.
2. 13 mm (1/2 inch) wide fiberglass reinforced pressure sensitive cloth tape to fasten cable to pipe at 300 mm (12 inch) intervals.
3. Pipe surface temperature control thermostat: Cast aluminum, NEMA 4 (watertight) enclosure, 15 mm (1/2 inch) NPT conduit hub, SPST switch rated 20 amps at 480 volts AC, with capillary and copper bulb sensor. Set thermostat to maintain pipe surface temperature at not less than 1.1 degrees C (34 degrees F).
4. Signs: Manufacturer's standard (NEC Code), stamped "ELECTRIC TRACED" located on the insulation jacket at 3000 mm (10 feet) intervals along the pipe on alternating sides.

PART 3 - EXECUTION

3.1 GENERAL

- A. The drawings show the general arrangement of pipe and equipment but do not show all required fittings and offsets that may be necessary to connect pipes to equipment, fan-coils, coils, radiators, etc., and to coordinate with other trades. Provide all necessary fittings, offsets and pipe runs based on field measurements and at no additional cost to the government. Coordinate with other trades for space available and relative location of HVAC equipment and accessories to be connected on ceiling grid. Pipe location on the drawings shall be altered by Contractor where necessary to avoid interferences and clearance difficulties.
- B. 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.
- C. Support piping securely. Refer to PART 3, Section 23 05 11, COMMON WORK RESULTS FOR HVAC. Install convertors and other heat exchangers at height sufficient to provide gravity flow of condensate to the flash tank and condensate pump.
- D. Install piping generally parallel to walls and column center lines, unless shown otherwise on the drawings. Space piping, including insulation, to provide 25 mm (one inch) minimum clearance between adjacent piping or other surface. Unless shown otherwise, slope drain piping down in the direction of flow not less than 25 mm (one inch) in 12 m (40 feet). Provide eccentric reducers to keep bottom of sloped piping flat.
- E. 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. Provide a union adjacent to one end of all threaded end valves. Control valves usually require reducers to connect to pipe sizes shown on the drawing. Install butterfly valves with the valve open as recommended by the manufacturer to prevent binding of the disc in the seat.
- F. Offset equipment connections to allow valving off for maintenance and repair with minimal removal of piping. Provide flexibility in equipment connections and branch line take-offs with 3-elbow swing joints where noted on the drawings.
- G. Tee water piping runouts or branches into the side of mains or other branches. Avoid bull-head tees, which are two return lines entering opposite ends of a tee and exiting out the common side.

- H. Provide manual air vent at all piping system high points and drain valves at all low points.
- I. Connect piping to equipment as shown on the drawings. Install components furnished by others such as:
 - 1. Water treatment pot feeders and condenser water treatment systems.
 - 2. Flow elements (orifice unions), control valve bodies, flow switches, pressure taps with valve, and wells for sensors.
- J. Thermometer Wells: In pipes 65 mm (2-1/2 inches) and smaller increase the pipe size to provide free area equal to the upstream pipe area.
- K. Firestopping: Fill openings around uninsulated piping penetrating floors or fire walls, with firestop material. For firestopping insulated piping refer to Section 23 07 11, HVAC INSULATION.
- L. Where copper piping is connected to steel piping, provide dielectric connections.

3.2 PIPE JOINTS

- A. Welded: Beveling, spacing and other details shall conform to ASME B31.1 and AWS B2.1. See Welder's qualification requirements under "Quality Assurance" in Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
 - 1. Welding shall be performed by experienced welders in a neat and workmanlike manner. Mitered elbows are not permitted. Odd angle elbows shall be cut from long radius elbows. The weld reinforcement shall be not less than 1/16" nor more than 1/8" above the normal surface of the joined sections. The reinforcement shall be crowned at the center and shall taper on each side to the surface being joined. The exposed surface of the weld shall present a workmanlike appearance and shall be free of depressions below the surface of the joined members.
 - 2. No welding of any kind shall be done when the temperature of the base metal is lower than 50°F. Material to be welded during freezing temperatures shall be made warm and dry before welding is started. Temperature of metal shall be "warm to the hand", or approximately 60°F.
 - 3. Inspection:
 - a. Welds will be inspected visually by supervisory representatives of the Architect and the Contractor.
 - b. Any weld judged defective by the Architect from a visual inspection shall be cut out and tested in the presence of the Owner or his representative. In the event any welder consistently produces a high percentage of unsatisfactory production welds, he shall be discharged at the request of the Owner, even though he is able to produce satisfactory welds when especially tested.
- B. Screwed: Threads shall conform to ASME B1.20; joint compound shall be applied to male threads only and joints made up so no more than three threads show. Coat exposed threads on steel pipe with joint compound, or red lead paint for corrosion protection.
- C. Mechanical Joint: Pipe grooving shall be in accordance with joint manufacturer's specifications. Lubricate gasket exterior including lips, pipe ends and housing interiors to prevent pinching the gasket during installation. Lubricant shall be as recommended by coupling manufacturer.

The grooved coupling manufacturer's factory trained representative shall provide on-site training for contractor's field personnel in the use of grooving tools and installation of grooved joint products. The representative shall periodically visit the jobsite and review contractor is following best recommended practices in grooved product installation. (A distributor's representative is not considered qualified to conduct the training or jobsite visit(s))

- D. 125 Pound Cast Iron Flange (Plain Face): Mating flange shall have raised face, if any, removed to avoid overstressing the cast iron flange.
- E. Solvent Welded Joints: As recommended by the manufacturer.

3.3 PRESSURE-SEALED PIPE CONNECTIONS FOR COPPER TUBING INSTALLATION

A. Installation

- 1. Press connections shall be made in accordance with manufacturer's installation instructions. The tubing shall be fully inserted into the fitting and the tubing marked at the shoulder of the fitting. The fitting alignment shall be checked against the mark on the tubing to assure the tubing is fully inserted in the fitting. The joints shall be pressed using tools approved by manufacturer.
- 2. Press joints shall provide allowance for thermal expansion and contraction of piping to be installed to follow layout shown on drawings.
- 3. System shall be tested by code standards and shall not have leaks at the rated pressure.

3.4 EXPANSION JOINTS (BELLOWS AND SLIP TYPE)

- A. Anchors and Guides: Provide type, quantity and spacing as recommended by manufacturer of expansion joint and as shown. A professional engineer shall verify in writing that anchors and guides are properly designed for forces and moments which will be imposed.
- B. Cold Set: Provide setting of joint travel at installation as recommended by the manufacturer for the ambient temperature during the installation.
- C. Preparation for Service: Remove all apparatus provided to restrain joint during shipping or installation. Representative of manufacturer shall visit the site and verify that installation is proper.
- D. Access: Expansion joints must be located in readily accessible space. Locate joints to permit access without removing piping or other devices. Allow clear space to permit replacement of joints and to permit access to devices for inspection of all surfaces and for adding packing.

3.5 LEAK TESTING ABOVEGROUND PIPING

- A. Inspect all joints and connections for leaks and workmanship and make corrections as necessary, to the satisfaction of the Resident Engineer. Tests may be either of those below, or a combination, as approved by the Resident Engineer.
- B. An operating test at design pressure, and for hot systems, design maximum temperature.

- C. A hydrostatic test at 1.5 times design pressure. For water systems the design maximum pressure would usually be the static head, or expansion tank maximum pressure, plus pump head. Factory tested equipment (convertors, exchangers, coils, etc.) need not be field tested. Isolate equipment where necessary to avoid excessive pressure on mechanical seals and safety devices.

3.6 FLUSHING AND CLEANING PIPING SYSTEMS

- A. Water Piping: Clean systems as recommended by the suppliers of chemicals specified in Section 23 25 00, HVAC WATER TREATMENT.
1. Initial flushing: Remove loose dirt, mill scale, metal chips, weld beads, rust, and like deleterious substances without damage to any system component. Provide temporary piping or hose to bypass coils, control valves, exchangers and other factory cleaned equipment unless acceptable means of protection are provided and subsequent inspection of hide-out areas takes place. Isolate or protect clean system components, including pumps and pressure vessels, and remove any component which may be damaged. Open all valves, drains, vents and strainers at all system levels. Remove plugs, caps, spool pieces, and components to facilitate early debris discharge from system. Sectionalize system to obtain debris carrying velocity of 1.8 m/S (6 feet per second), if possible. Connect dead-end supply and return headers as necessary. Flush bottoms of risers. Install temporary strainers where necessary to protect down-stream equipment. Supply and remove flushing water and drainage by various type hose, temporary and permanent piping and Contractor's booster pumps. Flush until clean as approved by the Resident Engineer.
 2. Cleaning: Using products supplied in Section 23 25 00, HVAC WATER TREATMENT, circulate systems at normal temperature to remove adherent organic soil, hydrocarbons, flux, pipe mill varnish, pipe joint compounds, iron oxide, and like deleterious substances not removed by flushing, without chemical or mechanical damage to any system component. Removal of tightly adherent mill scale is not required. Keep isolated equipment which is "clean" and where dead-end debris accumulation cannot occur. Sectionalize system if possible, to circulate at velocities not less than 1.8 m/S (6 feet per second). Circulate each section for not less than four hours. Blow-down all strainers, or remove and clean as frequently as necessary. Drain and prepare for final flushing.
 3. Final Flushing: Return systems to conditions required by initial flushing after all cleaning solution has been displaced by clean make-up. Flush all dead ends and isolated clean equipment. Gently operate all valves to dislodge any debris in valve body by throttling velocity. Flush for not less than one hour.

3.7 WATER TREATMENT

- A. Install water treatment equipment and provide water treatment system piping.
- B. Close and fill system as soon as possible after final flushing to minimize corrosion.
- C. Charge systems with chemicals specified in Section 23 25 00, HVAC WATER TREATMENT.
- D. Utilize this activity, by arrangement with the Resident Engineer, for instructing VA operating personnel.

3.8 ELECTRIC HEAT TRACING

- A. Install tracing as recommended by the manufacturer.
- B. Coordinate electrical connections.

3.9 OPERATING AND PERFORMANCE TEST AND INSTRUCTION

- A. Refer to PART 3, Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
- B. Adjust red set hand on pressure gages to normal working pressure.

--- END ---

SECTION 23 21 23
HYDRONIC PUMPS

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Hydronic pumps for Heating, Ventilating and Air Conditioning.
- B. Definitions:
 - 1. Capacity: Liters per second (L/s) (Gallons per minute (GPM)) of the fluid pumped.
 - 2. Head: Total dynamic head in kPa (feet) of the fluid pumped.
 - 3. Flat head-capacity curve: Where the shutoff head is less than 1.16 times the head at the best efficiency point.

1.2 RELATED WORK

- A. Section 01 00 00, GENERAL REQUIREMENTS.
- B. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.
- C. Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
- D. Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT.
- E. Section 23 21 13, HYDRONIC PIPING.
- F. Section 23 05 12, GENERAL MOTOR REQUIREMENTS FOR HVAC EQUIPMENT.
- G. Section 23 05 14, VARIABLE FREQUENCY DRIVES.
- H. Section 01 91 13, COMMISSIONING.

1.3 QUALITY ASSURANCE

- A. Refer to Paragraph, QUALITY ASSURANCE, in Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
- B. Design Criteria:
 - 1. Pumps design and manufacturer shall conform to Hydraulic Institute Standards.
 - 2. Pump sizes, capacities, pressures, operating characteristics and efficiency shall be as scheduled.

3. Head-capacity curves shall slope up to maximum head at shut-off. Curves shall be relatively flat for closed systems. Select pumps near the midrange of the curve, so the design capacity falls to the left of the best efficiency point, to allow a cushion for the usual drift to the right in operation, without approaching the pump curve end point and possible cavitation and unstable operation. Select pumps for open systems so that required net positive suction head (NPSHR) does not exceed the net positive head available (NPSHA).
 4. The head for pumps submitted for pumping through condensers and through chilled water coils and evaporators shall be increased, if necessary, to match the equipment approved for the project.
 5. Pump Driver: Furnish with pump. Size shall be non-overloading at any point on the head-capacity curve including one pump operation in a parallel or series pumping installation.
 6. Provide all pumps with motors, impellers, drive assemblies, bearings, coupling guard and other accessories specified. Statically and dynamically balance all rotating parts.
 7. Furnish each pump and motor with a nameplate giving the manufacturers name, serial number of pump, capacity in GPM and head in feet at design condition, horsepower, voltage, frequency, speed and full load current and motor efficiency.
 8. Test all pumps before shipment. The manufacturer shall certify all pump ratings.
 9. After completion of balancing, provide replacement of impellers or trim impellers to provide specified flow at actual pumping head, as installed.
 10. Furnish one spare seal and casing gasket for each pump to the Resident Engineer.
- C. Allowable Vibration Tolerance for Pump Units: Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT.
- D. Commissioning of a system or systems specified in this section shall be part of the construction process. Documentation and testing of these systems; as well as training of the VAMC operation and maintenance personnel, is required in cooperation with the VA Resident Engineer and the Commissioning Authority. Project Close-out is dependent on successful completion of all commissioning procedures, documentation, and issue closure. Refer to Section 019113, COMMISSIONING, for detailed commissioning requirements.

1.4 SUBMITTALS

- A. Submit in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.
- B. Manufacturer's Literature and Data:
1. Pumps and accessories.
 2. Motors and drives.
 3. Variable speed motor controllers.
- C. Manufacturer's installation, maintenance and operating instructions, in accordance with Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
- D. Characteristic Curves: Head-capacity, efficiency-capacity, brake horsepower-capacity, and NPSHR-capacity for each pump and for combined pumps in parallel or series service. Identify pump and show fluid pumped, specific gravity, pump speed and curves plotted from zero flow to maximum for the impeller being furnished and at least the maximum diameter impeller that can be used with the casing.

1.5 APPLICABLE PUBLICATIONS

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only:
- B. American Iron and Steel Institute (AISI):
 - AISI 1045.....Cold Drawn Carbon Steel Bar, Type 1045
 - AISI 416.....Type 416 Stainless Steel
- C. American National Standards Institute (ANSI):
 - ANSI B15.1-00.....Safety Standard for Mechanical Power Transmission Apparatus
 - ANSI B16.1-00.....Cast Iron Pipe Flanges and Flanged Fittings, Class 25, 125, 250 and 800
- D. American Society for Testing and Materials (ASTM):
 - A48-98Gray Iron Castings
 - B62-02Composition Bronze or Ounce Metal Castings
- E. Maintenance and Operating Manuals in accordance with Section 01 00 00, General Requirements.

PART 2 - PRODUCTS

2.1 CENTRIFUGAL PUMPS, BRONZE FITTED

In-Line Type, Base Mounted End Suction or Double Suction Type:

- A. Casing and Bearing Housing: Close-grained cast iron, ASTM A48.
- B. Casing Wear Rings: Bronze.
- C. Suction or Discharge 65 mm (2-1/2 inches) and Larger: Plain face flange, 850 kPa (125 psig), ANSI B16.1.
- D. Casing Vent: Manual brass cock at high point.
- E. Casing Drain and Gage Taps: 15 mm (1/2-inch) plugged connections minimum size.
- F. Bearings: Regreaseable ball or roller type. Provide lip seal and slinger outboard of each bearing.
- G. Impeller: Bronze, ASTM B62, enclosed type, keyed to shaft.
- H. Shaft: Steel, AISI Type 1045 or stainless steel.
- I. Shaft Seal: Manufacturer's standard mechanical type to suit pressure and temperature and fluid pumped.

- J. Shaft Sleeve: Bronze or stainless steel.
- K. Motor: Furnish with pump. Refer to Section 23 05 12, GENERAL MOTOR REQUIREMENTS FOR HVAC EQUIPMENT.
- L. Base Mounted Pumps:
1. Designed for disassembling for service or repair without disturbing the piping or removing the motor.
 2. Impeller Wear Rings: Bronze.
 3. Shaft Coupling: Non-lubricated steel flexible type or spacer type with coupling guard, ANSI B15.1, bolted to the baseplate.
 4. Base: Cast iron or fabricated steel for common mounting to a concrete base.
 5. Suction Diffuser:
 - a. 80 mm through 300 mm (3 inches through 12 inches): Ductile iron body pump inlet fitting with grooved system side and flanged pump outlet connections, rated to the working pressure of the mating flange with a maximum operating temperature of 110 degrees C (230 degrees F). Type 304 stainless steel frame and perforated sheet with 4 mm (5/32 inch) diameter holes, 20 mesh Type 304 stainless steel start-up pre-filter, base support boss required.
 - b. 350 mm through 600 mm (14 inches through 24 inches): Ductile iron body pump inlet fitting with grooved system side and Class 150 flanged pump side connections. Type 304 stainless steel frame and perforated sheet diffuser with 4 mm (5/32 inch) diameter holes, 20 mesh Type 304 stainless steel start-up pre-filter, base support boss required, 2065 kPa (300 psig) maximum pressure rating at 110 degrees C (230 degrees F)..
 - c. Suction Strainer, "Y" Type: Section 23 21 13, HYDRONIC PIPING.
 - 1) May be furnished in lieu of a suction diffuser at the Contractor's option. Provide equivalent support of pump suction piping.
- M. Variable Speed Pumps:
1. The pumps shall be the type shown on the drawings and specified herein flex coupled to an open drip-proof motor. Provide motors 30 kW (40 horsepower) and larger with thermal overload switches.
 2. Variable Speed Motor Controllers: Refer to Section 23 05 14, VARIABLE FREQUENCY DRIVES.
 3. Pump operation and speed control shall be as shown on the drawings.

2.2 TRI-SERVICE VALVE ASSEMBLY

- A. Install a tri-service valve assembly at the discharge side of the pump. Assembly shall provide a combination shutoff, throttling, and non-slam check service in one unit. Grooved end butterfly valve and check valve with flow measurement capabilities assembled with grooved joint couplings of the same manufacturer (style to be determined by system requirements), maximum pressure rating 2065 kPa (300 psig) at 110 degrees C (230 degrees F).

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Follow manufacturer's written instructions for pump mounting and start-up. Access/ Service space around pumps shall not be less than minimum space recommended by pumps manufacturer.
- B. Support piping adjacent to pump such that no weight is carried on pump casing. First 3 hangers for each pipe shall be spring and neoprene type.
- C. Permanently support in-line pumps by the connecting piping only, not from the casing or the motor eye bolt.
- D. Sequence of installation for base-mounted pumps:
 - 1. Level and shim the unit base and grout to the concrete pad.
 - 2. Shim the driver and realign the pump and driver. Correct axial, angular or parallel misalignment of the shafts.
 - 3. Connect properly aligned and independently supported piping.
 - 4. Recheck alignment.
- E. Provide drains for bases and seals for base mounted pumps, piped to and discharging into floor drains.
- F. Coordinate location of thermometer and pressure gauges as per Section 23 21 13, HYDRONIC PIPING.

3.2 START-UP

- A. Verify that the piping system has been flushed, cleaned and filled.
- B. Lubricate pumps before start-up.
- C. Prime the pump, vent all air from the casing and verify that the rotation is correct. To avoid damage to mechanical seals, never start or run the pump in dry condition.
- D. Verify that correct size heaters-motor over-load devices are installed for each pump controller unit.
- E. Perform field mechanical balancing if necessary to meet specified vibration tolerance.
- F. Ensure the disposable strainer is free of debris prior to testing and balancing of the hydronic system.
- G. After several days of operation, replace the disposable start-up strainer with a regular strainer in the suction diffuser.

3.3 FUNCTIONAL PERFORMANCE AND INTEGRATED SYSTEMS TESTING

- A. Functional Performance and Integrated Systems Testing (FP & IST) is part of the commissioning process. FP & IST shall be performed by the Contractor, and witnessed and documented by the Commissioning Authority. Refer to Section 019113, COMMISSIONING, for FP & IST requirements.

3.4 TRAINING

- A. Training of the VAMC operation and maintenance personnel shall be required in cooperation with the VA Resident Engineer. Provide competent, factory-authorized personnel to instruct operation and maintenance personnel concerning the location, operation, and troubleshooting of the installed systems. The instruction shall be scheduled in coordination with the VA Resident Engineer after submission and approval of formal training plans. Refer to Section 017900, DEMONSTRATION AND TESTING, and Section 019113, COMMISSIONING, for Contractor training requirements.

--- END ---

SECTION 23 22 13
STEAM AND CONDENSATE HEATING PIPING

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Steam, condensate and vent piping inside buildings. Flash tanks, valves, expansion joints, pressure reducing valves, traps and accessories. Boiler plant and outside steam distribution piping is covered in specification Section 33 63 00, STEAM ENERGY DISTRIBUTION and Section 23 21 11, BOILER PLANT PIPING SYSTEMS.

1.2 RELATED WORK

- A. General mechanical requirements and items, which are common to more than one section of Division 23: Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
- B. Converters: Section 23 21 23, HYDRONIC PIPING.
- C. Pumps: Section 23 22 23, STEAM CONDENSATE PUMPS.
- D. Piping insulation: Section 23 07 11, HVAC INSULATION.
- E. Water treatment for open and closed systems: Section 23 25 00, HVAC WATER TREATMENT.
- F. Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT.
- G. Temperature and pressure sensors and valve operators: Division 25, INTEGRATED AUTOMATION.
- H. Section 01 03 42, ALTERNATES: Alternate 9.36 for steam-to-clean steam generator and stainless steel piping serving humidifiers (in lieu of direct use of plant steam for humidification).

1.3 QUALITY ASSURANCE

- A. Section 23 05 11, COMMON WORK RESULTS FOR HVAC, which includes welding qualifications.

1.4 SUBMITTALS

- A. Submit in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.
- B. Manufacturer's Literature and Data:
 - 1. Pipe and equipment supports. Submit calculations for variable spring and constant support hangers.
 - 2. Pipe and tubing, with specification, class or type, and schedule.
 - 3. Pipe fittings, including miscellaneous adapters and special fittings.

4. Flanges, gaskets and bolting.
 5. Valves of all types.
 6. Strainers.
 7. Flexible connectors.
 8. Pipe alignment guides.
 9. Expansion joints.
 10. Expansion compensators.
 11. Flexible ball joints: Catalog sheets, performance charts, schematic drawings, specifications and installation instructions.
 12. All specified steam system components.
 13. Gages.
 14. Thermometers and test wells.
- C. Manufacturer's certified data report, Form No. U-1, for ASME pressure vessels:
1. Heat exchangers.
 2. Flash tanks.
- D. Coordination Drawings: Refer to Article, SUBMITTALS of Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
- E. As-Built Piping Diagrams: Provide drawing as follows for steam and steam condensate piping and other central plant and building equipment.
1. One wall-mounted stick file for prints. Mount stick file as directed by Owner.
 2. All as-built drawings in electronic format to be determined by Owner.

1.5 APPLICABLE PUBLICATIONS

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.
- B. American National Institute Standard (ANSI):
B1.20.1-01 Pipe Threads, General Purpose (Inch)
- C. American Society of Mechanical Engineers (ASME):
 B16.1-98 Cast Iron Pipe Flanges and Flanged Fittings
 B16.3-98 Malleable Iron Threaded Fittings
 B16.4-98 Gray Iron Threaded Fittings
 B16.9-01 Factory-Made Wrought Buttwelding Fittings
 B16.11-02 Forged Fittings, Socket-Welding and Threaded
 B16.14-91 Ferrous Pipe Plugs, Bushings, and Locknuts with Pipe Threads
 B16.22-98 Wrought Copper and Copper Alloy Solder-Joint Pressure Fittings
 B16.23-92 Cast Copper Alloy Solder Joint Drainage Fittings
 B16.24-01 Cast Copper Alloy Pipe Flanges and Flanged Fittings, Class 150, 300, 400, 600, 900, 1500 and 2500
 B16.39-98 Malleable Iron Threaded Pipe Unions, Classes 150, 250, and 300
 B31.1-01 Power Piping
 B31.9-96 Building Services Piping
 B40.100-98 Pressure Gauges and Gauge Attachments
 Boiler and Pressure Vessel Code: SEC VIII D1-2001, Pressure Vessels, Division 1

- D. American Society for Testing and Materials (ASTM):
- A47-99 Ferritic Malleable Iron Castings
 - A53-01 Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
 - A106-99 Seamless Carbon Steel Pipe for High-Temperature Service
 - A126-01 Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings
 - A181-01 Carbon Steel Forgings, for General-Purpose Piping
 - A183-98 Carbon Steel Track Bolts and Nuts
 - A216-98 Standard Specification for Steel Castings, Carbon, Suitable for Fusion Welding, for High Temperature Service
 - A285-01 Pressure Vessel Plates, Carbon Steel, Low-and-Intermediate-Tensile Strength
 - A307-00 Carbon Steel Bolts and Studs, 60,000 PSI Tensile Strength
 - A516-01 Pressure Vessel Plates, Carbon Steel, for Moderate-and- Lower Temperature Service
 - A536-99 Standard Specification for Ductile Iron Castings
 - B32-00 Solder Metal
 - B61-93 Steam or Valve Bronze Castings
 - B62-93 Composition Bronze or Ounce Metal Castings
 - B88-99 Seamless Copper Water Tube
- E. American Welding Society (AWS):
- A5.8-92 Filler Metals for Brazing and Braze Welding
 - B2.1-00 Welding Procedure and Performance Qualifications
- F. Manufacturers Standardization Society (MSS) of the Valve and Fitting Industry, Inc.:
- SP-67-95 Butterfly Valves
 - SP-70-98 Cast Iron Gate Valves, Flanged and Threaded Ends
 - SP-71-97 Gray Iron Swing Check Valves, Flanged and Threaded Ends
 - SP-72-99 Ball Valves with Flanged or Butt-Welding Ends for General Service
 - SP-78-98 Cast Iron Plug Valves, Flanged and Threaded Ends
 - SP-80-97 Bronze Gate, Globe, Angle and Check Valves
 - SP-85-94 Cast Iron Globe and Angle Valves, Flanged and Threaded Ends
- G. Military Specifications (Mil. Spec.):
- MIL-S-901D-1989 Shock Tests, H.I. (High Impact) Shipboard Machinery, Equipment, and Systems
- H. National Board of Boiler and Pressure Vessel Inspectors (NB): Relieving Capacities of Safety Valves and Relief Valves
- I. Tubular Exchanger Manufacturers Association: TEMA 18th Edition, 2000

PART 2 - PRODUCTS

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

- A. Provide in accordance with Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

2.2 PIPE AND TUBING

- A. Steam Piping: Steel, ASTM A53, Grade B, Seamless or ERW; or ASTM A106, Grade B, Seamless; Schedule 40.
- B. Steam Condensate Piping: Steel, ASTM A53, Grade B, Seamless or ERW; or ASTM A106, Grade B, Seamless; Schedule 80.
- C. Vent Piping: Galvanized Steel, ASTM A53 Grade B, Seamless or ERW; or ASTM A106 Grade B, Seamless; Schedule 40.
- D. Clean Steam Piping (Alternate 9.36): Stainless steel, ASTM A312 TP316L, seamless; Schedule 40.

2.3 FITTINGS FOR STEEL PIPE

- A. 65 mm (2-1/2 inches) and Larger: Welded or flanged joints. Mechanical couplings and fittings are optional for water piping only. All piping within inaccessible areas and/or shafts shall be welded.
 - 1. Butt welding fittings: ASME B16.9 with same wall thickness as connecting piping. Elbows shall be long radius type, unless otherwise noted. ANSI A234 WPB.
 - 2. Welding flanges and bolting: ASME B16.5:
 - a. Steam service: Weld neck or slip-on, raised face, with non-asbestos gasket. Non-asbestos gasket shall either be stainless steel spiral wound strip with flexible graphite filler or compressed inorganic fiber with nitrile binder rated for saturated and superheated steam service 750 degrees F and 1500 psi.
 - b. Flange bolting: Carbon steel machine bolts or studs and nuts, ASTM A307, Grade B.
- B. 50 mm (2 inches) and Smaller: Screwed or socket welded. All piping within inaccessible areas and/or shafts shall be welded.
 - 1. Butt welding: ASME B16.9 with same wall thickness as connecting piping. Carbon steel A105.
 - 2. Forged steel, socket welding or threaded: ASME B16.11. Carbon steel A105.
 - 3. Screwed: 300 pound malleable iron, ASME B16.3. Cast iron fittings are not acceptable for steam and steam condensate piping. Bushing reduction of a single pipe size, or use of close nipples, is not acceptable.
 - 4. Unions: ASME B16.39. Malleable Iron, 300 pound WSP.
 - 5. Steam line drip station and strainer quick-couple blowdown hose connection: Straight through, plug and socket, screw or cam locking type for 15 mm (1/2 inch) ID hose. No integral shut-off is required.
- C. Welded Branch and Tap Connections: Tee's, Forged steel weldolets, or branchlets and thredolets may be used for branch connections up to one pipe size smaller than the main. Forged steel half-couplings, ASME B16.11 may be used for drain, vent and gage connections. Fishmouth or shaped nipples will not be allowed.

2.4 DIELECTRIC FITTINGS

- A. Provide where copper tubing and ferrous metal pipe are joined.

- B. 50 mm (2 inches) and Smaller: Threaded dielectric union, ASME B16.39. Malleable iron 300 pound WSP.
- C. 65 mm (2 1/2 inches) and Larger: Flange union with dielectric gasket and bolt sleeves, ASME B16.42.
- D. Temperature Rating, 121 degrees C (250 degrees F) for steam condensate and as required for steam service.

2.5 SCREWED JOINTS

- A. Pipe Thread: ANSI B1.20.
- B. Lubricant or Sealant: Oil and graphite or other compound approved for the intended service.

2.6 VALVES

- A. Asbestos packing is not acceptable.
- B. All valves of the same type shall be products of a single manufacturer. Provide gate and globe valves with packing that can be replaced with the valve under full working pressure.
- C. Provide chain operators for valves 100 mm (4 inches) and larger when the centerline is located 2400 mm (8 feet) or more above the floor or operating platform.
- D. Gate Valves:
 - 1. 50 mm (2 inches) and smaller: MSS-SP80, ASTM B62 Cast Bronze, 1034 kPa (150 lb.), wedge disc, rising stem, union bonnet.
 - 2. 65 mm (2 1/2 inches) and larger: Flanged, raised face, outside screw and yoke.
 - a. High pressure steam 413 kPa (60 psig) and above nominal MPS system): Cast steel body, ASTM A216 grade WCB, 1034 kPa (150 psig) at 260 degrees C (500 degrees F), 11-1/2 to 13 percent chrome stainless steel solid disc and seats. Provide factory installed bypass with globe valve on valves 100 mm (4 inches) and larger.
 - b. All other services: MSS-SP 70, iron body, bronze mounted, 861 kPa (125 psig) wedge disc.
- E. Globe, Angle and Swing Check Valves:
 - 1. 50 mm (2 inches) and smaller: MSS-SP 80, bronze, rising stem, 1034 kPa (150 lb.) Globe and angle valves shall be union bonnet with metal plug type Teflon disc, integral and renewable seat.
 - 2. 65 mm (2 1/2 inches) and larger:
 - a. Globe valves for high pressure steam 413 kPa (60 psig) and above nominal MPS system): Cast steel body, ASTM A216 grade WCB, rising stem, flanged, OS&Y, 1034 kPa (150 psig) at 260 degrees C (500 degrees F), 11-1/2 to 13 percent chrome stainless steel disc and renewable seat rings.

- F. Non-Slam or Silent Check Valve: Spring loaded double disc globe swing check or internally guided flat disc lift type check for bubble tight shut-off. Provide where check valves are shown in chilled water and hot water piping. Check valves incorporating a balancing feature may be used.
1. Body: Steel, ASTM A216, Class WCB, or ductile iron, ASTM 536, flanged, grooved, or wafer type.
 2. Seat, disc and spring: 18-8 stainless steel.
- G. Swing Check Valves: For steam and steam condensate service. Valves to be Class 150 manufactured in accordance with MSS-SP 71. Raised face flanged ends with bolted bonnet and Stainless Steel disc and seat rings.
1. Body and bonnet conforming to ASTM A395 Ductile Iron, Class 150.
- H. Vacuum Breakers
1. Adjustable from 1/4" - 20" (8-508mm) Hg vacuum, factory set at 2" (51mm) Hg vacuum. For use on closed vessels and piping systems to control induced vacuum within safe limits. 3/4" NPT straight shank. Maximum operating temperature 366°F (186°C). Maximum operating pressure 150 psig (10.3 bar).
- I. High Performance Butterfly Valves for Steam Service: Sizes 2 1/2" and larger shall be an **ANSI class valve** equal to or greater than the class specified for the service but in no case be less than ANSI Class 150.
1. Body:
 - a. Carbon steel, fully lugged, suitable for bi-directional tight shut off to full rated pressure without a downstream flange.
 2. Valve shall have no disk contact with the seat when in the open position or any intermediate position. Seal suitable for the operating service and operating temperature plus 50°F. Bearings shall be constructed of SS/Graphite. Valve shall be of the triple off-set design. The disk shall be 316 stainless steel. The shaft shall be 17-4 PH stainless steel. The disk pin shall be 316 or 17-4 stainless steel. Seat retainer ring fasteners shall not in contact with system fluid.
 3. Operator shall be worm gear type, cast iron, ASTM A126. Housing Class B with bronze shaft bearings. Segment gear shall be Ductile iron ASTM A536. Handwheel shall be Ductile iron ASTM A536. Minimum diameter of handwheel shall be 12" for valve sizes through 20" and 18" for valves larger than 20". Position indicator and shall also indicate "open" and "closed" position with memory stop. All gearing shall be enclosed in a housing.

2.7 STRAINERS

- A. Basket or Y Type.
- B. High Pressure (>60 psig) Steam: Rated 1034 kPa (300 psig) saturated steam.
1. 65 mm (2-1/2 inches) and larger: Flanged cast steel or 300 psig ductile iron or carbon steel.
 2. 50 mm (2 inches) and smaller: Ductile Iron, ASTM A116 Grade B, or bronze, ASTM B-62 body with screwed connections, 250 psig.

- C. All Other Services: Rated 861 kPa (125 psig) saturated steam.
 - 1. 65 mm (2-1/2 inches) and larger: Flanged, iron body.
 - 2. 50 mm (2 inches) and smaller: Cast iron or bronze.
- D. Screens: Bronze, monel metal or 18-8 stainless steel, free area not less than 2-1/2 times pipe area, with perforations as follows:
 - 1. 75 mm (3 inches) and smaller: 20 mesh for steam and 1.1 mm (0.045 inch) diameter perforations for liquids.
 - 2. 100 mm (4 inches) and larger: 1.1 mm (0.045) inch diameter perforations for steam and 3.2 mm (0.125 inch) diameter perforations for liquids.

2.8 EXPANSION JOINTS

- A. General
 - 1. Furnish and install all necessary offsets, joints, expansion loops, compensators, anchors and guides so that no stress is placed on the piping systems or equipment due to thermal expansion.
 - 2. Make proper provision for expansion and contraction in all parts of piping systems wherever possible by means of pipe bends, pipe offsets, swing connections or changes in direction of piping. Where piping network cannot be employed to absorb expansion and contraction in the piping systems, provide expansion joint compensators.
 - 3. Expansion compensator elements shall be as specified herein and shall be selected by the manufacturer to withstand system pressure and temperature conditions and to absorb thermal expansion of the piping. Use of expansion compensators in non-accessible locations shall not be permitted.
 - 4. Where piping network cannot be employed to absorb expansion and contraction in the piping systems, provide expansion joint compensators. Securely anchor all piping utilizing expansion loops and joints to the building structure with steel angles, properly braced and welded to the pipe.
- B. Factory built devices, inserted in the pipe lines, designed to absorb axial cyclical pipe movement which results from thermal expansion and contraction. This includes factory-built or field-fabricated guides located along the pipe lines to restrain lateral pipe motion and direct the axial pipe movement into the expansion joints.
- C. Minimum Service Requirements:
 - 1. Pressure Containment:
 - a. Steam Service 35-200 kPa (5-30 psig): Rated 345 kPa (50 psig) at 148 degrees C (298 degrees F).
 - b. Steam Service 214-850 kPa (31-125 psig): Rated 1025 kPa (150 psig) at 186 degrees C (366 degrees F).
 - c. Steam Service 869-1025 kPa (126-150 psig): Rated 1375 kPa (200 psig) at 194 degrees C (382 degrees F).
 - d. Condensate Service: Rated 690 kPa (100 psig) at 154 degrees C (310 degrees F).
 - 2. Number of Full Reverse Cycles without failure: Minimum 1000.
 - 3. Movement: As shown on drawings plus recommended safety factor of manufacturer.

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- D. Manufacturing Quality Assurance: Conform to Expansion Joints Manufacturers Association Standards.
- E. Bellows - Internally Pressurized Type:
1. Multiple corrugations of Type 304 or Type A240-321 stainless steel.
 2. Internal stainless steel sleeve entire length of bellows.
 3. External cast iron equalizing rings for services exceeding 340 kPa (50 psig).
 4. Welded ends.
 5. Design shall conform to standards of EJMA and ASME B31.1.
 6. External tie rods designed to withstand pressure thrust force upon anchor failure if one or both anchors for the joint are at change in direction of pipeline.
 7. Integral external cover.
- F. Bellows - Externally Pressurized Type:
1. Multiple corrugations of Type 304 stainless steel.
 2. Internal and external guide integral with joint.
 3. Design for external pressurization of bellows to eliminate squirm.
 4. Welded ends.
 5. Conform to the standards of EJMA and ASME B31.1.
 6. Threaded connection at bottom, 25 mm (one inch) minimum, for drain or drip point.
 7. Integral external cover and internal sleeve.
- G. Expansion Joint Identification: Provide stamped brass or stainless steel nameplate on each expansion joint listing the manufacturer, the allowable movement, flow direction, design pressure and temperature, date of manufacture, and identifying the expansion joint by the identification number on the contract drawings.
- H. Guides: Provide factory-built guides along the pipe line to permit axial movement only and to restrain lateral and angular movement. Guides must be designed to withstand a minimum of 15 percent of the axial force which will be imposed on the expansion joints and anchors.
1. Pipe guides shall be of spider and sleeve type to insure multiplanar guiding and to allow complete insulation of the piping and shall be covered inside and outside with protective coating. Top half shall be removable.
- I. Inline Seismic Expansion Joint
1. The seismic expansion joint shall be fully enclosed in-line construction. Designs requiring elbows or a change in direction are not acceptable. The pressure/temperature rating shall be 150 psig at 400°F. Rated axial and lateral (all planes) motions shall be plus or minus 6", 12", 18" or 24" as required. The assembly shall consist of a Ball Joint at each end for lateral offset and a multi-ply externally pressurized expansion joint for axial motion. Bellows design shall be in accordance with the Standards of the Expansion Joint Manufacturer's Association, Inc. using ASME Section II, Part D allowable stresses. Internal vented guiding shall be included. All pipe including the expansion joint housing shall be ASTM A53 Gr. B standard weight.
- J. Spring Riser Supports
1. Refer to Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT.

K. Engineering Services

1. The Contractor shall provide a thermal stress analysis on all piping to confirm allowable stresses are below 80%.
2. The Contractor shall retain a registered Professional Engineer licensed to practice in the project state to review all loads imposed on the building structure and piping system to assure that no points are overstressed.
3. The maximum allowable stress shall be 15,000 psi for cold water, hot water, condensate, and steam and the maximum allowable stress shall be 2500 psi for generator exhaust piping if pipe material is low carbon steel A53 B or A106 B (Marks' Standard Handbook for Mechanical Engineers, Tenth Edition).
4. The Contractor shall submit shop drawings with calculations (with P.E. stamp) detailing the proposed anchor locations for review.
5. All anchor details and forces shall be submitted to the project structural engineer for review prior to any installation.

2.9 FLEXIBLE BALL JOINTS

- A. Design and Fabrication: One piece component construction, fabricated from steel with welded ends, designed for a working steam pressure of 1720 kPa (250 psig) and a temperature of 232 degrees C (450 degrees F). Each joint shall provide for 360 degrees rotation in addition to a minimum angular flexible movement of 30 degrees for sizes 6 mm (1/4 inch) to 150 mm (6 inch) inclusive, and 15 degrees for sizes 65 mm (2-1/2 inches) to 750 mm (30 inches). Joints through 350 mm (14 inches) shall have forged pressure retaining members; while size 400 mm (16 inches) through 760 mm (30 inches) shall be of one piece construction.
- B. Material:
1. Cast or forged steel pressure containing parts and bolting in accordance with Section II of the ASME Boiler Code or ASME B31.1. Retainer may be ductile iron ASTM A536, Grade 65-45-12, or ASME Section II SA 515, Grade 70.
 2. Gaskets: Steam pressure molded composition design for a temperature range of from minus 10 degrees C (50 degrees F) to plus 274 degrees C (525 degrees F).
- C. Certificates: Submit qualifications of ball joints in accordance with the following test data:
1. Low pressure leakage test: 41 kPa (6psig) saturated steam for 60 days.
 2. Flex cycling: 800 Flex cycles at 3445 kPa (500 psig) saturated steam.
 3. Thermal cycling: 100 saturated steam pressure cycles from atmospheric pressure to operating pressure and back to atmospheric pressure.
 4. Environmental shock tests: Forward certificate from a recognized test laboratory, that ball joints of the type submitted has passed shock testing in accordance with Mil. Spec MIL-S-901.
 5. Vibration: 170 hours on each of three mutually perpendicular axis at 25 to 125 Hz; 1.3 mm to 2.5 mm (0.05 inch to 0.1 inch) double amplitude on a single ball joint and 3 ball joint off set.

2.10 STEAM SYSTEM COMPONENTS

A. Steam Pressure Reducing Valves:

1. Type: Single-seated, metal diaphragm self-operated, spring-loaded, external or internal steam pilot-controlled, normally closed, adjustable set pressure. Pilot shall sense controlled pressure downstream of main valve.
2. Service and Performance: Provide controlled reduced pressure to steam piping systems. Valves shall an accurate delivery pressure within ± 1 lb. throughout the range of pressure and flow conditions scheduled, regardless of deviation of the inlet steam pressure. Valves shall function quietly and shut tight on deadend shutoff. Regulators shall respond quickly and accurately without pressure deviation when installed on a 2-stage reduction. The maximum or end point capacity of the regulator shall not pass more than 20% in excess of the required capacity. (Safety valve to be sized to pass 100% of the maximum or end point capacity). Valves shall be sized so that the valve body inlet velocity does not exceed 8000 fpm and the valve body outlet velocity does not exceed 20,000 fpm or the combined inlet and outlet velocity does not exceed 28,000 fpm.
3. Pressure control shall be smooth and continuous with maximum drop of 10 percent. Maximum flow capability of each valve shall not exceed capacity of downstream safety valve(s).
4. Main valve and pilot valve shall have replaceable valve plug and seat of stainless steel, monel, or similar durable material. Seats and discs shall be guaranteed by the manufacturer against the wire drawing action of steam. Stems shall be stainless steel. Main valve spring shall be installed in the general area of the diaphragm pressure plate to minimize stem guiding surface and to keep the spring out of the patch of the steam. Stuffing boxes will not be permitted. All parts must be accessible and replaceable without removal of the valve from the line. The pressure pilot shall be separate from the main valve and connected to it by unions. A strainer screen shall be built into the pilot inlet. Pilot shall be interchangeable with all sizes of main valves and connected to the main valve by unions. Bleedports and other orifice fittings shall be externally connected to facilitate troubleshooting and cleaning. Internal bleedports will not be permitted.
 - a. Pressure rating for high pressure steam: Not less than 1034 kPa (150 psig) saturated steam.
 - b. Connections: Flanged for valves 65 mm (2-1/2 inches) and larger; flanged or threaded ends for smaller valves.
5. Select pressure reducing valves to develop less than 85 dbA at 1500 mm (5 feet) elevation above adjacent floor, and 1500 mm (5 feet) distance in any direction. Inlet and outlet piping for steam pressure reducing valves shall be Schedule 80 minimum for required distance to achieve required levels or sound attenuators shall be applied.
 - a. Provide noise suppressors and muffling orifice plates downstream of each PRV valve. Each suppressor shall have its inlet the size of the reducing valve and be expanded to the outlet side equal to the final pipe size as shown on the plans. Suppressor shall be deceptive-reactive type, straight through design with no diverting baffles on its interior. All internal acoustical packing shall be of corrosion resistant material. Unit shall be capable of reducing the noise emanating from the downstream piping by at least 20 dB. Submit laboratory test data to support performance capabilities.
6. Provide inlet gate valve, steam strainer, outlet gate valve, bypass and safety valve per each PRV.

B. Safety Valves and Accessories:

1. Comply with ASME Boiler and Pressure Vessel Code, Section VIII. Capacities shall be certified by National Board of Boiler and Pressure Vessel Inspectors, maximum accumulation 10 percent. Provide lifting lever. Provide drip pan elbow where shown.
2. Safety valves shall be of size and setpoint as required by PRV manufacturer. Valves shall be cast iron body, lead seal, asbestos free packing and gasket and brass shaft. All internal parts made of cold rolled steel shall be cadmium plated. Provide drain pipe and valve to nearest floor drain and flexible connectors at pipe discharge.

C. Flash Tanks:

1. Horizontal or vertical vortex type, constructed of copper bearing steel, ASTM A516 or ASTM A285, for a steam working pressure of 861 kPa (125 psig) to comply with ASME Code for Unfired Pressure Vessels and stamped with "U" symbol. Perforated pipe inside tank shall be ASTM A53 Grade B, Seamless or ERW, or A106 Grade B Seamless, Schedule 80. Corrosion allowance of 1.6 mm (1/16 inch) may be provided in lieu of the copper bearing requirement. Provide data Form No. U-1. All tank seams shall be continuously welded. Tanks shall have (1) shop and (1) field coat of iron oxide primer. Provide tappings and supports as required and shown on the drawings. Tank shall have minimum 1/4" thick walls and shall be fully insulated.

D. Steam Trap:

1. Each type of trap shall be the product of a single manufacturer. Provide trap sets at all low points and at 61 m (200 feet) intervals on the horizontal main lines.
2. Floats and linkages shall provide sufficient force to open trap valve over full operating pressure range available to the system. Unless otherwise indicated on the drawings, traps shall be sized for capacities indicated at minimum pressure drop as follows:
 - a. For equipment with modulating control valve: 1.7 kPa (1/4 psig), based on a condensate leg of 300 mm (12 inches) at the trap inlet and gravity flow to the receiver.
 - b. For main line drip trap sets and other trap sets at steam pressure: Up to 70 percent of design differential pressure. Condensate may be lifted to the return line.
 - c. LPS steam service traps shall be closed float and thermostatic type Class 30. MPS and HPS steam service traps shall be inverted bucket type, Class 300.
3. Trap bodies: Bronze, cast iron, or semi-steel, constructed to permit ease of removal and servicing working parts without disturbing connecting piping. For systems without relief valve traps shall be rated for the pressure upstream of the PRV supplying the system.
 - a. Float and thermostatic type traps shall have cast iron body, ASTM A278, Class 30. Pipe connections shall be in the body and the entire trap mechanism attached to the cap. Float and mechanism shall be stainless steel with heat treated chrome steel valve. The float shall be Heliarc welded to avoid introduction of dissimilar metals. The thermostatic air vent shall be a balanced pressure phosphor bronze disc diaphragm type with stainless steel valve and seat.
 - b. Inverted bucket traps for high pressure service, Class 300, shall be fused steel with cap and body forgings made of 1030 carbon steel, inlet tube of alloy steel pipe, gasket bolts of high temperature low alloy steel, nuts of semi-finish hex, heat treated, stainless steel valve retainer, lever and guide pin assembly, chrome steel, heat treated valve and valve seat. Bucket shall be stainless steel cap and tube, cast iron weight.

4. Balanced pressure thermostatic elements: Phosphor bronze, stainless steel or monel metal.
 5. Valves and seats: Suitable hardened corrosion resistant alloy.
 6. Mechanism: Brass, stainless steel or corrosion resistant alloy.
 7. Floats: Stainless steel.
 8. Inverted bucket traps: Provide bi-metallic thermostatic element for rapid release of non-condensables.
 9. Drip points shall be provided at the ends of mains and at points where a rise in elevation is required, whether such traps are shown on the drawings or not, to suit the job installation conditions. Provide a dirt pocket of suitable size and length as detailed on the drawings fit with a cap. Drip traps shall be 3/4" size unless otherwise indicated.
- E. Thermostatic Air Vent (Steam)
1. Brass or iron body, balanced pressure bellows, stainless steel (renewable) valve and seat, rated 861 kPa (125 psig) working pressure, 20 mm (3/4 inch) screwed connections. Air vents shall be balanced pressure type that responds to steam pressure-temperature curve and vents air at any pressure.
- F. Steam Humidifiers: Refer to Section 23 84 13, HUMIDIFIERS.
- G. Steam Flow Meter/Recorder: Refer to Division 25, INTEGRATED AUTOMATION.
- H. Steam Exhaust Head:
1. Cast iron, fitted with baffle plates, to trap and drain condensed water.
- I. Steam Separator
1. Pressure and temperature rating suitable for service.
 2. 316 stainless steel construction.
 3. Designed to ensure moisture removal from steam line serving sterilizers.
 4. Line size inlet and outlet connections.
 5. Drain and vent connections.
- J. Steam Filter
1. Pressure and temperature rating suitable for service.
 2. 316 stainless steel construction.
 3. Efficiency: Filter element rated to remove minimum 95% of all particles exceeding 2 microns.
 4. Line size inlet and outlet connections
 5. Drain and vent connections.
- K. Condensate Cooler
1. The condensate cooler shall include a direct operated cooling control system to control the drain temperature as per the local code.
 2. The vessel and the cooling control valve shall be designed for the capacities as indicated on the drawings. The general layout of the system shall be as per the HVAC detail.
 3. Vessel shall be vertical design steel construction in accordance with ASME Section VIII code stamped for 150 psig service. The vessel shall have ANSI 150 flange connections for condensate inlet and vent. NPT connections shall be provided for condensate outlet and the pressure gauge. Vessel shall include legs for support. When required, the vessel shall be fitted with a sparge tube on cooling water supply and temperature gauges.

4. Direct-operated temperature control system shall consist of a main valve and controller. Controller shall be self-powered type providing proportional control. Valves to be furnished complete with control system and shall be normally closed for cooling control. Valve bodies shall be bronze or steel with stainless steel trim and screwed or flanged connections.
5. The controllers shall be brass with PVC covered, armor sheathed capillary with stainless steel sensor and capillary; solid oil-filled, hydraulically operated and shall incorporate packless glands and a gas-filled overheat protection device. Temperature setting knob shall be adjustable while in service.
6. The system shall include an adjustment scale in degrees Fahrenheit or Celsius and shall incorporate a tamperproof device. When required, sensor bulb shall be mounted in a separable well to allow removal from the equipment.

L. Unfired Steam Generators – Steam-to-“Clean”-Steam (Alternate 9.36)

1. Unfired Steam Generator shall be furnished as a complete package ready for installation including all necessary components for operation.
2. The unfired steam generator, steam to steam type, shall be of the sizes and capacities noted on the schedule. The unfired steam generator shall be factory mounted, wired, piped, and tested.
3. Feed water shall be provided with carbon de-chlorination system upstream of steam generator.
4. Provide duplex softener system if the unit is not fed with RO water.
5. Unfired Steam Generator shall be ASME Code constructed and stamped in accordance with Section VII, Division I, for Unfired Steam Generators and shall be U.L. listed. Unfired Steam Generators shall be registered with the National Board of Boiler and Pressure Vessel Inspectors, and signed copy of shop inspection report shall be furnished. When generating steam above 50 psi, Unfired Steam Generator shall be 100% x-rayed in accordance with Section VIII “Unfired Steam Generators” and shall bear the “UB” stamp. When generating steam below 50 psi, Unfired Steam Generator shall be in accordance with Section VIII “Unfired Steam Generators” and shall bear the “UB” stamp.
6. Unfired Steam Generator shall be mounted on a suitable I-Beam support skid, which shall be permanently welded to the shell.
7. Unfired Steam Generator shall be insulated with not less than 2” of Fiberglas insulation, protected by not less than 20 ga. thick enameled steel jacket.
8. Unfired Steam Generator shall be furnished with materials appropriate for the generated steam fluids noted on the schedule.
9. All unfired steam generator components subject to the source steam side shall be of carbon steel construction. Component piping on source steam side shall be (carbon steel) as specified in Section 232213.
10. Unfired Steam Generator shall be furnished with a source steam gauge to monitor the source steam pressure. Gauge shall be of copper or brass construction with a steel case and shall be of the appropriate range for the source steam pressure.
11. Unfired Steam Generator will be furnished with a pilot actuated control valve to modulate the incoming steam to maintain the desired output of steam pressure + 2 psi. Control valve shall be suitable for 150 psi at 300 F. Control valve pilot shall monitor output steam pressure and modulate the generator steam to maintain constant output pressure.
12. Unfired Steam Generator will be factory supplied with dual float and thermostatic traps, one for the coil and one for the drip before the control valve. Unfired Steam Generator shall have incoming steam strainer.
13. Unfired Steam Generators shall be furnished with an internal steam separator.
14. Unfired steam generator shall be factory furnished with a high water shut off. High water cut off shall include an electronic probe mounted in the top of the unit connected to an electric operated power to open spring to close ball valve for steam generator operating at or below 15 psi. For steam generators operating above 15 psi steam, high water shut-off shall open feed water pump circuit. In the event of high water, ball valve will close.

15. Unfired Steam Generators shall be provided with a set of dry contacts to alert the Building Automation System (BAS) of either a high pressure, low water, or high water condition occurs. Additionally, the unit shall be provided with a 120-volt alarm bell that is factory wired to sound at any of these conditions. Unfired Steam Generators shall be furnished with an alarm-silencing relay with red alarm light and manual push button.
16. Unfired Steam Generator shall be furnished with a relay for remote on-off control from the BAS.
17. Unfired Steam Generator shall be furnished with dry contacts to signal building management system on low water, high water or high pressure.
18. Unfired Steam Generator shall be furnished with a TDS (total dissolved solids) Blow Down system.
 - a. A factory installed time sample feed water blow down system consisting of a control which measures the total dissolved solids in the Unfired Steam Generator.
 - b. The blow down operates on a timed basis and if the total dissolved solids exceed the set point the valve shall blow down the steam generator until fresh water brings the total dissolved solids level to the desired setting.
 - c. Provide surface blow down dip tube.
 - d. Provided automated blow down controller.
 - e. Automatic blow off system shall be furnished with a NEMA I control system and all factory wired to a single point 120 volt connection.
 - f. Field piping of cold water to the unit's mixing valve and venting from the unit shall be the responsibility of the contractor in the field.
19. Provide two bottom taps, at opposite ends of the pressure vessel, with automated blow down valves.
20. Provide two or more inspection hand holes.
21. Provide an ASME pressure rated blow down separator and Condensate Cooler.
 - a. Provide a thermometer in the drain leg and a check valve is furnished on the cold water inlet. Tank is mounted and piped as part of the Unfired Steam Generator package.
22. Unfired Steam Generators shall be furnished as factory packages with all wiring to single terminal strip and will be factory pipes so contractor shall have field connections to city water, source steam, source steam condensate, clean steam outlet, drain and relief valve outlets.

2.11 GAGES, PRESSURE AND COMPOUND

- A. ASME B40.1, Accuracy Grade 1A, (pressure, vacuum, or compound), initial mid-scale accuracy 1 percent of scale (Qualify grade), aluminum or phenolic case, 115 mm (4-1/2 inches) in diameter, 6 mm (1/4 inch) NPT bottom connection, white dial with black graduations and pointer, clear glass or acrylic plastic window, suitable for board mounting. Provide red "set hand" to indicate normal working pressure.
- B. Provide brass, lever handle union cock. Provide brass/bronze pressure snubber for gages in water service. Provide brass pigtail syphon for steam gages. Movement components shall be stainless steel.

- C. Range of Gages: For services not listed provide range equal to at least 130 percent of normal operating range:

Low pressure steam to 103 kPa(15 psig)	0 to 207 kPa (30 psig).
Medium pressure steam nominal 413 kPa (16 psig to 60 psig)	0 to 689 kPa (100 psig).
High pressure steam nominal 620 kPa to 861 kPa (61to 125 psig)	0 to 1378 kPa (200 psig).

2.12 PRESSURE/TEMPERATURE TEST PROVISIONS

- A. Pete's Plug: 6 mm (1/4 inch) MPT by 75 mm (3 inches) long, brass body and cap, with retained safety cap, nordel self-closing valve cores, permanently installed in piping where shown, or in lieu of pressure gage test connections shown on the drawings.
- B. Provide one each of the following test items to the Resident Engineer:
1. 6 mm (1/4 inch) FPT by 3 mm (1/8 inch) diameter stainless steel pressure gage adapter probe for extra long test plug.
 2. 90 mm (3-1/2 inch) diameter, one percent accuracy, compound gage, 762 mm (30 inches) Hg to 689 kPa (100 psig) range.
 3. 0 - 104 degrees C (220 degrees F) pocket thermometer one-half degree accuracy, 25 mm (one inch) dial, 125 mm (5 inch) long stainless steel stem, plastic case.

2.13 FIRESTOPPING MATERIAL

- A. Refer to Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

PART 3 - EXECUTION

3.1 GENERAL

- A. The drawings show the general arrangement of pipe and equipment but do not show all required fittings and offsets that may be necessary to connect pipes to equipment, heat exchangers, coils, radiators, etc., and to coordinate with other trades. Provide all necessary fittings, offsets and pipe runs based on field measurements and at no additional cost to the government. Coordinate with other trades for space available and relative location of HVAC equipment and accessories to be connected on ceiling grid. Pipe location on the drawings shall be altered by contractor where necessary to avoid interferences and clearance difficulties.
- B. 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.
- C. Support piping securely. Refer to PART 3, Section 23 05 11, COMMON WORK RESULTS FOR HVAC. Install convertors and other heat exchangers at height sufficient to provide gravity flow of condensate to the flash tank and condensate pump. Provide supports as required.

- D. Install piping generally parallel to walls and column center lines, unless shown otherwise on the drawings. Space piping, including insulation, to provide 25 mm (one inch) minimum clearance between adjacent piping or other surface. Unless shown otherwise, slope steam, condensate and drain piping down in the direction of flow not less than 25 mm (one inch) in 12 m (40 feet). Provide eccentric reducers to keep bottom of sloped piping flat.
- E. 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. Provide a union adjacent to one end of all threaded end valves. Control valves usually require reducers to connect to pipe sizes shown on the drawing. Install butterfly valves with the valve open as recommended by the manufacturer to prevent binding of the disc in the seat.
- F. Offset equipment connections to allow valving off for maintenance and repair with minimal removal of piping. Provide flexibility in equipment connections and branch line take-offs with 3-elbow swing joints. Support piping independently at all equipment so that the equipment is not stressed by piping weight or expansion. Provide proper provision for expansion and contraction in all portions of pipe work, to prevent undue strains on piping or apparatus connected. Provide double swings at riser transfers and other offsets to take up expansion. Arrange riser branches to take up motion of riser. Branch runouts to equipment shall have a minimum of (3) elbows, adequately spaced.
- G. Joints shall be made tight and leakproof against test pressures. Leaks in screwed or flanged joints which cannot be eliminated by normal wrench tightening methods shall be repaired at the joint. Under no circumstances shall caulking be allowed. No joints shall be backed off to align pipe fittings. Provide extra heavy pipe for nipples where unthreaded portion of pipe is less than 1 1/2" long. Use of close nipples is not permitted. Avoid bull-head tees, which are two return lines entering opposite ends of a tee and exiting out the common side.
- H. Connect piping to equipment as shown on the drawings. Install components furnished by others such as:
 - 1. Flow elements (orifice unions), flow meters, control valve bodies, flow switches, pressure taps with valve, and wells for sensors.
- I. Firestopping: Fill openings around uninsulated piping penetrating floors or fire walls, with firestop material. For firestopping insulated piping refer to Section 23 07 11, HVAC INSULATION.
- J. Where copper piping is connected to steel piping, provide dielectric connections.
- K. At low points of steam lines provide traps adequately sized to collect condensate. All supply mains shall be dripped and trapped on any vertical lift. Provide capped full sized dirt pockets at all traps, riser heels, and wherever dirt and scale may accumulate.
- L. To meet job conditions, mains shall be set up (with drip connections to return line) to maintain headroom and clear other pipes as hereinbefore specified. System is to be arranged to secure venting of air to the return line at all low points in steam mains, without permitting ingress of air. All apparatus subject to high temperature differentials and high steam demand loads such as steam-water heat exchangers shall have vacuum breakers installed.
- M. Where condensate piping, to meet job conditions, may have to set down under stoops, doors, etc., and again rise after passing these, the sets shall be made with 45° fittings and with Y-laterals at each end, with brass plugs to permit easy cleaning of trapped portions of pipe.

At any points where return mains have to rise again, after being depressed, provide overhead "air lines" (not smaller than 1" in size) and connect the (2) high sides. Any turns in water sealed lines shall be made with crosses, with brass plugs in unused outlets to facilitate cleaning.

3.2 PIPE JOINTS

A. Welded: Beveling, spacing and other details shall conform to ASME B31.1 and AWS B2.1. See Welder's qualification requirements under "Quality Assurance" in Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

1. Welding shall be performed by experienced welders in a neat and workmanlike manner. Mitered elbows are not permitted. Odd angle elbows shall be cut from long radius elbows. The weld reinforcement shall be not less than 1/16" nor more than 1/8" above the normal surface of the joined sections. The reinforcement shall be crowned at the center and shall taper on each side to the surface being joined. The exposed surface of the weld shall present a workmanlike appearance and shall be free of depressions below the surface of the joined members.
2. No welding of any kind shall be done when the temperature of the base metal is lower than 50°F. Material to be welded during freezing temperatures shall be made warm and dry before welding is started. Temperature of metal shall be "warm to the hand", or approximately 60°F.
3. Inspection:
 - a. Welds will be inspected visually by supervisory representatives of the Architect and the Contractor.
 - b. Representative welds shall be x-ray tested by an Independent testing company as outlined below.
 - c. Any weld judged defective by the Architect from a visual inspection shall be cut out and tested in the presence of the Owner or his representative. In the event any welder consistently produces a high percentage of unsatisfactory production welds, he shall be discharged at the request of the Owner, even though he is able to produce satisfactory welds when especially tested.
 - d. Removal and replacement of test coupons and samplings shall be done at the expense of the Contractor.
 - e. The Owner reserves the right to ultrasonically or radio-graphically test any welds for full penetration.
4. Radio-graphic (X-ray) Testing. **X-Ray Testing is required on system listed in paragraph 3.2-A.4.C. Reference Pre-Bid RFI WP-09B-060.**
 - a. X-ray testing of welds shall be performed by certified weld inspectors of an independent testing agency, whose services shall be furnished by the Division 23 Contractor.
 - b. The welds shall meet the x-ray requirements of ASME B31.1
 - c. X-ray testing of the following systems is required:
 - 1) High Pressure steam systems (>75 psig).
 - a) All welds for pipe sizes larger than 2 inches.
 - 2) High pressure steam condensate systems:
 - a) 20% of the first 100 welds. Tested welds shall be selected at random by the Architect and Construction Manager.

- b) 10% of the remaining welds at the discretion of the Architect and Construction Manager.
 - 3) Medium and low pressure, steam condensate and pumped condensate systems:
 - a) 20% of the first 100 welds. Tested welds shall be selected at random by the Architect and Construction Manager.
 - b) 10% of the remaining welds at the discretion of the Architect and Construction Manager.
 - d. Should any x-ray tested weld fail inspection, the Owner reserves the right to have all welds x-ray tested, at no additional cost.
- B. Screwed: Threads shall conform to ASME B1.20; joint compound, suitable for design temperature and pressure of the piping system, shall be applied to male threads only and joints made up so no more than three threads show. Special care shall be used to avoid marring or damaging pipe and fitting surfaces. No joints shall be "backed-off" to align pipe and fittings. Coat exposed threads on steel pipe with joint compound, or red lead paint for corrosion protection.
- C. 125 Pound Cast Iron Flange (Plain Face): Mating flange shall have raised face, if any, removed to avoid overstressing the cast iron flange.
- D. Solvent Welded Joints: As recommended by the manufacturer.
- E. Apply "Never Freeze" compound on all flange bolts. Torque all bolts to suitable values using torque wrenches.
- F. All piping within inaccessible shafts, trenches or underground shall be all welded.

3.3 EXPANSION JOINTS (BELLOWS AND SLIP TYPE)

- A. Anchors and Guides: Provide type, quantity and spacing as recommended by manufacturer of expansion joint and as shown. A professional engineer shall verify in writing that anchors and guides are properly designed for forces and moments which will be imposed.
- B. Cold Set: Provide setting of joint travel at installation as recommended by the manufacturer for the ambient temperature during the installation.
- C. Preparation for Service: Remove all apparatus provided to restrain joint during shipping or installation. Representative of manufacturer shall visit the site and verify that installation is proper.
- D. Access: Expansion joints must be located in readily accessible space. Locate joints to permit access without removing piping or other devices. Allow clear space to permit replacement of joints and to permit access to devices for inspection of all surfaces and for adding packing.
- E. Anchors: All anchors shall be constructed from heavy steel and connected to the building construction. Contractor shall be responsible for any additional structural members that may be required for proper installation of hangers, anchors, guides and supports. The method of securing the anchors to the building construction must be approved by the Architect prior to installation.

3.4 STEAM TRAP PIPING

- A. Install to permit gravity flow to the trap. Provide gravity flow (avoid lifting condensate) from the trap where modulating control valves are used. Support traps weighing over 11 kg (25 pounds) independently of connecting piping.

3.5 LEAK TESTING

- A. Inspect all joints and connections for leaks and workmanship before insulation is installed and make corrections as necessary, to the satisfaction of the Resident Engineer. Tests may be either of those below, or a combination, as approved by the Resident Engineer.
 - 1. Furnish all labor, material, instruments, supplies and services and bear all costs for the accomplishment of the tests herein specified. All equipment and piping installed under this Contract shall be tested and found tight. Insulated or otherwise concealed piping shall be tested before being closed in. All leaking joints shall be corrected, retested and found tight. Tests of piping systems shall be conducted before connections to equipment are made and before piping is covered, buried or otherwise concealed.
 - 2. Correct all defects appearing under test and repeat the tests until no defects are discovered, leave the equipment clean and ready for use. Tests performed shall not relieve the Contractor of his responsibility for leaks which may develop after the tests are made. Systems found to have leaks shall be subjected to further tests when faulty joints have been repaired or replaced.
 - 3. Perform all tests other than herein specified which may be required by Legal Authorities or by Agencies to whose requirements this work is to conform. Tests shall conform to the requirements of Local Codes but shall not be less than the equivalent of the tests called for herein.
 - 4. Furnish all necessary testing apparatus, make all temporary connections and perform all testing operations required, at no additional cost to the Owner.
 - 5. Threaded joints that leak shall not be seal-welded to correct leakage.
- B. An operating test at design pressure, and for hot systems, design maximum temperature.
- C. A hydrostatic test at 1.5 times design pressure for (4) four hours without a drop in pressure. For water systems the design maximum pressure would usually be the static head, or expansion tank maximum pressure, plus pump head. Factory tested equipment (convertors, exchangers, coils, etc.) need not be field tested. Avoid excessive pressure on mechanical seals and safety devices.

3.6 FLUSHING AND CLEANING PIPING SYSTEMS

- A. Steam, Condensate and Vent Piping: Provide flushing and chemical cleaning as required. See Section 23 25 00 HVAC WATER TREATMENT. Accomplish further cleaning by pulling all strainer screens and cleaning all scale/dirt legs during start-up operation.

3.7 WATER TREATMENT

- A. Install water treatment equipment and provide water treatment system piping.
- B. Close and fill system as soon as possible after final flushing to minimize corrosion.

- C. Charge systems with chemicals specified in Section 23 25 00, HVAC WATER TREATMENT.
- D. Utilize this activity, by arrangement with the Resident Engineer, for instructing VA operating personnel.

3.8 OPERATING AND PERFORMANCE TEST AND INSTRUCTION

- A. Refer to PART 3, Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
- B. Adjust red set hand on pressure gages to normal working pressure.

3.9 UNFIRED STEAM GENERATOR INSTALLATION (ALTERNATE 9.36)

- A. Install generators in accordance with manufacturer's installation instructions. Install units plumb and level, to tolerance of 1/8" in 10' - 0" in both directions. Maintain manufacturer's recommended clearances around and over steam generators.
- B. Proper installation and operation of all components is the final responsibility of the installing contractor.
- C. Proper access space around a device should be left for servicing the component. No less than the minimum recommended by the manufacturer.
- D. Provide an adequate number of isolation valves for service and maintenance of the system and its components.
- E. Provide temperature and pressure gauges where and as detailed or directed.
- F. All piping shall be brought to equipment and pump connections in such a manner so as to prevent the possibility of any loads or stresses being applied to the connections or piping. All piping shall be fitted to the pumps even though piping adjustments may be required after the pipe is installed.
- G. Provide drains for relief valves and source side condensate. Relief valves shall be piped to and discharging into floor drains. Source side condensate shall be piped from trap to condensate pump or gravity return. Waste condensate shall be piped to and discharged into a floor drain; when necessary a low temperature condensate pump can be used to hold and pump **steam** condensate to the condensate draining system.
- H. On condensate coolers that require cooling water for condensate temperature reduction, provide cooling water supply piping and connections as required. Piping should be of adequate size to pass required flow rate.
- I. On components that require venting, contractor must provide vent piping from equipment vent connections and pipe to appropriate discharging location.
- J. Manufacturer's representative shall instruct the maintenance personnel in the care of the equipment and four (4) copies of his report shall be submitted to the Architect/Engineer.
- K. Provide start-up reports outlining factory provided start-up and equipment performance.

L. Electrical Wiring:

1. Connect field wiring to each generator as required. The contractor is responsible for field wiring generator(s), components, and safety devices on site as follows, per manufacturer's installation instructions:
2. Power supply wiring to equipment is furnished and installed in the field. Field installed control and interlock wiring required for a complete and functioning system shall be furnished and installed by others.
3. Control wiring associated with the Temperature Control System is furnished and installed under requirements of the Temperature Control System portion of the specifications.
 - a. Verify that electrical work installation is in accordance with manufacturer's submittal and installation requirements of Division 16 sections. Do not proceed with equipment start-up until electrical work is acceptable.
 - b. The field wiring shall include but not be limited to the following:
 - 1) 15 Amp control voltage line 115V/60Hz/1PH
 - 2) Makeup water pump (where required) appropriate line HP and voltage
 - 3) Temperature Control System connections to the generator control system including alarms, remote start/stop, and any miscellaneous trim

M. Field Quality Control

1. Flush and clean generators upon completion of installation, in accordance with manufacturer's start-up instructions.
2. Hydrostatically test assembled generators and piping in accordance with applicable sections of ASME Boiler and Pressure Vessel Code.
3. Start-up generators, in accordance with manufacturer's start-up instructions, and in presence of generator manufacturer's representative. Test controls and demonstrate compliance with requirements (coordinate with work of Division 25 Automatic Temperature Controls).
4. Adjust controls for maximum output efficiency. Replace damaged or malfunctioning controls and equipment.

--- END ---

SECTION 23 22 23
STEAM CONDENSATE PUMPS

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Steam condensate pumps for Heating, Ventilating and Air Conditioning.
- B. Definitions:
 - 1. Capacity: Liters per second (L/s) (Gallons per minute (GPM)) of the fluid pumped.
 - 2. Head: Total dynamic head in kPa (feet) of the fluid pumped.
 - 3. Flat head-capacity curve: Where the shutoff head is less than 1.16 times the head at the best efficiency point.

1.2 RELATED WORK

- A. Section 01 00 00, GENERAL REQUIREMENTS.
- B. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.
- C. Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
- D. Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT.
- E. Section 01 91 13, COMMISSIONING.
- F. Section 23 22 13, STEAM AND CONDENSATE HEATING PIPING.
- G. Section 23 05 12, GENERAL MOTOR REQUIREMENTS FOR HVAC EQUIPMENT.
- H. Section 26 29 11, LOW-VOLTAGE MOTOR STARTERS.

1.3 QUALITY ASSURANCE

- A. Refer to Paragraph, QUALITY ASSURANCE in Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
- B. Design Criteria:
 - 1. Pumps design and manufacturer shall conform to Hydraulic Institute Standards.
 - 2. Pump sizes, capacities, pressures, operating characteristics and efficiency shall be as scheduled.
 - 3. Select pumps for open systems so that required net positive suction head (NPSHR) does not exceed the net positive head available (NPSHA).
 - 4. Pump Driver: Furnish with pump. Size shall be non-overloading at any point on the head-capacity curve including one pump operation in a parallel or series pumping installation.

5. Provide all pumps with motors, impellers, drive assemblies, bearings, coupling guard and other accessories specified. Statically and dynamically balance all rotating parts.
 6. Furnish each pump and motor with a nameplate giving the manufacturers name, serial number of pump, capacity in GPM and head in feet at design condition, horsepower, voltage, frequency, speed and full load current and motor efficiency.
 7. Test all pumps before shipment. The manufacturer shall certify all pump ratings.
 8. After completion of balancing, provide replacement of impellers or trim impellers to provide specified flow at actual pumping head, as installed.
 9. Furnish one spare seal and casing gasket for each pump to the Project Manager.
- C. Allowable Vibration Tolerance for Pump Units: Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT.
- D. Commissioning of a system or systems specified in this section shall be part of the construction process. Documentation and testing of these systems; as well as training of the VAMC operation and maintenance personnel, is required in cooperation with the VA Resident Engineer and the Commissioning Authority. Project Close-out is dependent on successful completion of all commissioning procedures, documentation, and issue closure. Refer to Section 019113, COMMISSIONING, for detailed commissioning requirements.

1.4 SUBMITTALS

- A. Submit in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.
- B. Manufacturer's Literature and Data:
1. Pumps and accessories.
 2. Motors and drives.
 3. Motor controllers.
- C. Manufacturer's installation, maintenance and operating instructions, in accordance with Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
- D. Characteristic Curves: Head-capacity, efficiency-capacity, brake horsepower-capacity, and NPSHR-capacity for each pump and for combined pumps in parallel or series service. Identify pump and show fluid pumped, specific gravity, pump speed and curves plotted from zero flow to maximum for the impeller being furnished and at least the maximum diameter impeller that can be used with the casing.

1.5 APPLICABLE PUBLICATIONS

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only:
- B. American Iron and Steel Institute (AISI):
- | | |
|-----------|--|
| AISI 1045 | Cold Drawn Carbon Steel Bar, Type 1045 |
| AISI 416 | Type 416 Stainless Steel |
- C. American National Standards Institute (ANSI):
- | | |
|--------------------|---|
| ANSI B15.1-00..... | Safety Standard for Mechanical Power Transmission Apparatus |
| ANSI B16.1-00 | Cast Iron Pipe Flanges and Flanged Fittings, Class 25, 125, 250 and 800 |

- D. American Society for Testing and Materials (ASTM):
 - A48-98 Gray Iron Castings
 - B62-02 Composition Bronze or Ounce Metal Castings
- E. Maintenance and Operating Manuals in accordance with Section 01 00 00, GENERAL REQUIREMENTS.

PART 2 - PRODUCTS

2.1 CONDENSATE RETURN PUMP UNITS (ELECTRIC, PAD-MOUNTED)

- A. Type: Factory-assembled units consisting of vented horizontal pad-mounted receiver tank, simplex or duplex motor-driven pumps as shown, interconnecting piping, motor controls, and accessories. Arrangement of pumps, tank and accessories shall be as shown or specified.
- B. Service: Unit shall be designed to receive, store, and pump steam condensate having temperature as shown. Pumps and motors shall be suitable for continuous service.
- C. Performance: Refer to schedules on the drawings.
- D. Pumps: Centrifugal type as shown.
 - 1. Centrifugal Pumps: Bronze-fitted, vertical shafts, with mechanical shaft seals. Stainless steel or alloy steel shafts with bronze shaft sleeves. Pump shall be designed to allow removal of rotating elements without disturbing connecting piping or pump casing mounting. Bearings shall be grease-lubricated ball or roller type. Provide casing wearing rings.
- E. Electric Motor Drives: Open drip proof. Select motor sizes so that the motors are not overloaded at any point on the pump head-flow performance curve. Motor shall be designed for 40 °C ambient temperature.
- F. Receiver Tank: Cast iron with storage capacity and height of inlet connection as shown. Provide threaded or flanged openings for all pipe connections and facilities for mounting float switches. Openings for pipe sizes above 50 mm (2 inch) must be flanged. Receivers for simplex pumps shall include all facilities required for future mounting of additional pump and controls.
- G. Controls:
 - 1. Pump Operation: Provide float switches mounted on receiver tank to start and stop water pumps in response to changes in the water level in the receiver. Float switches shall be adjustable to permit the controlled water levels to be changed. Floats and connecting rods shall be copper, stainless steel or bronze. When a duplex pump unit is used, provide an alternator and a control to automatically start the second pump, when the first pump fails in keeping the receiver water level from rising.
 - 2. Starters: Provide combination magnetic starters with fusible disconnect switches or circuit breakers. Provide low voltage control circuits (120 volt maximum).
 - 3. Indicating Lights: Provide red light for each pump to show that the pump is running, green lights to show power is on.
 - 4. Manual Selector Switches: Provide "on-off-automatic" switch for each pump.
 - 5. Electrical Wiring: Shall be enclosed in liquid-tight flexible metal conduit. Wiring shall be suitable for 93 °C (200 °F) service.

6. Control Cabinet: NEMA 250, Type 2 or 4, enclosing all controls, with manual switches and indicating lights mounted on the outside of the panel. Attach to pump set with rigid steel framework unless other mounting is shown on the drawings.

H. Accessories Required:

1. Individual pump suction isolation valves.
 2. Thermometer on receiver below minimum water level.
 3. Basket-type inlet strainer with bolted cover, designed for 275 kPa (40 psi), 100 °C (210 °F). Provide basket with 3 mm (1/8-inch) diameter perforations.
 4. Water level gage on receiver. Provide gage cocks that automatically stop the flow of water when the glass is broken. Provide gage glass protection rods, and drain on lower gage cock.
- I. Sound and Vibration: Pump units shall conform to sound and vibration limits specified in Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT.

2.2 MECHANICAL CONDENSATE PUMP (PRESSURE-POWERED PUMPING TRAP)

- A. Type: Packaged receiver and simplex pump set including all controls and interconnecting piping and valves. Pumps shall be automatic, float-actuated, non-electric, steam motive power, designed to pump required condensate flow rate and discharge pressure.
- B. Service: Continuous duty, condensate at 100 °C (212 °F), motive steam available at 690kPa 100 psi. Design to operate with and to connect properly with the condensate return line elevation as shown.
- C. Performance: Refer to drawings for condensate flow and discharge pressure requirements and for receiver size.
- D. Pump Construction:
1. Pump Body: Cast iron rated for 1035 kPa (150 psi), 232 °C (450 °F). Low profile as necessary to accommodate the elevation of the inlet condensate pipe, obtain the required filling head, and obtain the required performance.
 2. Float mechanism: Stainless steel float and mechanism frame. Inconel X-750 spring assist float mechanism.
 3. Internal Pump Valves and Seats: Externally replaceable hardened stainless steel.
 4. Receiver Tank: ASME Code Section VIII designed for 850 kPa (125 psig). Refer to Paragraph, FLASH TANK.
 5. All piping shall be ASTM A53 or A106, ERW or seamless, Schedule 80.
- E. Receiver Construction:
1. Cylindrical welded steel tank with accessories. Conform to ASME Boiler and Pressure Vessel Code, Section VIII. Fabricate from steel sheets and plates or from steel pipe and pipe caps.
 2. Material of Construction:
 - a. Steel sheets and plates: ASTM A285, A414, A515, A516.
 - b. Steel pipe and pipe caps: Pipe ASTM A53A-S, A53A-E, A53B-S, A53B-E. Pipe Caps ASTM A234, ASME B16.9.

3. Design for 850 kPa (125 psi), 178 °C (353 °F).
 4. Piping Connections: Threaded half couplings for pipe sizes under 65 mm (2-1/2 inches). Flanged 1025 kPa (150 psi) ASME for pipe sizes over 50 mm (2 inches).
 5. ASME Forms: Furnish U-1 or U-1A, MANUFACTURERS' DATA REPORT FOR PRESSURE VESSELS.
 6. Supports: Unless shown otherwise, provide floor-mounted frame constructed with steel angles.
 7. Insulation: Do not insulate.
- F. Cleaning and Painting: Remove all dirt, heavy rust, mill scale, oil, welding debris from interior and exterior. Coat exterior with rust-resisting primer and manufacturer's standard coating.
- G. Accessories:
1. Water level gage glass on tank and pumps with protection rods, gage valves with drain.
 2. All necessary inlet and outlet check valves for proper operation.
 3. Industrial liquid-type thermometer on condensate outlet, dual range, 10 to 205 degrees C, 50 to 400 degrees F, 239 mm (9 inch) scale length, accuracy plus or minus one scale division.

2.3 FLASH TANK

- A. Type: Cylindrical welded steel tank with accessories as shown. Refer to detail on drawings.
- B. Service: Suitable for receiving, venting, storing and discharging to condensate return pump the effluent discharged from steam traps on high and medium pressure steam systems.
- C. Construction:
1. Conform to ASME Boiler and Pressure Vessel Code, Section VIII. Fabricate from steel sheets and plates or from steel pipe and pipe caps.
 2. Material of Construction:
 - a. Steel sheets and plates: ASTM A285, A414, A515, A516.
 - b. Steel pipe and pipe caps: Pipe ASTM A53A-S, A53A-E, A53B-S, A53B-E. Pipe Caps ASTM A234, ASME B16.9.
 3. Design tank for 850 kPa (125 psi), 178 °C (353 °F).
 4. Piping Connections: Threaded half couplings for pipe sizes under 65 mm (2-1/2 inches). Flanged 1025 kPa (150 psi) ASME for pipe sizes over 50 mm (2 inches).
 5. ASME Forms: Furnish U-1 or U-1A, MANUFACTURERS' DATA REPORT FOR PRESSURE VESSELS.
 6. Supports: Unless shown otherwise, provide floor-mounted frame constructed with steel angles.
 7. Condensate Pipe: Provide perforated Schedule 80 steel pipe inside tank as shown.
- D. Cleaning and Painting: Remove all dirt, heavy rust, mill scale, oil, welding debris from interior and exterior of tank. Coat exterior with rust-resisting primer (See Section 09 91 00, PAINTING).
- E. Insulation: Do not insulate.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Follow manufacturer's written instructions for pump mounting and start-up. Access/ Service space around pumps shall not be less than minimum space recommended by pumps manufacturer.
- B. Support piping adjacent to pump such that no weight is carried on pump casing. First 3 hangers for each pipe shall be spring and neoprene type.
- C. Permanently support in-line pumps by the connecting piping only, not from the casing or the motor eye bolt.
- D. Sequence of installation for base-mounted pumps:
 - 1. Level and shim the unit base and grout to the concrete pad.
 - 2. Shim the driver and realign the pump and driver. Correct axial, angular or parallel misalignment of the shafts.
 - 3. Connect properly aligned and independently supported piping.
 - 4. Recheck alignment.
- E. Pad-mounted Condensate Pump: Level, shim, bolt, and grout the unit base onto the concrete pad.
- F. Provide drains for bases and seals for base mounted pumps, piped to and discharging into floor drains.
- G. Coordinate location of thermometer and pressure gauges as per Section 23 22 13, STEAM AND CONDENSATE HEATING PIPING.

3.2 START-UP

- A. Verify that the piping system has been flushed, cleaned and filled.
- B. Lubricate pumps before start-up.
- C. Prime the pump, vent all air from the casing and verify that the rotation is correct. To avoid damage to mechanical seals, never start or run the pump in dry condition.
- D. Verify that correct size heaters-motor over-load devices are installed for each pump controller unit.
- E. Perform field mechanical balancing if necessary to meet specified vibration tolerance.

3.3 FUNCTIONAL PERFORMANCE AND INTEGRATED SYSTEMS TESTING

- A. Functional Performance and Integrated Systems Testing (FP & IST) is part of the commissioning process. FP & IST shall be performed by the Contractor, and witnessed and documented by the Commissioning Authority. Refer to Section 019113, COMMISSIONING, for FP & IST requirements.

3.4 TRAINING

- A. Training of the VAMC operation and maintenance personnel shall be required in cooperation with the VA Resident Engineer. Provide competent, factory-authorized personnel to instruct operation and maintenance personnel concerning the location, operation, and troubleshooting of the installed systems. The instruction shall be scheduled in coordination with the VA Resident Engineer after submission and approval of formal training plans. Refer to Section 017900, DEMONSTRATION AND TESTING, and Section 019113, COMMISSIONING, for Contractor training requirements.

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SECTION 23 23 00
REFRIGERANT PIPING

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Field refrigerant piping for direct expansion HVAC systems. Field refrigerant piping and associated drain and condenser water piping for walk-in coolers and freezers, including required pipe insulation. Field refrigerant piping and associated drain and condenser water piping for laboratory refrigerators, including required pipe insulation. Field refrigerant piping and associated drain and condenser water piping for mortuary refrigerators, including required pipe insulation.
- B. Refrigerant piping shall be sized, selected, and designed either by the equipment manufacturer or in strict accordance with the manufacturer's published instructions. The schematic piping diagram shall show all accessories such as, stop valves, level indicators, liquid receivers, oil separator, gauges, thermostatic expansion valves, solenoid valves, moisture separators and driers to make a complete installation.
- C. Definitions:
 - 1. Refrigerating system: Combination of interconnected refrigerant-containing parts constituting one closed refrigeration circuit in which a refrigerant is circulated for the purpose of extracting heat.
 - a. Low side means the parts of a refrigerating system subjected to evaporator pressure.
 - b. High side means the parts of a refrigerating system subjected to condenser pressure.
 - 2. Brazed joint: A gas-tight joint obtained by the joining of metal parts with alloys which melt at temperatures higher than 449 degrees C (849 degrees F) but less than the melting temperatures of the joined parts.

1.2 RELATED WORK

- A. Section 11 41 21, WALK-IN COOLERS and FREEZERS: Piping requirements for freezers and refrigerators.
- B. Section 11 53 23, LABORATORY REFRIGERATORS: Piping requirements for freezers and refrigerators.
- C. Section 11 78 13, MORTUARY REFRIGERATORS: Piping requirements for freezers and refrigerators.
- D. Section 23 05 11, COMMON WORK RESULTS FOR HVAC: General mechanical requirements and items, which are common to more than one section of Division 23.
- E. Section 23 07 11, HVAC INSULATION: Requirements for piping insulation.
- F. Section 23 21 13, HYDRONIC PIPING: Requirements for water and drain piping and valves.

1.3 QUALITY ASSURANCE

- A. Refer to specification Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
- B. Comply with ASHRAE Standard 15, Safety Code for Mechanical Refrigeration. The application of this Code is intended to assure the safe design, construction, installation, operation, and inspection of every refrigerating system employing a fluid which normally is vaporized and liquefied in its refrigerating cycle.
- C. Comply with ASME B31.5: Refrigerant Piping and Heat Transfer Components.
- D. Products shall comply with UL 207 "Refrigerant-Containing Components and Accessories, "Nonelectrical"; or UL 429 "Electrical Operated Valves."

1.4 SUBMITTALS

- A. Submit in accordance with specification Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, and SAMPLES.
- B. Shop Drawings:
 - 1. Complete information for components noted, including valves and refrigerant piping accessories, clearly presented, shall be included to determine compliance with drawings and specifications for components noted below:
 - a. Tubing and fittings
 - b. Valves
 - c. Strainers
 - d. Moisture-liquid indicators
 - e. Filter-driers
 - f. Flexible metal hose
 - g. Liquid-suction interchanges
 - h. Oil separators (when specified)
 - i. Gages
 - j. Pipe and equipment supports
 - k. Refrigerant and oil
 - l. Pipe/conduit roof penetration cover
 - m. Soldering and brazing materials
 - 2. Layout of refrigerant piping and accessories, including flow capacities, valves locations, and oil traps slopes of horizontal runs, floor/wall penetrations, and equipment connection details.
- C. Certification: Copies of certificates for welding procedure, performance qualification record and list of welders' names and symbols.
- D. Design Manual: Furnish two copies of design manual of refrigerant valves and accessories.

1.5 APPLICABLE PUBLICATIONS

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.
- B. Air Conditioning, Heating, and Refrigeration Institute (ARI/AHRI):
 495-1999 (R2002) Standard for Refrigerant Liquid Receivers
 730-2005 Flow Capacity Rating of Suction-Line Filters and Suction-Line Filter-Driers
 750-2007 Thermostatic Refrigerant Expansion Valves
 760-2007 Performance Rating of Solenoid Valves for Use with Volatile Refrigerants
- C. American Society of Heating Refrigerating and Air Conditioning Engineers (ASHRAE):
 ANSI/ASHRAE 15-2007 Safety Standard for Refrigeration Systems (ANSI)
 ANSI/ASHRAE 17-2008 Method of Testing Capacity of Thermostatic Refrigerant Expansion Valves (ANSI)
 63.1-95 (RA 01) Method of Testing Liquid Line Refrigerant Driers (ANSI)
- D. American National Standards Institute (ANSI):
 ASME (ANSI) A13.1-2007 Scheme for Identification of Piping Systems
 Z535.1-2006 Safety Color Code
- E. American Society of Mechanical Engineers (ASME):
 ANSI/ASME B16.22-2001 (R2005)
 Wrought Copper and Copper Alloy Solder-Joint Pressure Fittings (ANSI)
 ANSI/ASME B16.24-2006 Cast Copper Alloy Pipe Flanges and Flanged Fittings, Class 150, 300, 400, 600, 900, 1500 and 2500 (ANSI)

 ANSI/ASME B31.5-2006 Refrigeration Piping and Heat Transfer Components (ANSI)
 ANSI/ASME B40.100-2005 Pressure Gauges and Gauge Attachments
 ANSI/ASME B40.200-2008 Thermometers, Direct Reading and Remote Reading
- F. American Society for Testing and Materials (ASTM)
 A126-04 Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings
 B32-08 Standard Specification for Solder Metal
 B88-03 Standard Specification for Seamless Copper Water Tube
 B88M-05 Standard Specification for Seamless Copper Water Tube (Metric)
 B280-08 Standard Specification for Seamless Copper Tube for Air Conditioning and Refrigeration Field Service
- G. American Welding Society, Inc. (AWS):
 Brazing Handbook
 A5.8/A5.8M-04 Standard Specification for Filler Metals for Brazing and Braze Welding
- H. Federal Specifications (Fed. Spec.)
 Fed. Spec. GG
- I. Underwriters Laboratories (U.L.):
 U.L.207-2009 Standard for Refrigerant-Containing Components and Accessories, Nonelectrical
 U.L.429-99 (Rev.2006) Standard for Electrically Operated Valves

PART 2 - PRODUCTS

2.1 PIPING AND FITTINGS

- A. Refrigerant Piping: For piping up to 100 mm (4 inch) use Copper refrigerant tube, ASTM B280, cleaned, dehydrated and sealed, marked ACR on hard temper straight lengths. Coils shall be tagged ASTM B280 by the manufacturer. For piping over 100 mm (4 inch) use A53 Black SML steel.
- B. Water and Drain Piping: Copper water tube, ASTM B88M, Type B or C (ASTM B88, Type M or L). Optional drain piping material: Schedule 80 flame retardant Polypropylene plastic.
- C. Fittings, Valves and Accessories:
 - 1. Copper fittings: Wrought copper fittings, ASME B16.22.
 - a. Brazed Joints, refrigerant tubing: Cadmium free, AWS A5.8/A5.8M, 45 percent silver brazing alloy, Class BAg-5.
 - b. Solder Joints, water and drain: 95-5 tin-antimony, ASTM B32 (95TA).
 - 2. Steel fittings: ASTM wrought steel fittings.
 - a. Refrigerant piping – Welded Joints.
 - 3. Flanges and flanged fittings: ASME B16.24.
 - 4. Refrigeration Valves:
 - a. Stop Valves: Brass or bronze alloy, packless, or packed type with gas tight cap, frost proof, back seating.
 - b. Pressure Relief Valves: Comply with ASME Boiler and Pressure Vessel Code; UL listed. Forged brass with nonferrous, corrosion resistant internal working parts of high strength, cast iron bodies conforming to ASTM A126, Grade B. Set valves in accordance with ASHRAE Standard 15.
 - c. Solenoid Valves: Comply with ARI 760 and UL 429, UL-listed, two-position, direct acting or pilot-operated, moisture and vapor-proof type of corrosion resisting materials, designed for intended service, and solder-end connections. Fitted with suitable NEMA 250 enclosure of type required by location and normally closed holding coil.
 - d. Thermostatic Expansion Valves: Comply with ARI 750. Brass body with stainless-steel or non-corrosive non ferrous internal parts, diaphragm and spring-loaded (direct-operated) type with sensing bulb and distributor having side connection for hot-gas bypass and external equalizer. Size and operating characteristics as recommended by manufacturer of evaporator and factory set for superheat requirements. Solder-end connections. Testing and rating in accordance with ASHRAE Standard 17.
 - e. Check Valves: Brass or bronze alloy with swing or lift type, with tight closing resilient seals for silent operation; designed for low pressure drop, and with solder-end connections. Direction of flow shall be legibly and permanently indicated on the valve body.
 - 5. Strainers: Designed to permit removing screen without removing strainer from piping system, and provided with screens 80 to 100 mesh in liquid lines DN 25 (NPS 1) and smaller, 60 mesh in liquid lines larger than DN 25 (NPS 1), and 40 mesh in suction lines.

- Provide strainers in liquid line serving each thermostatic expansion valve, and in suction line serving each refrigerant compressor not equipped with integral strainer.
6. Refrigerant Moisture/Liquid Indicators: Double-ported type having heavy sight glasses sealed into forged bronze body and incorporating means of indicating refrigerant charge and moisture indication. Provide screwed brass seal caps.
 7. Refrigerant Filter-Dryers: UL listed, angle or in-line type, as shown on drawings. Conform to ARI Standard 730 and ASHRAE Standard 63.1. Heavy gage steel shell protected with corrosion-resistant paint; perforated baffle plates to prevent desiccant bypass. Size as recommended by manufacturer for service and capacity of system with connection not less than the line size in which installed. Filter driers with replaceable filters shall be furnished with one spare element of each type and size.
 8. Flexible Metal Hose: Seamless bronze corrugated hose, covered with bronze wire braid, with standard copper tube ends. Provide in suction and discharge piping of each compressor.

2.2 GAGES

- A. Temperature Gages: Comply with ASME B40.200. Industrial-duty type and in required temperature range for service in which installed. Gages shall have Celsius scale in 1-degree (Fahrenheit scale in 2-degree) graduations and with black number on a white face. The pointer shall be adjustable. Rigid stem type temperature gages shall be provided in thermal wells located within 1525 mm (5 feet) of the finished floor. Universal adjustable angle type or remote element type temperature gages shall be provided in thermal wells located 1525 to 2135 mm (5 to 7 feet) above the finished floor. Remote element type temperature gages shall be provided in thermal wells located 2135 mm (7 feet) above the finished floor.
- B. Vacuum and Pressure Gages: Comply with ASME B40.100 and provide with throttling type needle valve or a pulsation dampener and shut-off valve. Gage shall be a minimum of 90 mm (3-1/2 inches) in diameter with a range from 0 kPa (0 psig) to approximately 1.5 times the maximum system working pressure. Each gage range shall be selected so that at normal operating pressure, the needle is within the middle-third of the range.
 1. Suction: 101 kPa (30 inches Hg) vacuum to 1723 kPa (gage) (250 psig).
 2. Discharge: 0 to 3445 kPa (gage) (0 to 500 psig).

2.3 THERMOMETERS AND WELLS

- A. Refer to specification Section 23 21 13, HYDRONIC PIPING.

2.4 PIPE SUPPORTS

- A. Refer to specification Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

2.5 ELECTRICAL HEAT TRACING SYSTEM

- A. Refer to specification Section 23 21 13, HYDRONIC PIPING. Provide for freezer unit cooler drain piping.

2.6 REFRIGERANTS AND OIL

- A. Provide EPA approved refrigerant and oil for proper system operation.

2.7 PIPE/CONDUIT ROOF PENETRATION COVER

- A. Prefabricated Roof Curb: Galvanized steel or extruded aluminum 300 mm (12 inches) overall height, continuous welded corner seams, treated wood nailer, 38 mm (1-1/2 inch) thick, 48 kg/cu.m (3 lb/cu.ft.) density rigid mineral fiberboard insulation with metal liner, built-in cant strip (except for gypsum or tectum decks). For surface insulated roof deck, provide raised cant strip (recessed mounting flange) to start at the upper surface of the insulation. Curbs shall be constructed for pitched roof or ridge mounting as required to keep top of curb level.
- B. Penetration Cover: Galvanized sheet metal with flanged removable top. Provide 38 mm (1-1/2 inch) thick mineral fiber board insulation.
- C. Flashing Sleeves: Provide sheet metal sleeves for conduit and pipe penetrations of the penetration cover. Seal watertight penetrations.

2.8 PIPE INSULATION FOR DX HVAC SYSTEMS

- A. Refer to specification Section 23 07 11, HVAC INSULATION.

2.9 PIPE INSULATION FOR WALK-IN COOLERS AND FREEZERS AND LABORATORY REFRIGERATORS AND MORTUARY REFRIGERATORS

- A. Flexible elastomeric: Refer to specification Section 23 07 11, HVAC INSULATION.
- B. Insulate refrigerant suction piping from unit cooler to condensing unit. Use 20 mm (3/4-inch) thick insulation on piping inside the refrigerator or freezer and 40 mm (1-1/2 inch) thick insulation (double layer required) on piping outside the refrigerated space.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install refrigerant piping and refrigerant containing parts in accordance with ASHRAE Standard 15 and ASME B31.5
 - 1. Install piping as short as possible, with a minimum number of joints, elbow and fittings.
 - 2. Install piping with adequate clearance between pipe and adjacent walls and hangers to allow for service and inspection. Space piping, including insulation, to provide 25 mm (1 inch) minimum clearance between adjacent piping or other surface. Use pipe sleeves through walls, floors, and ceilings, sized to permit installation of pipes with full thickness insulation.
 - 3. 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. Provide a union adjacent to one end of all threaded end valves. Control valves usually require reducers to connect to pipe sizes shown on the drawing.
 - 4. Use copper tubing in protective conduit when installed below ground.

5. Install hangers and supports per ASME B31.5 and the refrigerant piping manufacturer's recommendations.

B. Joint Construction:

1. Brazed Joints: Comply with AWS "Brazing Handbook" and with filler materials complying with AWS A5.8/A5.8M.
 - a. Use Type BcuP, copper-phosphorus alloy for joining copper socket fittings with copper tubing.
 - b. Use Type BAg, cadmium-free silver alloy for joining copper with bronze or steel.
 - c. Swab fittings and valves with manufacturer's recommended cleaning fluid to remove oil and other compounds prior to installation.
 - d. Pass nitrogen gas through the pipe or tubing to prevent oxidation as each joint is brazed. Cap the system with a reusable plug after each brazing operation to retain the nitrogen and prevent entrance of air and moisture.

- C. Protect refrigerant system during construction against entrance of foreign matter, dirt and moisture; have open ends of piping and connections to compressors, condensers, evaporators and other equipment tightly capped until assembly.

- D. Pipe relief valve discharge to outdoors for systems containing more than 45 kg (100 lbs) of refrigerant.

- E. Firestopping: Fill openings around uninsulated piping penetrating floors or fire walls, with firestop material. For firestopping insulated piping refer to Section 23 07 11, HVAC INSULATION.

3.2 PIPE AND TUBING INSULATION

- A. Refer to specification Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

- B. Apply two coats of weather-resistant finish as recommended by the manufacturer to insulation exposed to outdoor weather.

3.3 SIGNS AND IDENTIFICATION

- A. Each refrigerating system erected on the premises shall be provided with an easily legible permanent sign securely attached and easily accessible, indicating thereon the name and address of the installer, the kind and total number of pounds of refrigerant required in the system for normal operations, and the field test pressure applied.

- B. Systems containing more than 50 kg (110 lb) of refrigerant shall be provided with durable signs, in accordance with ANSI A13.1 and ANSI Z535.1, having letters not less than 13 mm (1/2 inch) in height designating:

1. Valves and switches for controlling refrigerant flow, the ventilation and the refrigerant compressor(s).
2. Signs on all exposed high pressure and low pressure piping installed outside the machinery room, with name of the refrigerant and the letters "HP" or "LP."

3.4 FIELD QUALITY CONTROL

- A. Prior to initial operation examine and inspect piping system for conformance to plans and specifications and ASME B31.5. Correct equipment, material, or work rejected because of defects or nonconformance with plans and specifications, and ANSI codes for pressure piping.
- B. After completion of piping installation and prior to initial operation, conduct test on piping system according to ASME B31.5. Furnish materials and equipment required for tests. Perform tests in the presence of Resident Engineer. If the test fails, correct defects and perform the test again until it is satisfactorily done and all joints are proved tight.
 - 1. Every refrigerant-containing parts of the system that is erected on the premises, except compressors, condensers, evaporators, safety devices, pressure gages, control mechanisms and systems that are factory tested, shall be tested and proved tight after complete installation, and before operation.
 - 2. The high and low side of each system shall be tested and proved tight at not less than the lower of the design pressure or the setting of the pressure-relief device protecting the high or low side of the system, respectively, except systems erected on the premises using non-toxic and non-flammable Group A1 refrigerants with copper tubing not exceeding DN 18 (NPS 5/8). This may be tested by means of the refrigerant charged into the system at the saturated vapor pressure of the refrigerant at 20 degrees C (68 degrees F) minimum.
- C. Test Medium: A suitable dry gas such as nitrogen or shall be used for pressure testing. The means used to build up test pressure shall have either a pressure-limiting device or pressure-reducing device with a pressure-relief device and a gage on the outlet side. The pressure relief device shall be set above the test pressure but low enough to prevent permanent deformation of the system components.
- D. Refrigerator/Freezer Start-up and Performance Tests: Specification Section 11 41 21, WALK-IN COOLERS and FREEZERS, Section 11 78 13, MORTUARY REFRIGERATORS.

3.5 SYSTEM TEST AND CHARGING

- A. System Test and Charging: As recommended by the equipment manufacturer or as follows:
 - 1. Connect a drum of refrigerant to charging connection and introduce enough refrigerant into system to raise the pressure to 70 kPa (10 psi) gage. Close valves and disconnect refrigerant drum. Test system for leaks with halide test torch or other approved method suitable for the test gas used. Repair all leaking joints and retest.
 - 2. Connect a drum of dry nitrogen to charging valve and bring test pressure to design pressure for low side and for high side. Test entire system again for leaks.
 - 3. Evacuate the entire refrigerant system by the triplicate evacuation method with a vacuum pump equipped with an electronic gage reading in mPa (microns). Pull the system down to 665 mPa (500 microns) 665 mPa (2245.6 inches of mercury at 60 degrees F) and hold for four hours then break the vacuum with dry nitrogen (or refrigerant). Repeat the evacuation two more times breaking the third vacuum with the refrigeration to be charged and charge with the proper volume of refrigerant.

--- E N D ---