CITY OF YONKERS
HUDSON RIVER MUSEUM
BOILER REPLACEMENT
BID ISSUE

MECHANICAL SPECIFICATIONS
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SECTION 230500 - COMMON WORK RESULTS FOR HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. These basic Mechanical Requirements apply to all Division 23 Sections.

B. The work of this Section consists of providing of all materials, labor and equipment and the like necessary and/or required for the complete execution of all HVAC and related work for this project, as required by the contract documents.

1.2 RELATED DOCUMENTS

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

1.3 PRODUCTS FURNISHED BUT NOT INSTALLED UNDER RESPECTIVE SECTIONS OF THIS DIVISION

A. Motor starters shall be furnished under this Division. Refer to Specification Section 230513 Common motor requirements for HVAC equipment" for technical information.

1.4 REFERENCES

A. ASHRAE - American Society of Heating, Refrigerating and Air Conditioning Engineers Guides and Standards, latest editions.

B. SMACNA - Sheet Metal and Air Conditioning Contractors National Association.

C. ASME - American Society of Mechanical Engineers.

D. UL - Underwriters Laboratory.

E. NFPA - National Fire Protection Association.

1.5 REGULATORY REQUIREMENTS/CODES AND STANDARDS

A. All equipment and installation methods shall conform to the applicable standards and/or recommendations set forth in the New York State Building Code, Local Codes as well as all Codes and Standards listed in the General and Supplemental Conditions sections of the specification, as well as the following specific codes
   1. NY State Building Code,
   2. NY State Mechanical Code
   3. NY State Fuel Gas Code
   4. NY State Plumbing Code
   5. All Supplemental Yonkers Code

1.6 FEES & PERMITS

A. The Contractor shall be responsible to file drawings, pay necessary fees and obtain all permits related to the scope of work.

1.7 QUALITY ASSURANCE

A. The Contractor shall have the work indicated on the drawings and/or specified in each section performed by vendors or mechanics experienced and skilled in its implantation or by a “Specialist”, “Specialty Contractor” or “Specialty Subcontractor” under contractual agreement with the Contractor. These terms mean an individual or firm of established reputation, or, if newly organized, whose personnel have previously established a reputation in the same field, which is regularly engaged in, and which maintains a regular force of workmen skilled in either manufacturing or fabricating items required by the Contract, installing items required by the Contract, or otherwise performing work required by the Contract.

B. Where the Contract Specifications require installation by a "Specialist," that term shall also be deemed to mean either the manufacturer of the item, an individual or firm licensed by the manufacturer, or an individual or firm who will perform such work under the manufacturer's direct supervision.

1.8 PROJECT/SITE CONDITIONS

A. Install Work in locations shown on Drawings, unless prevented by Project conditions.

B. Prepare drawings showing proposed arrangement of Work to meet Project conditions, including changes to Work specified in other Sections.

1.9 SCOPE OF WORK

A. This Contractor shall be responsible for coordinating his work with all other trades.

B. The Contractor shall provide all materials, labor, equipment, tools, appliances, services, hoisting, scaffolding, supervision and overhead for the furnishing and installing of all mechanical work and related work including but not limited to the following:
1. Alternate boiler plan scope of work.
2. Demolition of existing work including, piping, Boilers miscellaneous equipment, fans, and ductwork
3. Boiler’s for steam and hot water
4. Hot water pumps.
5. Hydronic piping valves, fittings, and specialties
6. Steam piping and valves, fittings, specialties
7. Condensate pumps and receiver tanks
8. Expansion tanks.
9. Unit heaters, duct heaters
10. Fans
11. Ductwork and specialties.
12. Pipe and duct insulation.
13. Equipment Supports
14. Automatic temperature controls.

15. Vibration isolation.
16. Equipment supports.
17. Motor starters and disconnects.
18. Protection.
19. Identification.
20. Coordination.
21. Phasing.
22. Rigging.
23. Testing and Balancing Reports Air and Water.
24. Shop Drawings.
25. As-Built Drawings and Maintenance Manuals.
26. Warrantees.
27. Commissioning

C. NOTE THE ALTERNATE SCOPE OF WORK. This alternate scheme for the boiler plant replacement is intended to take the place of the base work and shall include only a new steam boiler plant in the Glenview building that will serve both buildings. All specications, general and and supplemental conditions as well as details shall apply to both the base and the alternate scopes of work.

PART 2 - PRODUCTS – NOT USED

PART 3 - EXECUTION

3.1 GENERAL

A. Construct all apparatus of materials and pressure ratings suitable for the conditions encountered during continuous operation.

B. Construct all equipment in accordance with requirements of all applicable codes. All pressure vessels and safety devices that fall within the scope of the ASME Code shall conform to the Code and bear the ASME label or stamp.

C. Match and balance all system components to achieve compatibility of equipment or satisfactory operation and performance throughout the entire operating temperature and control ranges. All installations shall be in accordance with manufacturer's recommendations.

D. Provide all controls, wiring, piping, valves, accessories and other components necessary to make all systems complete and operable.

E. The contractor shall warranty all work, including labor and materials, and equipment furnished and installed as part of this contract for a minimum period of ONE year from the date of acceptance by the owner, in writing. Certain equipment, such as underground fuel tanks, may have longer warranties as indicated in the specifications. In such cases the longer of the two warranties shall prevail.

3.2 SHOP DRAWINGS AND SUBMITTALS (COORDINATE WITH DIVISION 1)

A. Shop drawings and samples shall be prepared and submitted in accordance with the requirements established in the contract and shall consist of all items listed in the following paragraphs.

B. Manufacturer's data or shop drawings giving full information as to dimensions, materials, and all information pertinent to the adequacy of the submitted equipment shall be submitted for review. Shop drawings shall include, but not be limited to the following:

C. Submit all Mechanical equipment noted and scheduled on plans including but not limited to the following:
1. Automatic Temperature Controls, Operation Sequences & Wiring Diagrams, and Control Diagrams hardware and software
2. Motor Starters and Controllers
3. Hydronic piping, valves and specialties
4. Steam piping valves and specialties
5. Expansion tanks
6. Water Treatment Equipment Tanks
7. Fans
8. Boilers
9. Unit heaters
10. Chemical feeders
11. Temperature regulating valves
12. Condensate pumps receiver tanks and controls
13. Boiler feed pumps and receiver tank and controls
14. Vibration isolation
15. Hangers and Inserts
16. Equipment Supports and Vibration Eliminators
17. Sheet Metal Construction Standards
18. Piping Layout (1/4 scale)
19. Ductwork Layout (1/4 scale)
20. Insulation (piping and ductwork)
21. Fan Curves and Sound Rating
22. Heat exchanger
23. Motorized Dampers
24. Diffusers Registers and Grilles
25. Balancing Reports Water
26. Coordinated Composite Drawings on Mylar with Piping, Ductwork, Conduits, Lights, registers Grilles and Smoke Detectors, etc.
27. Commissioning plan, prefunctional tests and functional tests.

D. The contractor shall, upon award, submit a schedule for the engineer’s review indicating when each of the above shop drawings shall be submitted. Submittals shall be made in a timely manner as the project progresses in accordance with the Construction manager or General contractor’s work schedules. The contractor shall allow sufficient time for the engineers to perform his review. A minimum of 10 business days shall be required. Untimely submittals shall be cause for the owner to make a delay against the contractor.

E. Demolition, purchase and or installation shall not begin until shop drawings pertaining to the equipment associated with any related potion of the work have been submitted.

F. Sheet metal shop drawings shall indicate all existing and/or new lights, walls, piping, structural elements, existing work, etc. and dimension locations of ductwork including elevations in relation to these items.

G. Where shop drawings have been reviewed by the Engineer, such review shall not be considered as a guarantee of measurements or building conditions. Where drawings have been reviewed, said review does not mean that drawings have been checked in detail; said review does not substantiate any quantities and in any way relieve the Contractor from his responsibility nor the necessity of furnishing materials or performing work required by the Contract Drawings and Specifications. It does not relieve the contractor of the responsibility to perform all work to accepted industry standards and in a code compliant manor. Approval of shop drawings containing errors does not relieve the contractor from making corrections at his expense.

H. Where substitutions are submitted for approval, the review shall be for general performance comparison to the specified product. Products shall not be reviewed for size, clearance or coordination with other trades. Coordination with other trades shall be the responsibility of the contractor. And changes to existing conditions or changes required to the work of other trades such as a result of substituted material or equipment approved or not shall be the responsibility of this contractor.

I. Approval of shop drawings

1. The Contractor shall be specifically responsible for checking equipment dimensions and clearances and confirming that equipment will fit into the designated space and connect properly to adjoining equipment and/or materials.

2. Submittals marked "Make Corrections Noted" give authority to proceed in accordance with the notes. However, if drawings are also marked "Amend and Resubmit", corrected drawings must be resubmitted for final review.

3. Submittals marked "Rejected" do not give authority to proceed with any portion of the work shown there-on. Drawings must be resubmitted.

4. Submittals marked "Rejected" or "Amend and Resubmit" shall include a specific written response to the engineer’s comments. Resubmission of a submittal without a written response to the engineer’s comments will be considered incomplete and shall be returned un-reviewed.

3.3 CHARTS AND TAGS

A. The Contractor shall provide three sets of charts and diagrams of all piping systems indicating the number and location of valves, controls, etc.

B. All valves, dampers, and controls shall be designated with brass tags. Refer to section 23 05 23 Identification for HVAC Piping and equipment

C. General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section

3.4 PAINTING

A. All motors, fans and all other factory manufactured, and assembled apparatus shall be factory coated with one coat of primer and one coat of machinery enamel standard color at the factory and after installation, all finishes shall be cleaned and touched up to repair any damage incurred during construction.

B. All piping shall be painted in colors conforming with OSHA Standards. All new and existing exposed iron and supplementary dunnage steel shall be finished according to specifications.

C. All supports, nuts, bolts and hanger fasteners located outside shall be galvanized or nickel plated.

3.5 RIGGING

A. Furnish all labor, materials and equipment required to rig equipment and materials.

B. The rigger shall secure any necessary permits and comply with all applicable Federal, State and local safety regulations. A copy of permits to be kept at both the project site and Engineer's Office.

C. The rigger shall have a minimum of five (5) years of practical experience and hold a master riggers license if required.

D. The procedure for rigging shall be submitted to the Engineer for review. All possible precautions should be taken to prevent damage to the structure, streets, sidewalks, curbs, lawns, etc.

3.6 CUTTING AND PATCHING

A. All cutting and patching required for piping, ductwork, control conduits, etc., passing through walls, floors, and roof shall be provided by the Contractor under this contract unless otherwise noted. This Contractor shall be responsible for any damage done to the structure due to his negligence.

B. Patching materials and application shall match existing construction.

C. Where applicable, new holes for piping installation shall be core drilled.

D. Pipe Sleeves & Fire-stopping:

1. Provide for all pipes, conduits ducts, and other elements passing through floors, walls, partitions and structural elements, sleeves as specified. Sleeves shall be of adequate diameter to allow for a minimum of 3/4 inches clear all around sleeve and pipe. When pipe, conduit ducts or other such element penetrates other than fire rated assembly and is insulated, insulation shall pass continuously through sleeves with 1/2-inch clearance between insulation and sleeve.

2. Where pipes, conduits and other such elements penetrate fire rated assemblies, or where holes or voids are created to extend mechanical systems through fire rated assemblies (walls, floors, ceilings, structure, etc.); sleeves and fire-stopping systems shall be installed.

E. Furnish access doors, to the General Contractor for installation where required in finished walls, partitions and the like for access to junction boxes, controls, valves, etc, concealed behind finished construction.

F. Submit location drawings and sizes for review prior to installation.

3.7 PROTECTION-COORDINATE WITH DIVISION 1

A. Special protection is required for installation of a Derrick or other device for rigging purposes. This Contractor shall coordinate with the rigger to facilitate rigging work.

B. Recommendations and Provisions of ANSI Bulletin A10.2 and OSHA shall be complied with in-so-far as applicable to the work.

C. The Contractor shall provide temporary partitions or tarpaulins to protect adjacent spaces and/or equipment. He shall be responsible for any damage or injury to person or property of any character resulting from any act, omission, neglect or misconduct in his manner or method of executing his work.

D. The Contractor shall restore at his own expense such property to a condition similar or equal to that existing before such damage or injury in an acceptable manner.

E. The Contractor, furthermore, shall conduct his operations in such a manner as to prevent dust and debris from transferring on to adjoining property or into existing spaces.

F. All openings cut in walls, floors, roof or ceilings of the building, for conduit, pipe, ductwork, etc., shall be closed off with box-type temporary protective enclosures of ¼" tempered hardboard, except when mechanics are actually working at the particular opening. Enclosures shall be constructed of fireproof 2x4 frame, four (4) sides covered and made completely dust and watertight.

G. All finished floor areas through which the contractor must pass with materials or equipment shall be protected with a layer of ¼" hardboard, "Masonite", "Ramboard" laid with joints taped together.

H. The roof shall be protected with ½" plywood in all areas of work.

3.8 EQUIPMENT SUPPORTS

A. A.Provide supplementary steel dunnage, curbs, angle iron stands, etc., to properly set and install all equipment, including supports necessary to properly pitch piping.

3.9 WELDING

A. Welding and equipment shall conform to the American Welding Society's Code for Welding in Building Construction, latest edition as well as state and local laws and ordinances.

B. The handling and storage of all welding materials, acetylene and oxygen tanks, burners, and other equipment required for the execution of welding and cutting work shall be subject at all times to the approval of the Owner and/or Architect. All welding materials and gas tanks shall be promptly removed from the premises upon completion of each day's work or stored in a manner satisfactory

to the owner. Welding and equipment shall conform to the American Welding Society's Code for Welding in Building Construction, latest edition as well as state and local laws and ordinances.

C. Provide all temporary ventilation, and ventilation air systems required during welding operations as required by OSHA.

3.10 AS-BUILT DRAWINGS

A. The Contractor shall provide a complete set of As-Built drawings showing actual installation and locations of all new and existing equipment, piping, and ductwork in the entire building. Schedules shall be revised to indicate actual equipment installed.

B. As-Built drawings shall be submitted as per contract requirements in accordance with Division 1 and shall be submitted in paper format for review. Accepted as built drawings shall then be submitted in AutoCAD and PDF electronically on hard disc.

3.11 CONDITIONS

A. Inspection: Prior to all work of this Section, carefully inspect the installed work of all other trades and verify that all such work is complete to the point where this installation may properly commence. Verify that the work of this Section may be completed in strict accordance with all pertinent codes and regulations, the approved Shop Drawings, and the Manufacturers' recommendations.

B. Discrepancies: In the event of discrepancy, immediately notify the Engineer. Do not proceed in areas of discrepancy until all such discrepancies have been fully resolved.

3.12 INSTALLATION OF EQUIPMENT

A. Locations: Install all equipment in the locations shown on the approved Shop Drawings except where specifically otherwise approved on the job by the Owner and/or Engineer.

B. Interferences: Avoid interference with structure, and with work of other trades, preserving adequate headroom and clearing all doors and passageways to the approval of the Engineer.

C. Inspection: Check each piece of equipment in the system for defects, verifying that all parts are properly furnished and installed, and that all items function properly, and that all adjustments have been made.

3.13 CLOSING-IN OF UNINSPECTED WORK

A. General: Do not allow or cause any of the work to be covered up or enclosed until it has been inspected, tested, and accepted by the Engineer and by all other authorities having jurisdiction.

B. Uncovering: Should any of the work of this Section be covered up or enclosed before it has been completely inspected, tested, and approved, do all things necessary to uncover all such work. After the work has been completely inspected, tested, and approved, provide all materials and labor necessary and make all repairs necessary to restore the work to its original and proper condition at no additional cost to the owner.

3.14 BUILDING ACCESS

A. The Contractor shall inform himself fully regarding peculiarities and limitations of space available for the passage and installation of all equipment and materials under the Contract.

B. Verify and coordinate removal of existing construction and/or knock-down of equipment to suit conditions. Special attention should be given to equipment installation. Provide all labor and material to facilitate installation.

3.15 COOPERATION WITH OTHER TRADES AND PHASING

A. Cooperate with other trades in order that all systems in the work may be installed in the best arrangements.

B. Coordinate as required with all other trades to share space in common areas and to provide the maximum of access to each system.

C. This Contractor shall submit fully coordinated shop drawings showing all piping, ductwork and equipment as well as relevant work of all other trades such as light, conduits, structural and steel, which may impact the final size or placement of piping, ductwork, equipment, diffusers and grilles.

D. The work shall be scheduled and phased in accordance with the requirements of the contract and the client. Prior to the commencement of work the HVAC contractor shall submit a schedule in writing to the Architect and owner for approval. There shall be no shutdowns of any systems without prior written approval from the owner. The contractor shall include in his bid all costs associated with providing temporarily piping controls, ductwork and fans and air conditioning units to maintain operations in the phase II area while work is being performed on the Phase I area. It shall also be noted that ductwork, piping and controls will have to be extended through the phase II work areas in order to reach the area(s) under construction in phase I as part of this work. The contractor shall include in his bid all provisions to perform such phasing work

3.16 CLEANING

A. It is the intent of the contract documents that all work, including the inside of equipment be left in a clean condition. All construction dirt shall be removed from material and equipment.

B. All removed items shall be taken off the premises and discarded in a manner satisfactory to the Owner.

3.17 COMPLETENESS

A. It is the intent of the contract documents to provide complete systems. Completeness shall mean not only that all material and equipment has been installed properly, but that all material and equipment is installed, adjusted, and operating as per the design intent in the opinion of the Engineer and in accordance with generally accepted industry good practice.

3.18 FIRE PREVENTION DURING HOT WORK

A. Before starting operations, the Contractor shall furnish trained personnel to provide fire watches for locations where hot work is to be performed. One fire watcher may observe several locations

in a relatively small contiguous area. Contractor shall furnish suitable type, fully-charged, operable portable fire extinguisher to each fire watcher.

B. The Contractor shall provide fire watchers who know how to operate the fire extinguisher, how to turn on a fire alarm and how to summon the fire department.

C. Before starting operations, take suitable precautions to minimize the hazard of a fire communicating to the opposite side of walls, floors, ceilings and roofs from the operations.

3.19 SAFETY MEASURES

A. Hot work shall not be done in or near rooms or areas where flammable liquids or explosive vapors are present or thought to be present. A combustible gas indicator (explosimeter) test shall be conducted to assure that each area is safe. The Contractor is responsible for arranging and paying for each test.

B. Insofar as possible, the Contractor shall remove and keep the area free from all combustibles, including rubbish, paper and waste within a radius of 25 feet from hot operations.

C. If combustible material cannot be removed, the Contractor shall furnish fireproof blankets to cover such materials. At the direction of the owner floors, walls, and ceilings of combustible material shall be wetted thoroughly with water before, during, and after operations sufficiently to afford adequate protection.

D. Where possible, the Contractor shall furnish and use baffles of metal or gypsum board to prevent the spraying of sparks, hot slag and other hot particles into surrounding combustible material.

E. The Contractor shall prevent the spread of sparks and particles of hot metal through open windows, doors, and holes and cracks in floors, walls, ceilings, and roofs.

F. Cylinders of gas used in hot work shall be placed a safe distance from the work. The Contractor shall provide hoses and equipment free of deterioration, malfunction, and leaks. Suitable supports shall be provided to prevent accidental overturning of cylinders. All cylinder control valves shall be shut off while in use with the gas pressure regulator set at 15 psi or less.

G. When hot work operations are completed or ended for the day, each location of the days work shall be inspected by the Contractor 30 to 60 minutes after completion of operations to detect for hidden or smoldering fires and to ensure that proper housekeeping is maintained. Contractor shall cleanup the area of work at the end of each shift or workday.

H. Where sprinkler protection exists, the sprinkler system shall be maintained without interruption while operations are being performed. If operations are performed close to automatic sprinkler heads, gypsum board sheets or damp cloth guards may be used to shield the individual heads temporarily. The heads shall be inspected by the Contractor immediately after hot work operations cease, to ensure all materials have been removed from the heads and that the heads have not been damaged.

I. Suitable type, fully charged, operable portable fire extinguisher shall be available at all times during hot work operations.

J. If any of the above safeguards are not employed, or are violated, the Contracting owners Representative may, by written notice, stop the work until compliance is obtained. Such stoppage shall not relieve the Contractor form performing his work within the Contract period for the Contract price.

3.20 USE OF OWNERS EQUIPMENT

A. The contractor shall not use any the owner's HVAC system or equipment, new or existing, for any purpose. The contractor shall provide temporary HVAC equipment, ductwork, power, and controls for use during construction for the purpose of ventilation, or heating during the construction process. All such equipment, ductwork, power, and controls shall be removed and the completion of work.

3.21 CONSTRUCTION PHOTOGRAPHS

1. Maintain key plan with each set of construction photographs that identifies each photographic location.

A. Retain "Preconstruction Photographs" Paragraph below if required to show preexisting conditions. Coordinate with pre-demolition photographs specified in Section 024116 "Structure Demolition," Section 024119 "Selective Demolition," and Section 311000 "Site Clearing."

B. Preconstruction Photographs: Before commencement of the Work, take photographs of Project site and surrounding properties, including existing items to remain during construction, from different vantage points, as directed by Construction Manager.

1. Flag and areas construction limits before taking construction photographs.
2. Take a minimum of 24 photographs of existing areas of work either on or adjoining property, to accurately record physical conditions at start of construction.

C. Concealed Work Photographs: Before proceeding with installing work that will conceal other work, take photographs sufficient in number, with annotated descriptions, to record nature and location of concealed Work, including, but not limited to, the following:

1. Existing utilities.
2. Mechanical equipment rooms.
3. Piping ductwork and HVAC equipment, boilers
4. Electrical conduit.
5. Waterproofing and weather-resistant barriers.

D. Requirements in "Periodic Construction Photographs" Paragraph below are minimal but adequate for many projects. If needed, add requirement for photographs to be taken of spaces that contain utilities before enclosing finishes are installed. Last option is generally used with monthly photographs.

E. Periodic Construction Photographs: Take 24 photographs coinciding with the cutoff date associated with each Application for Payment. Select vantage points to show status of construction and progress since last photographs were taken.

F. Final Completion Construction Photographs: Take 100 photographs after date of Substantial Completion for submission as Project Record Documents.

END OF SECTION

SECTION 230513 - COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

B. Division 24 - Equipment Wiring Systems: Electrical characteristics and wiring connections.

1.2 SUMMARY

A. Section includes general requirements for single-phase and polyphase, general-purpose, horizontal, small and medium, squirrel-cage induction motors for use on alternating-current power systems up to 600 V and installed at equipment manufacturer's factory or shipped separately by equipment manufacturer for field installation.

1.3 COORDINATION

A. Coordinate features of motors, installed units, and accessory devices to be compatible with the following:

1. Motor controllers.
2. Torque, speed, and horsepower requirements of the load.
3. Ratings and characteristics of supply circuit and required control sequence.
4. Ambient and environmental conditions of installation location.

1.4 REFERENCES

A. AFBMA 9 - Load Ratings and Fatigue Life for Ball Bearings.

B. AFBMA 11 - Load Ratings and Fatigue Life for Roller Bearings.

C. NEMA MG 1 - Motors and Generators.

D. NFPA 70 - National Electrical Code.

1.5 REGULATORY REQUIREMENTS

A. Conform to UL Component Recognition for appropriate sizes.

B. Conform to NFPA 70 applicable electrical code, Underwriters Laboratories, Inc., and NEMA

C. Conform to I ECC 2015

1.6 DELIVERY, STORAGE, AND PROTECTION

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

1.7 WARRANTY

A. Provide five-year manufacturer warranty for all motors larger than ½ horsepower.

PART 2 - PRODUCTS

MANUFACTURERS

A. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

1. Gould.
2. Century.
3. General Electric.
4. Square D

2.2 GENERAL MOTOR REQUIREMENTS

A. Comply with NEMA MG 1 unless otherwise indicated.

B. Comply with IEEE 841 for severe-duty motors.

C. All electric motors of sizes and types as specified for driving mechanical equipment shall be provided under this section.

D. Electrical Service: All motors shall be 60 Hertz unless otherwise noted. Refer to Electrical Specifications for required electrical characteristics.

E. Motors: Design for continuous operation in 40° C environment, and for temperature rise in accordance with ANSI/NEMA MG limits for insulation class, Service Factor, and motor enclosure type. Motors shall be of sufficient size for duty to be performed.

F. Visible Nameplate: Indicating manufacturer's name and model number, motor horsepower, RPM, frame size, voltage, phase, cycles, full load amps, insulation system class, service factor, maximum ambient temperature, temperature rise at rated horsepower, minimum efficiency, power factor.

G. Electrical Connection: Conduit connection boxes, threaded for conduit. For fractional horsepower motors where connection is made directly, provide screwed conduit connection in

end frame. Size motor boxes to receive motor feeders and ground cable indicated on electrical drawing schedules.

H. Duty: Continuous duty at ambient temperature of 40 deg C and at altitude of 3300 feet above sea level.

I. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.

2.3 MOTOR EFFICIENCY

A. Electric motors shall meet the minimum efficiency requirement of the following tables in accordance with International Energy conservation code when tested in accordance with DOE CFR 431. Performance data shall be certified by approved testing agency.

B. Subtype I motors – NEMA premium efficiency as per table NEMA MG 1 table 12-12 and the Energy Conservation code table 405.8(1). This shall apply to general purpose, T-frame, single speed, squirrel cage, induction type; 230/460-V, NEMA Designs A or B, continuous rated, 60 Hz, from 1 to 200 hp, 2-, 4- and 6-pole (3600-, 1800- and 1200-rpm), open and enclosed. Subtype I motors 250 hp to 500 hp motor efficiency shall be able NEMA MG 1 table 12-11 and the Energy Conservation Code table 405.8(1).

C. Subtype II motors – NEMA efficiency as per table NEMA MG 1 table 12-11 and Energy Conservation code table 405.8(2). This shall apply to general purpose motors but can be configured as U-frame motors; NEMA Design C motors; close-coupled pump motors; footless motors; vertical solid shaft normal thrust motors (as tested in a horizontal position); eight-pole (900 rpm) motors, and polyphase motors with a voltage of not more than 600 V (other than 230 or 460 V).

D. Minimum average full load efficiency of polyphase small electric motors up to 3 hp shall be in accordance with Table C405.8(3) of the International Energy Conservation Code

E. Minimum average full load efficiency for capacitor-start, capacitor-run and capacitor-start induction-run small electric motors up to 3 hp shall be in accordance with Table C405.8(4) of the International Energy Conservation Code.

2.4 POLYPHASE MOTORS

A. Description: NEMA MG 1, Design B, medium induction motor.

B. Service Factor: 1.15.

C. Multispeed Motors: Variable torque.

1. For motors with 2:1 speed ratio, consequent pole, single winding.
2. For motors with other than 2:1 speed ratio, separate winding for each speed.

D. Multispeed Motors: Separate winding for each speed.

E. Rotor: Random-wound, squirrel cage.

F. Bearings: Regreasable, shielded, antifriction ball bearings suitable for radial and thrust loading. Grease lubricated anti-friction ball bearings with housings equipped with plugged provision for relubrication, rated for minimum AFBMA 9, L-10 life of 200,000 hours. Calculate bearing load with NEMA minimum V-belt pulley with belt center line at end of NEMA standard shaft extension. Stamp bearing sizes on nameplate.

G. Thermistor System (Motor Frame Sizes 254T and Larger): Three PTC thermistors embedded in motor windings and epoxy encapsulated solid state control relay with wiring to terminal box.

H. Sound Power Levels: To NEMA MG 1.

I. Temperature Rise: Match insulation rating.

J. Insulation: Class B or better.

K. Code Letter Designation:

1. Motors 15 HP and Larger: NEMA starting Code F or Code G.
2. Motors Smaller Than 15 HP: Manufacturer's standard starting characteristic.

L. Enclosure Material: Cast iron for motor frame sizes 324T and larger; rolled steel for motor frame sizes smaller than 324T.

2.5 ADDITIONAL REQUIREMENTS FOR POLYPHASE MOTORS

A. Motors Used with Reduced-Voltage and Multispeed Controllers: Match wiring connection requirements for controller with required motor leads. Provide terminals in motor terminal box, suited to control method.

B. Use part winding Start above 254T Frame Size: Use part of winding to reduce locked rotor starting current to approximately 60 percent of full winding locked rotor current while providing approximately 50 percent of full winding locked rotor torque.

C. Motors Used with Variable-Frequency Controllers: Ratings, characteristics, and features coordinated with and approved by controller manufacturer.

1. Windings: Copper magnet wire with moisture-resistant insulation varnish, designed and tested to resist transient spikes, high frequencies, and short time rise pulses produced by pulse-width-modulated inverters.
2. Premium-Efficient Motors: Class B temperature rise; Class F insulation.
3. Inverter-Duty Motors: Class F temperature rise; Class H insulation.
4. Thermal Protection: Comply with NEMA MG 1 requirements for thermally protected motors.

D. Severe-Duty Motors: Comply with IEEE 841, with 1.15 minimum service factor.

2.6 SINGLE-PHASE MOTORS

A. Motors larger than 1/20 hp shall be one of the following, to suit starting torque and requirements of specific motor application:

1. Permanent-split capacitor.
2. Split phase.
3. Capacitor start, inductor run.
4. Capacitor start, capacitor run.

B. Multispeed Motors: Variable-torque, permanent-split-capacitor type.

C. Bearings: Pre-lubricated, antifriction ball bearings or sleeve bearings suitable for radial and thrust loading.

D. Motors 1/20 HP and Smaller: Shaded-pole type.

E. Thermal Protection: Internal protection to automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature rating of motor insulation. Thermal-protection device shall automatically reset when motor temperature returns to normal range.

F. Drip-proof Enclosure: Class A (50 degrees C temperature rise) insulation, NEMA Service Factor, pre-lubricated sleeve ball bearings.

2.7 POWER FACTOR CORRECTION

A. Provide a capacitor for each three phase, single speed motor rated 3 HP or larger shall be provided to correct the full load power factor to 95%. The capacitor shall be mounted at the motor for connection across the motor terminals by Electrical Contractor

B. Capacitors;
1. Capacitors shall be totally enclosed, fused and with discharge resistors.
2. Capacitors based on nominal motor RPM shall be provided in accordance with the following table to correct power factor to 95% and verify sizes with motor manufacturer.

Motor HP	Capacitor KVAR 3600 RPM Motor	Capacitor KVAR 1800 RPM Motor
3	1.5	1.5
5	2	2
7.5	2.5	2.5
10	3	3
15	4	4
20	5	5
25	6	6
30	7	7
40	9	9
50	12	12
60	14	14

2.8 STARTERS

A. GENERAL

1. Starters for motors operating at 120 volts shall be manual starters unless otherwise indicated. Starters for motors operating at other than 120 volts shall be magnetic starters.
2. All starters shall be enclosed. Enclosures shall be surface mounted NEMA 1 unless otherwise indicated.
3. Where weatherproof starters are required, the enclosure shall be NEMA 4.
4. It shall be verified that the correct overload heaters have been installed in the starter before energizing any motor. Sizing shall be based on motor nameplate current and taking into account any reduction in current due to power factor correction.
5. Alternate Manufacturers –
   a. Allen-Bradley
   b. Crouse-Hinds Co.
   c. Cutler-Hammer, Inc.
   d. General Electric Co.
   e. Square D Co.
   f. Westinghouse Electric Corp.

B. MANUAL STARTERS

1. Two-pole, toggle operated, thermal overload device in each phase leg, handle guard for padlocking toggle handle and with indicated control and signal devices.

2. Where a motor is controlled automatically by an interlock or pilot device, a “HAND-OFF-AUTO” switch shall be provided in the starter cover. Where the rating of the interlock or pilot device is inadequate to control the motor currents directly, a properly rated contactor shall be provided between the controlling device and the motor.

3. An “ON” pilot light shall be provided in the starter cover.

C. MAGNETIC STARTERS

1. Starters shall be sized in accordance with NEMA standards and the following table, except that starters shall not be smaller than NEMA size 0. Starters shall be provided with one N.O. electrical holding interlock, under voltage protection and two additional auxiliary contacts within the same enclosure. NEMA size starters shall be provided as follows

STARTER SIZE	MAX HP AT 460 VOLTS
0	5
1	10
2	25

2. All starters shall be combination type with the starter and disconnect in the same enclosure. All starters shall be Type 2 coordination protected. Fuses shall be Bussman "Low Peak" type or equal sized at 125% of motor nameplate rating. Verify and coordinate requirements for fused disconnect switches with the Electrical Contractor prior to ordering starters.

3. Provide S.S.P.B. or H-O-A switches and pilot light in covers as required to facilitate control operation sequences.

D. CRITICAL FAULT

1. Where starters are not integral to equipment and are furnished and installed separately from equipment by the contractor, provide a 3 phase line voltage monitor by ICM Controls model 450 or approved equal. Unit shall be installed in the motor starter or in a separate enclosure with the same rating as the starter. It shall be arranged to monitor critical faults including phase loss or reversal, and when detected, de-energize the load. It shall monitor non-critical faults including high/low voltage, voltage unbalance and when detected, after a time delay de-energize the load.

PART 3 - EXECUTION

A. Suitable starting and controlling equipment and devices shall be furnished and installed as specified hereinafter and as shown on the Drawings. The starting equipment shall be arranged, generally, in control groups, or in certain cases, as isolated combination starters as specified or indicated. The Heating Ventilating and Air Conditioning Sequences of Operation, drawings and specifications shall be referred to for the manner of control, operation and monitoring of motors and the electrically operated equipment.

B. A starter and disconnect switch or combination motor starter disconnect shall be provided for every motor and each and every electrically operated piece of equipment by this contractor except where complete starters and controls are furnished by the manufacturer of the motor or piece of equipment. Starters shall be internally wired to provide the required control operation

and monitoring. All control devices such as push buttons, break-glass stations, alternators, relays, pilot lights, etc., shall be provided as required for operation of mechanical equipment. All roof top and remotely located equipment shall have remote starters as located on plan and shall have local disconnect switches. All equipment located in equipment rooms can use combination starters/disconnects located within line of site of controlled equipment. All starters and disconnect switches shall be in enclosures suitable for the environment in which they are installed. Starters and disconnect switches located in machine rooms shall use NEMA 1. Starters and disconnect switches located outdoors shall use NEMA 4x. Starters and disconnect switches located in machine rooms which are subject to potential water damage shall use NEMA 2

C. Starting equipment and devices specified in this section shall be furnished by the mechanical subcontractor and shall be installed by the Electrical subcontractor. In general the mechanical subcontractor shall furnish all motor starters and disconnect switches except where they are an integral part of a motor control center, in this case starters and disconnects shall be provided, (furnished and installed), by the electrical contractor. The Electrical subcontractor shall also provide all wiring necessary to supply power to the electric motors specified under this section, including connections from the starters to the motors. Starters and disconnects shall also include variable frequency drives.

D. The mechanical Contractor shall furnish and install all wiring between control devices and controlled equipment furnished under this Section, including interlock control wiring between motor starters, and all automatic temperature control wiring. All wiring shall be installed in conformance with applicable codes and the requirements of the Electrical Division of the Specifications.

E. The Electrical Contractor shall furnish a 120 volt power source to temperature control panels and equipment requiring a separate 120 volt control power source. Power for control circuits for all devices connecting to motor starters shall be obtained from 120-volt control transformers provided in each starter operating at other than 120 volts. Provide transformers for all low voltage control systems as required.

F. Furnish detailed composite wiring diagrams and such other information necessary to assure the proper connection, operation and control of motorized equipment, including interlocks, automatic controls, safety controls and all auxiliary circuits.

G. All control units shall be furnished with a nameplate indicating which device or equipment it controls, the voltage. Additional nameplates on each push button, selector switch and pilot light indicating their functions shall be provided. Nameplates shall be laminated phenolic with white letters on black background, minimum 2” high.

H. All motors supplied either with equipment or installed separately that are to be used in conjunction with variable frequency drive shall be inverter duty motors.

END OF SECTION 230513

SECTION 230517 - SLEEVES AND ESCUTCHEONS FOR HVAC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Sleeves.
2. Stack-sleeve fittings.
3. Sleeve-seal systems.
4. Sleeve-seal fittings.
5. Grout.
6. Escutcheons.
7. Floor plates.
8. Acoustic split seal rings

1.3 ACTION SUBMITTALS

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

PART 2 - PRODUCTS

2.1 SLEEVES

A. Cast-Iron Wall Pipes: Cast or fabricated of cast or ductile iron and equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop unless otherwise indicated.

B. Galvanized-Steel Wall Pipes: ASTM A 53/A 53M, Schedule 40, with plain ends and welded steel collar; zinc coated.

C. Galvanized-Steel-Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc coated, with plain ends.

D. PVC-Pipe Sleeves: ASTM D 1785, Schedule 40.

E. Galvanized-Steel-Sheet Sleeves: 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint.

F. Molded-PE or -PP Sleeves: Removable, tapered-cup shaped, and smooth outer surface with nailing flange for attaching to wooden forms.

G. Molded-PVC Sleeves: With nailing flange for attaching to wooden forms.

2.2 STACK-SLEEVE FITTINGS

A. Description: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring, bolts, and nuts for membrane flashing.

1. Underdeck Clamp: Clamping ring with setscrews.

2.3 SLEEVE-SEAL SYSTEMS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Advance Products & Systems, Inc.
2. Airex Manufacturing.
3. CALPICO, Inc.
4. Metraflex Company (The).
5. Link Seal

B. Description: Modular sealing-element unit, designed for field assembly, for filling annular space between piping and sleeve.

1. Sealing Elements: EPDM-rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
2. Pressure Plates: Carbon steel or Stainless steel.
3. Connecting Bolts and Nuts: Carbon steel, with corrosion-resistant coating, or Stainless steel of length required to secure pressure plates to sealing elements.

2.4 SLEEVE-SEAL FITTINGS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Advance Products & Systems, Inc.
2. GPT; an EnPro Industries company.
3. Metraflex Company (The).
4. Proco Products, Inc.
5. Fernco

B. Description: Manufactured heavy rubber or EPDM, sleeve-to-pipe water stop assembly. Unit has rubber water stop collar with center opening to match piping OD. Connected with stainless steel hose clamps. Made for copper or plastic carrier pipes. Size up to 4” sleeve and 3” carrier pipe.

2.5 GROUT

A. Standard: ASTM C 1107/C 1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.

B. Characteristics: Nonshrink; recommended for interior and exterior applications.

C. Design Mix: 5000-psi, 28-day compressive strength.

D. Packaging: Premixed and factory packaged.

2.6 ESCUTCHEONS

A. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped brass with chrome-plated finish and spring-clip fasteners.

B. One-Piece, Stamped-Steel Type: With chrome-plated finish and spring-clip fasteners.

C. Split-Casting Brass Type: With polished, chrome-plated finish and with concealed hinge and setscrew.

D. Split-Plate, Stamped-Steel Type: With chrome-plated finish, concealed hinge, and spring-clip fasteners.

2.7 FLOOR PLATES

A. One-Piece Floor Plates: Cast-iron flange with holes for fasteners.

B. Split-Casting Floor Plates: Cast brass with concealed hinge.

2.8 ACOUSTIC SPLIT SEALS

A. Acoustic Split Seals; consist of pipe halves with minimum 3/4" thick neoprene sponge cemented to the inner faces. The seal shall be tightened around the pipe to eliminate clearance between the inner sponge face and the piping. Grout seals to make it integral with the floor, wall or ceiling in masonry construction. Seals shall project a minimum of 1" past either face of the wall. Where temperatures exceed 240F, 10 lb. density fiberglass may be used in lieu of the sponge. Seals shall be Type SPS or SWS as manufactured by Mason Industries, Inc.

PART 3 - EXECUTION

3.1 SLEEVE INSTALLATION

A. Install sleeves for piping passing through penetrations in floors, partitions, roofs, and walls.

B. For sleeves that will have sleeve-seal system installed, select sleeves of size large enough to provide 1-inch annular clear space between piping and concrete slabs and walls.

C. Install sleeves in concrete floors, concrete roof slabs, and concrete walls as new slabs and walls are constructed.
   1. Cut sleeves to length for mounting flush with both surfaces.
      a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches above finished floor level.
   2. Using grout, seal the space outside of sleeves in slabs and walls without sleeve-seal system.

D. Install sleeves for pipes passing through interior partitions.

1. Cut sleeves to length for mounting flush with both surfaces.
2. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.
3. Seal annular space between sleeve and piping or piping insulation; use joint sealants appropriate for size, depth, and location of joint. Comply with requirements for sealants specified in Section 079200 "Joint Sealants."

E. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements for firestopping specified in Section 078413 "Penetration Firestopping."

3.2 STACK-SLEEVE-FITTING INSTALLATION

A. Install stack-sleeve fittings in new slabs as slabs are constructed or existing slabs for new risers.

1. Install fittings that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.
2. Secure flashing between clamping flanges for pipes penetrating floors with membrane waterproofing. Comply with requirements for flashing specified in Section 076200 "Sheet Metal Flashing and Trim."
3. Using grout, seal the space around outside of stack-sleeve fittings.

B. Fire-Barrier Penetrations: Maintain indicated fire rating of floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements for firestopping specified in Section 078413 "Penetration Firestopping."

3.3 SLEEVE-SEAL-SYSTEM INSTALLATION

A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at service piping entries into building.

B. Select type, size, and number of sealing elements required for piping material and size and for sleeve ID or hole size. Position piping in center of sleeve. Center piping in penetration, assemble sleeve-seal system components, and install in annular space between piping and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make a watertight seal.

C. Coordinate the minimum size of sleeves with the pipe. Sleeves for plumbing piping shall be 2x the diameter of the service pipe.

3.4 SLEEVE-SEAL-FITTING INSTALLATION

A. Install sleeve-seal fittings in new walls and slabs as they are constructed.

B. Assemble fitting components of length to be flush with both surfaces of concrete slabs and walls. Position water stop flange to be centered in concrete slab or wall.

C. Secure nailing flanges to concrete forms.

D. Using grout, seal the space around outside of sleeve-seal fittings.

3.5 SLEEVE AND SLEEVE-SEAL SCHEDULE

A. Provide sleeve seal systems for all underground pipes.

B. Provide sleeve seal system or fitting for above ground pipe.

3.6 ESCUTCHEON INSTALLATION

A. Install escutcheons for piping penetrations of walls, ceilings, and finished floors.

B. Install escutcheons with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.

1. Escutcheons for New Piping: (one piece)
   a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.
   b. Chrome-Plated Piping: One-piece, cast-brass or split-casting brass type with polished, chrome-plated finish.
   c. Insulated Piping: One-piece, stamped-steel type or split-plate, stamped-steel type with concealed hinge.
   d. Bare Piping at Wall, Floor and ceiling Penetrations in Finished Spaces: One-piece, stamped-steel type or split-plate, stamped-steel type with concealed hinge.
   e. Bare Piping in Unfinished Service Spaces: One-piece, stamped-steel type or split-plate, stamped-steel type with concealed hinge.
   f. Bare Piping in Equipment Rooms: One-piece, stamped-steel type or split-plate, stamped-steel type with concealed hinge or split-plate, stamped-steel type with exposed-rivet hinge.

2. Escutcheons for Existing Piping: (split ring)

   a. Chrome-Plated Piping: Split-casting brass type with polished, chrome-plated finish.
   b. Insulated Piping: Split-plate, stamped-steel type with concealed or exposed-rivet hinge.
   c. Bare Piping at Wall, Floor and ceiling Penetrations in Finished Spaces: Split-plate, stamped-steel type with concealed hinge.
   d. Bare Piping in Unfinished Service Spaces: Split-plate, stamped-steel type with concealed hinge.
   e. Bare Piping in Equipment Rooms: Escutcheons not required

C. Install floor plates for piping penetrations of equipment-room floors.

D. Install floor plates with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.

1. New Piping: One-piece, floor-plate type.
2. Existing Piping: Split-casting, floor-plate type.

3.7 ACOUSTIC SPLIT SEAL

A. Install Acoustic split seals on all hydronic piping 2” and over, penetrating mechanical equipment room walls.

3.8 FIELD QUALITY CONTROL

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

END OF SECTION 230517.5

SECTION 230519 - METERS AND GAGES FOR HVAC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Bimetallic-actuated thermometers.
2. Filled-system thermometers.
3. Liquid-in-glass thermometers.
4. Thermowells.
5. Dial-type pressure gages.
6. Gage attachments.
7. Test plugs.
8. Test-plug kits.

B. Related Sections:

1. Section 221114 " Natural-Gas Piping"
2. Section 232216 "Steam and Condensate Piping Specialties" for steam and condensate meters.

1.3 ACTION SUBMITTALS

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

B. Wiring Diagrams: For power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Product Certificates: For each type of meter and gage, from manufacturer.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For meters and gages to include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 Thermometer Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Trerice, H. O. Co.
2. Watts; a Watts Water Technologies company.
3. Weiss Instruments, Inc.
4. Weksler Glass Thermometer Corp.

2.2 BIMETALLIC-ACTUATED THERMOMETERS

A. Standard: ASME B40.200.

B. Case: Liquid-filled and sealed type(s); stainless steel with 5-inch nominal diameter.

C. Dial: Nonreflective aluminum with permanently etched scale markings and scales in deg F and deg C.

D. Connector Type(s): Union joint, adjustable angle, with unified-inch screw threads.

E. Connector Size: 1/2 inch, with ASME B1.1 screw threads.

F. Stem: 0.25 or 0.375 inch in diameter; stainless steel.

G. Window: Plain glass.

H. Ring: Stainless steel.

I. Element: Bimetal coil.

J. Pointer: Dark-colored metal.

K. Accuracy: Plus or minus 1 percent of scale range.

2.3 FILLED-SYSTEM THERMOMETERS

A. Direct-Mounted, Metal-Case, Vapor-Actuated Thermometers:
1. Standard: ASME B40.200.
2. Case: Sealed type, cast aluminum or drawn steel; 5-inch nominal diameter.
3. Element: Bourdon tube or other type of pressure element.
4. Movement: Mechanical, dampening type, with link to pressure element and connection to pointer.
5. Dial: Nonreflective aluminum with permanently etched scale markings graduated in deg F and deg C.
6. Pointer: Dark-colored metal.
7. Window: Glass.
8. Ring: Stainless steel.

9. Connector Type(s): Union joint, adjustable, 180 degrees in vertical plane, 360 degrees in horizontal plane, with locking device; with ASME B1.1 screw threads.
10. Thermal System: Liquid-filled bulb in copper-plated steel, aluminum, or brass stem and of length to suit installation.

    a. Design for Air-Duct Installation: With ventilated shroud.
    b. Design for Thermowell Installation: Bare stem.

11. Accuracy: Plus, or minus 1 percent of scale range.

B. Remote-Mounted, Metal-Case, Vapor-Actuated Thermometers:
1. Standard: ASME B40.200.
2. Case: Sealed type, cast aluminum or drawn steel; 4-1/2-inch nominal diameter with back or front flange and holes for panel mounting.
3. Element: Bourdon tube or other type of pressure element.
4. Movement: Mechanical, with link to pressure element and connection to pointer.
5. Dial: Nonreflective aluminum with permanently etched scale markings graduated in deg F and deg C.
6. Pointer: Dark-colored metal.
7. Window: Glass.
8. Ring: Stainless steel.
9. Connector Type(s): Union joint, back or bottom; with ASME B1.1 screw threads.
10. Thermal System: Liquid-filled bulb in copper-plated steel, aluminum, or brass stem and of length to suit installation.

    a. Design for Air-Duct Installation: With ventilated shroud.
    b. Design for Thermowell Installation: Bare stem.

11. Accuracy: Plus, or minus 1 percent of scale range.

2.4 LIQUID-IN-GLASS THERMOMETERS

A. Metal-Case, Compact-Style, Liquid-in-Glass Thermometers:
1. Standard: ASME B40.200.
2. Case: Cast aluminum; 6-inch nominal size.
3. Case Form: Back angle unless otherwise indicated.
4. Tube: Glass with magnifying lens and blue or red organic liquid.
5. Tube Background: Nonreflective aluminum with permanently etched scale markings graduated in deg F and deg C.
6. Window: Glass or plastic.
7. Stem: Aluminum or brass and of length to suit installation.

    a. Design for Air-Duct Installation: With ventilated shroud.
    b. Design for Thermowell Installation: Bare stem.

8. Connector: 3/4 inch, with ASME B1.1 screw threads.
9. Accuracy: Plus, or minus 1 percent of scale range or one scale division, to a maximum of 1.5 percent of scale range.

B. Metal-Case, Industrial-Style, Liquid-in-Glass Thermometers:

1. Standard: ASME B40.200.
2. Case: Cast aluminum; 9-inch nominal size unless otherwise indicated.
3. Case Form: Adjustable angle Back angle unless otherwise indicated.
4. Tube: Glass with magnifying lens and blue or red organic liquid.
5. Tube Background: Nonreflective aluminum with permanently etched scale markings graduated in deg F and deg C.
6. Window: Glass.
7. Stem: Aluminum and of length to suit installation.

    a. Design for Air-Duct Installation: With ventilated shroud.
    b. Design for Thermowell Installation: Bare stem.

8. Connector: 1-1/4 inches, with ASME B1.1 screw threads.
9. Accuracy: Plus or minus 1 percent of scale range or one scale division, to a maximum of 1.5 percent of scale range.

2.5 DUCT-THERMOMETER MOUNTING BRACKETS

A. Description: Flanged bracket with screw holes, for attachment to air duct and made to hold thermometer stem.

2.6 THERMOWELLS

A. Thermowells:

1. Standard: ASME B40.200.
2. Description: Pressure-tight, socket-type fitting made for insertion into piping tee fitting.
3. Material for Use with Copper Tubing: CNR or CUNI.
4. Material for Use with Steel Piping: CRES CSA.
5. Type: Stepped shank unless straight or tapered shank is indicated.
6. External Threads: NPS 1/2, NPS 3/4, or NPS 1, ASME B1.20.1 pipe threads.
7. Internal Threads: 1/2, 3/4, and 1 inch, with ASME B1.1 screw threads.
8. Bore: Diameter required to match thermometer bulb or stem.
9. Insertion Length: Length required to match thermometer bulb or stem.
10. Lagging Extension: Include on thermowells for insulated piping and tubing.
11. Bushings: For converting size of thermowell's internal screw thread to size of thermometer connection.

B. Heat-Transfer Medium: Mixture of graphite and glycerin.

2.7 PRESSURE GAGES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Trerice, H. O. Co.
    b. Watts; a Watts Water Technologies company.
    c. Weiss Instruments, Inc.

d. Weksler Glass Thermometer Corp.

B. Direct-Mounted, Metal-Case, Dial-Type Pressure Gages:

1. Standard: ASME B40.100.

2. Case: Liquid-filled Sealed Solid-front, pressure relief type(s); cast aluminum or drawn steel; 4-1/2-inch nominal diameter.
3. Pressure-Element Assembly: Bourdon tube unless otherwise indicated.
4. Pressure Connection: Brass, with NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe threads and bottom-outlet type unless back-outlet type is indicated.
5. Movement: Mechanical, with link to pressure element and connection to pointer.
6. Dial: Nonreflective aluminum with permanently etched scale markings graduated in psi and kPa.
7. Pointer: Dark-colored metal.
8. Window: Glass.
9. Ring: Metal.
10. Accuracy: Grade A, plus or minus 1 percent of middle half of scale range.

2.8 GAGE ATTACHMENTS

A. Snubbers: ASME B40.100, brass; with NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe threads and piston-type surge-dampening device. Include extension for use on insulated piping.

B. Siphons: Loop-shaped section of brass or stainless-steel pipe with NPS 1/4 or NPS 1/2 pipe threads.

C. Valves: Brass or stainless-steel needle, with NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe threads.

2.9 TEST PLUGS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Trerice, H. O. Co.
2. Watts; a Watts Water Technologies company.
3. Weiss Instruments, Inc.
4. Weksler Glass Thermometer Corp.

B. Description: Test-station fitting made for insertion into piping tee fitting.

C. Body: Brass or stainless steel with core inserts and gasketed and threaded cap. Include extended stem on units to be installed in insulated piping.

D. Thread Size: NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe thread.

E. Minimum Pressure and Temperature Rating: 500 psig at 200 deg F.

F. Core Inserts: EPDM self-sealing rubber.

2.10 TEST-PLUG KITS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Sisco Manufacturing Company, Inc.
2. Trerice, H. O. Co.
3. Watts; a Watts Water Technologies company.
4. Weiss Instruments, Inc.

B. Furnish one test-plug kit(s) containing two thermometer(s), one pressure gage and adapter, and carrying case. Thermometer sensing elements, pressure gage, and adapter probes shall be of diameter to fit test plugs and of length to project into piping.

C. Low-Range Thermometer: Small, bimetallic insertion type with 1- to 2-inch- diameter dial and tapered-end sensing element. Dial range shall be at least 25 to 125 deg F.

D. High-Range Thermometer: Small, bimetallic insertion type with 1- to 2-inch- diameter dial and tapered-end sensing element. Dial range shall be at least 0 to 220 deg F.

E. Pressure Gage: Small, Bourdon-tube insertion type with 2- to 3-inch- diameter dial and probe. Dial range shall be at least 0 to 200 psig.

F. Carrying Case: Metal or plastic, with formed instrument padding.

2.11 SIGHT FLOW INDICATORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. ARCHON Industries, Inc.
2. Dwyer Instruments, Inc.
3. Emerson Process Management; Rosemount Division.
4. OPW Engineered Systems; OPW Fluid Transfer Group; a Dover company.
5. Pentair Valves & Controls; Penberthy Brand.

B. Description: Piping inline-installation device for visual verification of flow.

C. Construction: Bronze or stainless-steel body, with sight glass and ball, flapper, or paddle wheel indicator, and threaded or flanged ends.

D. Minimum Pressure Rating: 150 psig.

E. Minimum Temperature Rating: 200 deg F.

F. End Connections for NPS 2 and Smaller: Threaded.

G. End Connections for NPS 2-1/2 and Larger: Flanged.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install thermowells with socket extending one-third of pipe diameter and in vertical position in piping tees.

B. Install thermowells of sizes required to match thermometer connectors. Include bushings if required to match sizes.

C. Install thermowells with extension on insulated piping.

D. Fill thermowells with heat-transfer medium.

E. Install direct-mounted thermometers in thermowells and adjust vertical and tilted positions.

F. Install remote-mounted thermometer bulbs in thermowells and install cases on panels; connect cases with tubing and support tubing to prevent kinks. Use minimum tubing length.

G. Install duct-thermometer mounting brackets in walls of ducts. Attach to duct with screws.

H. Install direct-mounted pressure gages in piping tees with pressure gage located on pipe at the most readable position.

I. Install remote-mounted pressure gages on panel.

J. Install valve and snubber in piping for each pressure gage for fluids (except steam).

K. Install valve and syphon fitting in piping for each pressure gage for steam.

L. Install test plugs in piping tees.

M. Install flow indicators in piping systems in accessible positions for easy viewing.

N. Assemble and install connections, tubing, and accessories between flow-measuring elements and flowmeters according to manufacturer's written instructions.

O. Install flowmeter elements in accessible positions in piping systems.

P. Install wafer-orifice flowmeter elements between pipe flanges.

Q. Install differential-pressure-type flowmeter elements, with at least minimum straight lengths of pipe, upstream and downstream from element according to manufacturer's written instructions.

R. Install permanent indicators on walls or brackets in accessible and readable positions.

S. Install connection fittings in accessible locations for attachment to portable indicators.

T. Mount thermal-energy meters on wall if accessible; if not, provide brackets to support meters.

U. Install thermometers in the following locations:

1. Inlet and outlet of each hydronic zone.
2. Inlet and outlet of each hydronic boiler.
3. Two inlets and two outlets of each heat exchanger.

V. Install pressure gages in the following locations:

1. Discharge of each pressure-reducing valve.
2. Inlet and outlet of each chiller chilled-water and condenser-water connection.
3. Suction and discharge of each pump.

3.2 CONNECTIONS

A. Install meters and gages adjacent to machines and equipment to allow service and maintenance of meters, gages, machines, and equipment.

B. Connect flowmeter-system elements to meters.

C. Connect flowmeter transmitters to meters.

D. Connect thermal-energy meter transmitters to meters.

3.3 ADJUSTING

A. After installation, calibrate meters according to manufacturer's written instructions.

B. Adjust faces of meters and gages to proper angle for best visibility.

3.4 THERMOMETER SCHEDULE

A. Thermometers at inlet and outlet of each **hydronic zone** shall be one of the following:

1. Sealed, bimetallic-actuated type.
2. Direct or Remote-mounted, metal-case, vapor-actuated type.
3. Compact or Industrial-style, liquid-in-glass type.
4. Test plug with EPDM self-sealing rubber inserts.
5. Industrial-style, liquid-in-glass type.

B. Industrial type, liquid in glass type thermometers shall be installed at all the inlets and outlets of each of the following equipment:
1. Hydronic pump
2. Hydronic boiler
3. Thermal storage tank
4. Water source heat pump
5. Heat exchanger
6. Air handling units
7. Provide test with EPDM self-sealing rubber inserts

C. Thermometers at inlet and outlet of each **hydronic coil in air-handling units or duct mounted** and built-up central systems shall be one of the following:

1. Liquid-filled or Sealed, bimetallic-actuated type.
2. Direct or Remote-mounted, metal-case, vapor-actuated type.
3. Compact or Industrial-style, liquid-in-glass type.
4. Test plug with EPDM self-sealing rubber inserts.

D. Thermometers at outside-, return-, supply-, and mixed-air ducts shall be one of the following:

1. Liquid-filled or Sealed, bimetallic-actuated type.
2. Direct or Remote-mounted, metal-case, vapor-actuated type.
3. Compact or Industrial-style, liquid-in-glass type.

E. Thermometer stems shall be of length to match thermowell insertion length.

3.5 THERMOMETER SCALE-RANGE SCHEDULE

A. Scale Range for Chilled-Water Piping: 0 to 150 deg F.

B. Scale Range for Condenser-Water Piping: 0 to 150 deg F.

C. Scale Range for Heating, Hot-Water Piping: 0 to 250 deg F.

D. Scale Range for Steam and Steam-Condensate Piping: 0 to 250 deg F.

E. Scale Range for Air Ducts: 0 to 150 deg F.

3.6 PRESSURE-GAGE SCHEDULE

A. Pressure gages at all the inlet and discharge connections of each of the following equipment shall be liquid filled and sealed direct mounting, metal case.
1. Pressure-reducing valve
2. Hydronic pump
3. Hydronic boiler
4. Chiller
5. Thermal storage tank
6. Water source heat pump
7. Cooling tower
8. Heat exchanger
9. Air handling and duct mounted units' coils
10. Provide test with EPDM self-sealing rubber inserts

3.7 PRESSURE-GAGE SCALE-RANGE SCHEDULE

A. Scale Range for Chilled-Water Piping: 0 to 200 psi.

B. Scale Range for Condenser-Water Piping: 0 to 150 psi.

C. Scale Range for Heating, Hot-Water Piping: 0 to 160 psi.

D. Scale Range for Steam Piping: 0 to 100 psi.

3.8 FLOWMETER SCHEDULE

A. Flowmeters for Cooling Tower cold-water make up piping: Turbine type.

END OF SECTION 230519

SECTION 230523.11 - VALVES FOR HVAC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Bronze angle valves.
2. Globe valves.
3. Ball Valves
4. Butterfly Valves.
5. Check Valves
6. Gate Valves
7. Chainwheels.

1.3 DEFINITIONS

A. CWP: Cold working pressure.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of valve.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Prepare valves for shipping as follows:

1. Protect internal parts against rust and corrosion.
2. Protect threads, flange faces, grooves, and weld ends.
3. Set angle and globe valves closed to prevent rattling.

B. Use the following precautions during storage:

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

C. Use sling to handle large valves; rig sling to avoid damage to exposed parts. Do not use handwheels or stems as lifting or rigging points.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR VALVES

A. Source Limitations for Valves: Obtain each type of valve from single source from single manufacturer.

B. ASME Compliance:

1. ASME B1.20.1 for threads for threaded-end valves.
2. ASME B16.1 for flanges on iron valves.
3. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
4. ASME B16.18 for solder joint.
5. ASME B31.1 for power piping valves.
6. ASME B31.9 for building services piping valves.

C. Refer to HVAC valve schedule articles for applications of valves.

D. Valve Pressure and Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.

E. Valve Sizes: Same as upstream piping unless otherwise indicated.

F. Valves in Insulated Piping:

1. Include 2-inchstem extensions.
2. Extended operating handle of nonthermal-conductive material, and protective sleeves that allow operation of valves without breaking the vapor seals or disturbing insulation.
3. Memory stops that are fully adjustable after insulation is applied.

G. Valve Actuator Types:

1. Gear Actuator: For valves NPS 8 and larger.
2. Handlever: For valves NPS 6 and smaller.
3. Chainwheel: Device for attachment to gear, stem, or other actuator of size and with chain for mounting height, according to "Valve Installation" Article.

H. .Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Apollo Valves; Conbraco Industries, Inc.
b. Crane; Crane Energy Flow Solutions.
c. Milwaukee Valve Company.
d. NIBCO INC.
e. Stockham; Crane Energy Flow Solutions.
f. Watts; a Watts Water Technologies company.
g. Keystone

GLOBE VALVES

2.2 BRONZE ANGLE VALVES

A. Class 125 Bronze Angle Valves:

1. Description:

a. Standard: MSS SP-80, Type 1.
b. CWP Rating: 200 psig.
c. Body Material: ASTM B 62, bronze with integral seat and screw-in bonnet.
d. Ends: Threaded.
e. Stem and Disc: Bronze
f. Packing: Asbestos free.
g. Handwheel: Malleable iron, bronze, or aluminum.

B. Class 150 Bronze Angle Valves:

1. Description:

a. Standard: MSS SP-80, Type 1.
b. CWP Rating: 300 psig.
c. Body Material: ASTM B 62, bronze with integral seat and union-ring bonnet.
d. Ends: Threaded.
e. Stem and Disc: Bronze
f. Packing: Asbestos free.
g. Handwheel: Malleable iron, bronze, or aluminum.

2.3 BRONZE GLOBE VALVES

A. Class 125 Bronze Globe Valves:

1. Description:

a. Standard: MSS SP-80, Type 1.
b. CWP Rating: 200 psig.
c. Body Material: ASTM B 62, bronze with integral seat and screw-in bonnet.
d. Ends: Threaded or solder joint.
e. Stem and Disc: Bronze.
f. Packing: Asbestos free.
g. Handwheel: Malleable iron, bronze, or aluminum.

B. Class 150 Bronze Globe Valves:

1. Description:

a. Standard: MSS SP-80, Type 2.
b. CWP Rating: 300 psig.
c. Body Material: ASTM B 62, bronze with integral seat and union-ring bonnet.

d. Ends: Threaded.
e. Stem: Bronze.
f. Disc: Bronze or PTFE.
g. Packing: Asbestos free.
h. Handwheel: Malleable iron, bronze, or aluminum.

2.4 IRON GLOBE VALVES

A. Class 125 Iron Globe Valves:
1. Description:

a. Standard: MSS SP-85, Type I.
b. CWP Rating: 200 psig.
c. Body Material: ASTM A 126, gray iron with bolted bonnet.
d. Ends: Flanged.
e. Trim: Bronze.
f. Packing and Gasket: Asbestos free.
g. Operator: Handwheel or chainwheel.

B. Class 250 Iron Globe Valves:
1. Description:

a. Standard: MSS SP-85, Type I.
b. CWP Rating: 500 psig.
c. Body Material: ASTM A 126, gray iron with bolted bonnet.
d. Ends: Flanged.
e. Trim: Bronze.
f. Packing and Gasket: Asbestos free.
g. Operator: Handwheel or chainwheel.

BALL VALVES

2.5 BRASS BALL VALVES

A. One-Piece Brass Ball Valves:
1. Description:

a. Standard: MSS SP-110.
b. CWP Rating: 400 psig.
c. Body Design: One piece.
d. Body Material: Forged brass.
e. Ends: Threaded.
f. Seats: PTFE.
g. Stem: Brass.
h. Ball: Chrome-plated brass.
i. Port: Reduced.

B. Two-Piece Brass Ball Valves with Full Port and Brass Trim:

1. Description:

    a. Standard: MSS SP-110.
    b. SWP Rating: 150 psig.
    c. CWP Rating: 600 psig.
    d. Body Design: Two piece.
    e. Body Material: Forged brass.
    f. Ends: Threaded.
    g. Seats: PTFE.
    h. Stem: Brass.
    i. Ball: Chrome-plated brass.
    j. Port: Full.

C. Two-Piece Brass Ball Valves with Full Port and Stainless-Steel Trim:
1. Description:

    a. Standard: MSS SP-110.
    b. SWP Rating: 150 psig.
    c. CWP Rating: 600 psig.
    d. Body Design: Two piece.
    e. Body Material: Forged brass.
    f. Ends: Threaded.
    g. Seats: PTFE.
    h. Stem: Stainless steel.
    i. Ball: Stainless steel, vented.
    j. Port: Full.

D. Two-Piece Brass Ball Valves with Regular Port and Brass Trim:
1. Description:

    a. Standard: MSS SP-110.
    b. SWP Rating: 150 psig.
    c. CWP Rating: 600 psig.
    d. Body Design: Two piece.
    e. Body Material: Forged brass.
    f. Ends: Threaded.
    g. Seats: PTFE.
    h. Stem: Brass.
    i. Ball: Chrome-plated brass.
    j. Port: Regular.

E. Two-Piece Brass Ball Valves with Regular Port and Stainless-Steel Trim:
1. Description:

    a. Standard: MSS SP-110.
    b. SWP Rating: 150 psig.
    c. CWP Rating: 600 psig.
    d. Body Design: Two piece.
    e. Body Material: Brass or bronze.
    f. Ends: Threaded.
    g. Seats: PTFE.

h. Stem: Stainless steel.
i. Ball: Stainless steel, vented.
j. Port: Regular.

2.6 BRONZE BALL VALVES

A. One-Piece Bronze Ball Valves with Bronze Trim:
1. Description:

a. Standard: MSS SP-110.
b. CWP Rating: 400 psig.
c. Body Design: One piece.
d. Body Material: Bronze.
e. Ends: Threaded.
f. Seats: PTFE.
g. Stem: Bronze.
h. Ball: Chrome-plated brass.
i. Port: Reduced.

B. One-Piece Bronze Ball Valves with Stainless-Steel Trim:
1. Description:

a. Standard: MSS SP-110.
b. CWP Rating: 600 psig.
c. Body Design: One piece.
d. Body Material: Bronze.
e. Ends: Threaded.
f. Seats: PTFE.
g. Stem: Stainless steel.
h. Ball: Stainless steel, vented.
i. Port: Reduced.

C. Two-Piece Bronze Ball Valves with Full Port and Bronze or Brass Trim:
1. Description:

a. Standard: MSS SP-110.
b. SWP Rating: 150 psig.
c. CWP Rating: 600 psig.
d. Body Design: Two piece.
e. Body Material: Bronze.
f. Ends: Threaded.
g. Seats: PTFE.
h. Stem: Bronze.
i. Ball: Chrome-plated brass.
j. Port: Full.

D. Two-Piece Bronze Ball Valves with Full Port and Stainless-Steel Trim:
1. Description:

a. Standard: MSS SP-110.

b. SWP Rating: 150 psig.
c. CWP Rating: 600 psig.
d. Body Design: Two piece.
e. Body Material: Bronze.
f. Ends: Threaded.
g. Seats: PTFE.
h. Stem: Stainless steel.
i. Ball: Stainless steel, vented.
j. Port: Full.

E. Two-Piece Bronze Ball Valves with Regular Port and Bronze or Brass Trim:
1. Description:

a. Standard: MSS SP-110.
b. SWP Rating: 150 psig.
c. CWP Rating: 600 psig.
d. Body Design: Two piece.
e. Body Material: Bronze.
f. Ends: Threaded.
g. Seats: PTFE.
h. Stem: Bronze.
i. Ball: Chrome-plated brass.
j. Port: Regular.

F. Two-Piece Bronze Ball Valves with Regular Port and Stainless-Steel Trim:
1. Description:

a. Standard: MSS SP-110.
b. SWP Rating: 150 psig.
c. CWP Rating: 600 psig.
d. Body Design: Two piece.
e. Body Material: Bronze.
f. Ends: Threaded.
g. Seats: PTFE.
h. Stem: Stainless steel.
i. Ball: Stainless steel, vented.
j. Port: Regular.

2.7 IRON BALL VALVES

A. Class 125 Iron Ball Valves:
1. Description:

a. Standard: MSS SP-72.
b. CWP Rating: 200 psig.
c. Body Design: Split body.
d. Body Material: ASTM A 126, gray iron.
e. Ends: Flanged.
f. Seats: PTFE.
g. Stem: Stainless steel.

h. Ball: Stainless steel.
i. Port: Full.

BUTTERFLY VALVES

2.8 HIGH-PERFORMANCE BUTTERFLY VALVES

A. Class 150, Single-Flange, High-Performance Butterfly Valves:
1. Description:

a. Standard: MSS SP-68.
b. CWP Rating: 285 psig at 100 deg F.
c. Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
d. Body Material: Carbon steel, **cast iron, ductile iron, or stainless steel. Match piping system**
e. Seat: Reinforced PTFE or metal.
f. Stem: Stainless steel; offset from seat plane.
g. Disc: Carbon steel.
h. Service: Bidirectional.

B. Class 300, Single-Flange, High-Performance Butterfly Valves:
1. Description:

a. Standard: MSS SP-68.
b. CWP Rating: 720 psig at 100 deg F.
c. Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
d. Body Material**: Carbon steel, cast iron, or ductile iron. Match piping system**
e. Seat: Reinforced PTFE or metal.
f. Stem: Stainless steel; offset from seat plane.
g. Disc: Carbon steel.
h. Service: Bidirectional.

CHECK VALVES

2.9 BRONZE LIFT CHECK VALVES

A. Class 125 Lift Check Valves with Bronze Disc:
1. Description:

a. Standard: MSS SP-80, Type 1.
b. CWP Rating: 200 psig.
c. Body Design: Vertical flow.
d. Body Material: ASTM B 61 or ASTM B 62, bronze.
e. Ends: Threaded.
f. Disc: Bronze.

B. Class 125 Lift Check Valves with Nonmetallic Disc:

1. Description:

    a. Standard: MSS SP-80, Type 2.
    b. CWP Rating: 200 psig.
    c. Body Design: Vertical flow.
    d. Body Material: ASTM B 61 or ASTM B 62, bronze.
    e. Ends: Threaded.
    f. Disc: NBR or PTFE.

2.10 BRONZE SWING CHECK VALVES

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

        a. Standard: MSS SP-80, Type 3.
        b. CWP Rating: 200 psig.
        c. Body Design: Horizontal flow.
        d. Body Material: ASTM B 62, bronze.
        e. Ends: Threaded.
        f. Disc: Bronze.

B. Class 125, Bronze Swing Check Valves with Nonmetallic Disc:
    1. Description:

        a. Standard: MSS SP-80, Type 4.
        b. CWP Rating: 200 psig.
        c. Body Design: Horizontal flow.
        d. Body Material: ASTM B 62, bronze.
        e. Ends: Threaded.
        f. Disc: PTFE.

C. Class 150, Bronze Swing Check Valves with Bronze Disc:
    1. Description:

        a. Standard: MSS SP-80, Type 3.
        b. CWP Rating: 300 psig.
        c. Body Design: Horizontal flow.
        d. Body Material: ASTM B 62, bronze.
        e. Ends: Threaded.
        f. Disc: Bronze.

D. Class 150, Bronze Swing Check Valves with Nonmetallic Disc:
    1. Description:

        a. Standard: MSS SP-80, Type 4.
        b. CWP Rating: 300 psig.
        c. Body Design: Horizontal flow.
        d. Body Material: ASTM B 62, bronze.
        e. Ends: Threaded.
        f. Disc: PTFE.

2.11 IRON SWING CHECK VALVES

A. Class 125, Iron Swing Check Valves with Metal Seats:
1. Description:

a. Standard: MSS SP-71, Type I.
b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.
c. NPS 14 to NPS 24, CWP Rating: 150 psig.
d. Body Design: Clear or full waterway.
e. Body Material: ASTM A 126, gray iron with bolted bonnet.
f. Ends: Flanged.
g. Trim: Bronze.
h. Gasket: Asbestos free.

B. Class 125, Iron Swing Check Valves with Nonmetallic-to-Metal Seats:
1. Description:

a. Standard: MSS SP-71, Type I.
b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.
c. NPS 14 to NPS 24, CWP Rating: 150 psig.
d. Body Design: Clear or full waterway.
e. Body Material: ASTM A 126, gray iron with bolted bonnet.
f. Ends: Flanged.
g. Trim: Composition.
h. Seat Ring: Bronze.
i. Disc Holder: Bronze.
j. Disc: PTFE.
k. Gasket: Asbestos free.

C. Class 250, Iron Swing Check Valves with Metal Seats:
1. Description:

a. Standard: MSS SP-71, Type I.
b. NPS 2-1/2 to NPS 12, CWP Rating: 500 psig.
c. NPS 14 to NPS 24, CWP Rating: 300 psig.
d. Body Design: Clear or full waterway.
e. Body Material: ASTM A 126, gray iron with bolted bonnet.
f. Ends: Flanged.
g. Trim: Bronze.
h. Gasket: Asbestos free.

2.12 IRON SWING CHECK VALVES WITH CLOSURE CONTROL

A. Class 125, Iron Swing Check Valves with Lever- and Spring-Closure Control:
1. Description:

a. Standard: MSS SP-71, Type I.
b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.
c. NPS 14 to NPS 24, CWP Rating: 150 psig.
d. Body Design: Clear or full waterway.

e. Body Material: ASTM A 126, gray iron with bolted bonnet.
f. Ends: Flanged.
g. Trim: Bronze.
h. Gasket: Asbestos free.
i. Closure Control: Factory-installed, exterior lever and spring.

GATE VALVES

A. Class 125, RS, Bronze Gate Valves:
1. Description:

a. Standard: MSS SP-80, Type 2.
b. CWP Rating: 200 psig.
c. Body Material: ASTM B 62, bronze with integral seat and screw-in bonnet.
d. Ends: Threaded[**or solder joint**].
e. Stem: Bronze.
f. Disc: Solid wedge; bronze.
g. Packing: Asbestos free.
h. Handwheel: Malleable iron, bronze, or aluminum.

B. Class 150, RS, Bronze Gate Valves:
1. Description:

a. Standard: MSS SP-80, Type 2.
b. CWP Rating: 300 psig.
c. Body Material: ASTM B 62, bronze with integral seat and union-ring bonnet.
d. Ends: Threaded.
e. Stem: Bronze.
f. Disc: Solid wedge; bronze.
g. Packing: Asbestos free.
h. Handwheel: Malleable iron[**, bronze, or aluminum**].

C. Class 125, OS&Y, Iron Gate Valves:
1. Description:

a. Standard: MSS SP-70, Type I.
b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.
c. NPS 14 to NPS 24, CWP Rating: 150 psig.
d. Body Material: ASTM A 126, gray iron with bolted bonnet.
e. Ends: Flanged.
f. Trim: Bronze.
g. Disc: Solid wedge.
h. Packing and Gasket: Asbestos free.

D. Class 250, OS&Y, Iron Gate Valves:
1. Description:

a. Standard: MSS SP-70, Type I.
b. NPS 2-1/2 to NPS 12, CWP Rating: 500 psig.
c. NPS 14 to NPS 24, CWP Rating: 300 psig.

d. Body Material: ASTM A 126, gray iron with bolted bonnet.
e. Ends: Flanged.
f. Trim: Bronze.
g. Disc: Solid wedge.
h. Packing and Gasket: Asbestos free.

2.13 CHAINWHEELS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Babbitt Steam Specialty Co.
2. Roto Hammer Industries.
3. Trumbull Industries.

B. Description: Valve actuation assembly with sprocket rim, chain guides, chain, and attachment brackets for mounting chainwheels directly to handwheels.

1. Sprocket Rim with Chain Guides: Ductile or cast iron Aluminum, of type and size required for valve.
2. Chain: Hot-dip-galvanized steel, of size required to fit sprocket rim.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine valve interior for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.

B. Operate valves in positions from fully open to fully closed. Examine guides and seats made accessible by such operations.

C. Examine threads on valve and mating pipe for form and cleanliness.

D. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Verify that gasket is of proper size, that its material composition is suitable for service, and that it is free from defects and damage.

E. Do not attempt to repair defective valves; replace with new valves.

3.2 VALVE INSTALLATION GENERAL

A. Valve Pressure and Temperature Ratings: select valves such the rating is greater than the system operating pressure and temperature and or as required. All valves for this project shall have the following minimum ratings.
1. SWP Rating: 150 psig.

2. CWP Rating: 600 psig.
3. If valves with specified CWP ratings are unavailable, the same types of valves with higher CWP ratings may be substituted

B. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.

C. Locate valves for easy access and provide separate support where necessary.

D. Install valves in horizontal piping with stem at or above center of pipe.

E. Install valves in position to allow full stem movement.

F. Install chainwheels on operators for all valves NPS 6 and larger and more than 96 inches above floor. Extend chains to 60 inches above finished floor.

G. Install valve tags. Comply with requirements in Section 230553 "Identification for HVAC Piping and Equipment" for valve tags and schedules.

H. Install check valves for proper direction of flow and as follows:

1. Swing Check Valves: In horizontal position with hinge pin level.
2. Center-Guided and Plate-Type Check Valves: In horizontal or vertical position, between flanges.
3. Lift Check Valves: With stem upright and plumb.

3.3 ADJUSTING

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

3.4 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

A. If valve applications are not indicated, use the following:

1. Throttling Service Steam: Globe valves.

B. Select valves with the following end connections:

1. For Copper Tubing, NPS 2 and Smaller: Threaded ends except where solder-joint valve-end option is indicated in valve schedules.
2. For Copper Tubing, NPS 2-1/2 to NPS 4: Flanged ends except where threaded valve-end option is indicated in valve schedules.
3. For Copper Tubing, NPS 5 and Larger: Flanged ends.
4. For Steel Piping, NPS 2 and Smaller: Threaded ends.
5. For Steel Piping, NPS 2-1/2 to NPS 4: Flanged ends except where threaded valve-end option is indicated in valve schedules.
6. For Steel Piping, NPS 5 and Larger: Flanged ends.
7. For valves exposed to glycol, UV and hydronic applications EPDM gaskets and seats.

3.5 HYDRONIC VALVE SCHEDULE

A. Pipe NPS 21/2” and Smaller: Bronze or brass body. Class 250, nonmetallic disc, with soldered, or threaded ends. Ball, gate, globe, check style.

B. Pipe NPS 3”and Larger: Iron body valves, Class 250 with flanged ends. Ball, gate, globe butterfly, check style.

3.6 LOW-PRESSURE STEAM AND STEAM CONDENSATE VALVE SCHEDULE (15 PSIG OR LESS)

A. Pipe NPS 2 1/2” and Smaller: Bronze or brass body. Class 250, bronze, brass nonmetallic disc, with soldered or threaded ends. Ball, gate, globe, check style.

B. Pipe NPS 3” and Larger: Iron body valves, Class 250 with flanged ends. Ball, gate, globe, check style.

C. Do not use butterfly valves for steam applications.

END OF SECTION 230523.11

SECTION 230529 - HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Metal pipe hangers and supports.
2. Trapeze pipe hangers.
3. Fiberglass pipe hangers.
4. Metal framing systems.
5. Thermal-hanger shield inserts.
6. Fastener systems.
7. Pipe stands.
8. Equipment supports.

1.3 DEFINITIONS

A. MSS: Manufacturers Standardization Society of The Valve and Fittings Industry Inc.

1.4 PERFORMANCE REQUIREMENTS

A. Delegated Design: Design trapeze pipe hangers and equipment supports, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

B. Structural Performance: Hangers and supports for HVAC piping and equipment shall withstand the effects of gravity loads and stresses within limits and under conditions indicated according to ASCE/SEI 7.

1. Design supports for multiple pipes, including pipe stands, capable of supporting combined weight of supported systems, system contents, and test water.
2. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.
3. Design seismic-restraint hangers and supports for piping and equipment.

1.5 ACTION SUBMITTALS

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

B. Shop Drawings: Signed and sealed by a qualified professional engineer. Show fabrication and installation details and include calculations for the following; include Product Data for components:

1. Trapeze pipe hangers.
2. Metal framing systems.
3. Pipe stands.
4. Equipment supports.

C. Delegated-Design Submittal: For trapeze hangers indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Detail fabrication and assembly of trapeze hangers.
2. Design Calculations: Calculate requirements for designing trapeze hangers.

1.6 INFORMATIONAL SUBMITTALS

A. Welding certificates.

1.7 QUALITY ASSURANCE

A. Structural Steel Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

B. Pipe Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.

PART 2 - PRODUCTS

2.1 METAL PIPE HANGERS AND SUPPORTS

A. Carbon-Steel Pipe Hangers and Supports:

1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
2. Galvanized Metallic Coatings: Pre-galvanized or hot dipped.
3. Nonmetallic Coatings: Plastic coating, jacket, or liner.
4. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
5. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel.

B. Stainless-Steel Pipe Hangers and Supports:

1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
2. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
3. Hanger Rods: Continuous-thread rod, nuts, and washer made of stainless steel.

C. Copper Pipe Hangers:

1. Description: MSS SP-58, Types 1 through 58, copper-coated-steel, factory-fabricated components.
2. Hanger Rods: Continuous-thread rod, nuts, and washer made of copper-coated steel or stainless steel.

2.2 TRAPEZE PIPE HANGERS

A. Description: MSS SP-69, Type 59, shop- or field-fabricated pipe-support assembly made from structural carbon-steel shapes with MSS SP-58 carbon-steel hanger rods, nuts, saddles, and U-bolts.

2.3 METAL FRAMING SYSTEMS

A. MFMA Manufacturer Metal Framing Systems:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

    a. B-line, an Eaton business.
    b. Flex-Strut Inc.
    c. Thomas & Betts Corporation; A Member of the ABB Group.
    d. Unistrut; Part of Atkore International.
    e. Wesanco, Inc.

2. Description: Shop- or field-fabricated pipe-support assembly for supporting multiple parallel pipes.

3. Standard: MFMA-4.
4. Channels: Continuous slotted steel channel with inturned lips.
5. Channel Nuts: Formed or stamped steel nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
6. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel or stainless steel.
7. Metallic Coating: Electroplated zinc, Hot-dipped galvanized, Mill galvanized, In-line, hot galvanized, or Mechanically-deposited zinc.
8. Paint Coating: Epoxy or Alkyd.
9. Plastic Coating: PVC or Polyurethane.

B. Non-MFMA Manufacturer Metal Framing Systems:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

    a. Anvil International.
    b. ERICO International Corporation.

c. PHD Manufacturing, Inc.

2. Description: Shop- or field-fabricated pipe-support assembly made of steel channels, accessories, fittings, and other components for supporting multiple parallel pipes.

3. Standard: Comply with MFMA-4.
4. Channels: Continuous slotted steel channel with inturned lips.
5. Channel Nuts: Formed or stamped steel nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
6. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel or stainless steel.
7. Coating: Zinc, Paint or PVC.

2.4 THERMAL-HANGER SHIELD INSERTS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Clement Support Services.
2. ERICO International Corporation.
3. National Pipe Hanger Corporation.
4. Pipe Shields Inc.
5. Piping Technology & Products, Inc.
6. Rilco Manufacturing Co., Inc.

B. Insulation-Insert Material for Hot and cold Piping: Water-repellent treated, ASTM C 533, Type I calcium silicate with 100-psig minimum compressive strength.

C. For Trapeze or Clamped Systems: Insert and shield shall cover entire circumference of pipe.

D. For Clevis or Band Hangers: Insert and shield shall cover lower 180 degrees of pipe.

E. Insert Length: Extend 2 inches beyond sheet metal shield for piping operating below ambient air temperature.

2.5 FASTENER SYSTEMS

A. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened Portland cement concrete with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

B. Mechanical-Expansion Anchors: Insert-wedge-type, stainless- steel anchors, for use in hardened Portland cement concrete; with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

2.6 PIPE STANDS

A. General Requirements for Pipe Stands: Shop- or field-fabricated assemblies made of manufactured corrosion-resistant components to support roof-mounted piping.

B. Compact Pipe Stand: One-piece plastic unit with integral-rod roller, pipe clamps, or V-shaped cradle to support pipe, for roof installation without membrane penetration.

C. Low-Type, Single-Pipe Stand: One-piece stainless-steel base unit with plastic roller, for roof installation without membrane penetration.

D. High-Type, Single-Pipe Stand:

1. Description: Assembly of base, vertical and horizontal members, and pipe support, for roof installation without membrane penetration.
2. Base: Stainless steel.
3. Vertical Members: Two or more cadmium-plated-steel or stainless-steel, continuous-thread rods.
4. Horizontal Member: Cadmium-plated-steel or stainless-steel rod with plastic or stainless-steel, roller-type pipe support.

E. High-Type, Multiple-Pipe Stand:

1. Description: Assembly of bases, vertical and horizontal members, and pipe supports, for roof installation without membrane penetration.
2. Bases: One or more; plastic.
3. Vertical Members: Two or more protective-coated-steel channels.
4. Horizontal Member: Protective-coated-steel channel.
5. Pipe Supports: Galvanized-steel, clevis-type pipe hangers.

F. Curb-Mounted-Type Pipe Stands: Shop- or field-fabricated pipe supports made from structural-steel shapes, continuous-thread rods, and rollers, for mounting on permanent stationary roof curb.

2.7 EQUIPMENT SUPPORTS

A. Description: Welded, shop- or field-fabricated equipment support made from structural carbon-steel shapes.

2.8 MISCELLANEOUS MATERIALS

A. Structural Steel: ASTM A 36/A 36M, carbon-steel plates, shapes, and bars; black and galvanized.

B. Grout: ASTM C 1107, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout; suitable for interior and exterior applications.

1. Properties: Nonstaining, noncorrosive, and nongaseous.
2. Design Mix: 5000-psi, 28-day compressive strength.

C. Flashing;
Metal Flashing: 26gage galvanized steel.

1. Metal Counter-flashing: 22 gage thick galvanized steel.

2. Flexible Flashing: 47 mil thick sheet butyl or other material compatible with roofing. Verify with roofing manufacturer.

3. Caps: Steel, 22-gage minimum; 16 gage at fire resistant elements.

D. Sleeves:
1. Ductwork Sleeve 18 gauge Installation and Closure for Fire Rated Walls and Floors: Fire damper assembly with continuous angles on all sides as per NFPA-90A requirements.

2. Provide and install sleeves for all penetrations in accordance with Division 1.

E. Escutcheons;
1. Chrome plated cast brass escutcheons with set screws on all exposed piping at wall penetrations in finished spaces.

F. Hanger Rods:
1. Hanger Rods: Hot rolled steel threaded both ends, threaded one end, or continuous threaded. In accordance with the following schedule.

HANGER ROD SIZE SCHEDULE	
Pipe Size (in)	Min Rod Dia (in)
¾” to 2”	3/8”
½” to 3-1/2”	½”
4” to 5”	5/8”
6”	¾”
8” to 12”	7/8”
14”	1”
16” to 18”	1-1/8”
20”	1-1/4”
24”	1-1/2”
30”	1-7/8”

2. Hanger spacing shall be in accordance with the following schedule for maximum allowable distance. Provide hanger all changes in direction.

PIPE SUPPORT SPACING SCHEDULE		
Pipe Material/ Size (in)	Maximum Horizontal Spacing (ft)	Maximum Vertical Spacing (ft)
Steel		
Up to 1 ¼”	8	15
1 ½” to 2 ½”	10	15
3” and over	12	15
Copper Pipe	8	10

Copper Tubing		
Up to 1 ¼”	6	10
1 ½” and over	8	10
PVC / HDPE		
Up to 1”	3	10
1 1/4” and over	4	10

3. Fiberglass piping supports spacing shall be in accordance with the manufactures guidelines.

2.9 VIBRATION ISOLATION HANGERS

A. Vibration isolation pipe hangers: pre-compressed and locked at the rated deflection by means of a resilient up-stop to keep the piping or equipment at a fixed elevation during installation. The hangers shall be designed with a release mechanism to free the spring after the installation is complete and the hanger is subjected to its full load. Deflection shall be clearly indicated by means of a scale. Submittals shall include a drawing of the hanger showing the 30° capability. Hangers shall be type PC30N as manufactured by Mason Industries, Inc

PART 3 - EXECUTION

3.1 HANGER AND SUPPORT INSTALLATION

A. Metal Pipe-Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Install hangers, supports, clamps, and attachments as required to properly support piping from the building structure.

B. Metal Trapeze Pipe-Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Arrange for grouping of parallel runs of horizontal piping, and support together on field-fabricated trapeze pipe hangers.

1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size or install intermediate supports for smaller diameter pipes as specified for individual pipe hangers.
2. Field fabricate from ASTM A 36/A 36M, carbon-steel shapes selected for loads being supported. Weld steel according to AWS D1.1/D1.1M.

C. Metal Framing System Installation: Arrange for grouping of parallel runs of piping, and support together on field-assembled metal framing systems.

D. Thermal-Hanger Shield Installation: Install in pipe hanger or shield for insulated piping.

E. Fastener System Installation:

1. Install powder-actuated fasteners for use in lightweight concrete or concrete slabs less than 4 inches thick in concrete after concrete is placed and completely cured. Use operators that are licensed by powder-actuated tool manufacturer. Install fasteners according to powder-actuated tool manufacturer's operating manual.

2. Install mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.

F. Install hangers and supports complete with necessary attachments, inserts, bolts, rods, nuts, washers, and other accessories.

G. Equipment Support Installation: Fabricate from welded-structural-steel shapes.

H. Install hangers and supports to allow controlled thermal and seismic movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.

I. Install lateral bracing with pipe hangers and supports to prevent swaying.

J. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, NPS 2-1/2 and larger and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.

K. Load Distribution: Install hangers and supports so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.

L. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and to not exceed maximum pipe deflections allowed by ASME B31.9 for building services piping.

M. Insulated Piping:

1. Attach clamps and spacers to piping.

    a. Piping Operating above Ambient Air Temperature: Clamp may project through insulation.
    b. Piping Operating below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.
    c. Do not exceed pipe stress limits allowed by ASME B31.9 for building services piping.

2. Install MSS SP-58, Type 39, protection saddles on all piping with roller hangers installed outside of insulation. Fill interior voids with insulation that matches adjoining insulation.

    a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.

3. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier not on roller hangers. Shields shall span an arc of 180 degrees.

    a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.

4. Shield Dimensions for Pipe: Not less than the following:

    a. NPS 1/4 to NPS 3-1/2: 12 inches long and 0.048 inch thick.

b. NPS 4: 12 inches long and 0.06 inch thick.
c. NPS 5 and NPS 6: 18 inches long and 0.06 inch thick.
d. NPS 8 to NPS 14: 24 inches long and 0.075 inch thick.
e. NPS 16 to NPS 24: 24 inches long and 0.105 inch thick.

5. Pipes NPS 8 and Larger: Include wood or reinforced calcium-silicate-insulation inserts of length at least as long as protective shield.
6. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.

3.2 EQUIPMENT SUPPORTS

A. Fabricate structural-steel stands to suspend equipment from structure overhead or to support equipment above floor.

B. Grouting: Place grout under supports for equipment and make bearing surface smooth.

C. Provide lateral bracing, to prevent swaying, for equipment supports.

3.3 METAL FABRICATIONS

A. Cut, drill, and fit miscellaneous metal fabrications for trapeze pipe hangers and equipment supports.

B. Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded because of shipping size limitations.

C. Field Welding: Comply with AWS D1.1/D1.1M procedures for shielded, metal arc welding; appearance and quality of welds; and methods used in correcting welding work; and with the following:

1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
2. Obtain fusion without undercut or overlap.
3. Remove welding flux immediately.
4. Finish welds at exposed connections so no roughness shows after finishing and so contours of welded surfaces match adjacent contours.

3.4 ADJUSTING

A. Hanger Adjustments: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.

B. Trim excess length of continuous-thread hanger and support rods to 1-1/2 inches.

3.5 PAINTING

A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.

1. Apply paint by brush or spray to provide a minimum dry film thickness of 2.0 mils.

B. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply cold galvanizing-repair paint to comply with ASTM A 780. ZRC cold galvanizing compound

3.6 HANGER AND SUPPORT SCHEDULE

A. Specific hanger and support requirements are in Sections specifying piping systems and equipment.

B. Comply with MSS SP-69 for pipe-hanger selections and applications that are not specified in piping system Sections.

C. Use hangers and supports with galvanized metallic coatings for piping and equipment that will not have field-applied finish.

D. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.

E. Use carbon-steel pipe hangers and supports or metal trapeze pipe hangers and metal framing systems and attachments for general service applications.

F. Use stainless-steel pipe hangers and stainless-steel attachments for hostile environment applications.

G. Use copper-plated pipe hangers and copper or stainless-steel attachments for copper piping and tubing.

H. Use padded hangers for piping that is subject to scratching.

I. Use thermal-hanger shield inserts for insulated piping and tubing.

J. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated, stationary pipes NPS 1/2 to NPS 30.
2. Yoke-Type Pipe Clamps (MSS Type 2): For suspension of up to 1050 deg F, pipes NPS 4 to NPS 24, requiring up to 4 inches of insulation.
3. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes NPS 3/4 to NPS 36, requiring clamp flexibility and up to 4 inches of insulation.
4. Pipe Hangers (MSS Type 5): For suspension of pipes NPS 1/2 to NPS 4, to allow off-center closure for hanger installation before pipe erection.

5. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8.
6. Adjustable, Swivel-Ring Band Hangers (MSS Type 10): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8.
7. Extension Hinged or Two-Bolt Split Pipe Clamps (MSS Type 12): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 3.
8. Pipe Saddle Supports (MSS Type 36): For support of pipes NPS 4 to NPS 36, with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate.
9. Pipe Stanchion Saddles (MSS Type 37): For support of pipes NPS 4 to NPS 36, with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate, and with U-bolt to retain pipe.
10. Adjustable Pipe Saddle Supports (MSS Type 38): For stanchion-type support for pipes NPS 2-1/2 to NPS 36 if vertical adjustment is required, with steel-pipe base stanchion support and cast-iron floor flange.
11. Single-Pipe Rolls (MSS Type 41): For suspension of pipes NPS 1 to NPS 30, from two rods if longitudinal movement caused by expansion and contraction might occur.
12. Adjustable Roller Hangers (MSS Type 43): For suspension of pipes NPS 2-1/2 to NPS 24, from single rod if horizontal movement caused by expansion and contraction might occur.
13. Complete Pipe Rolls (MSS Type 44): For support of pipes NPS 2 to NPS 42 if longitudinal movement caused by expansion and contraction might occur but vertical adjustment is not necessary.
14. Pipe Roll and Plate Units (MSS Type 45): For support of pipes NPS 2 to NPS 24 if small horizontal movement caused by expansion and contraction might occur and vertical adjustment is not necessary.
15. Adjustable Pipe Roll and Base Units (MSS Type 46): For support of pipes NPS 2 to NPS 30 if vertical and lateral adjustment during installation might be required in addition to expansion and contraction.

K. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers NPS 3/4 to NPS 24.
2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers NPS 3/4 to NPS 24 if longer ends are required for riser clamps.

L. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches for heavy loads.
2. Steel Clevises (MSS Type 14): For 120 to 450 deg F piping installations.
3. Swivel Turnbuckles (MSS Type 15): For use with MSS Type 11, split pipe rings.
4. Malleable-Iron Sockets (MSS Type 16): For attaching hanger rods to various types of building attachments.
5. Steel Weldless Eye Nuts (MSS Type 17): For 120 to 450 deg F piping installations.

M. Building Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction, to attach to top flange of structural shape.
3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
6. C-Clamps (MSS Type 23): For structural shapes.
7. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.
8. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.
9. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.
10. Malleable-Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.
11. Welded-Steel Brackets: For support of pipes from below or for suspending from above by using clip and rod. Use one of the following for indicated loads:

    a. Light (MSS Type 31): 750 lb.
    b. Medium (MSS Type 32): 1500 lb.
    c. Heavy (MSS Type 33): 3000 lb.

12. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
13. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.

N. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel-Pipe-Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.
2. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.
3. Thermal-Hanger Shield Inserts: For supporting insulated pipe.

O. Spring Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Restraint-Control Devices (MSS Type 47): Where indicated to control piping movement.
2. Spring Cushions (MSS Type 48): For light loads if vertical movement does not exceed 1-1/4 inches.
3. Spring-Cushion Roll Hangers (MSS Type 49): For equipping Type 41, roll hanger with springs.
4. Spring Sway Braces (MSS Type 50): To retard sway, shock, vibration, or thermal expansion in piping systems.
5. Variable-Spring Hangers (MSS Type 51): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from hanger.

6. Variable-Spring Base Supports (MSS Type 52): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from base support.
7. Variable-Spring Trapeze Hangers (MSS Type 53): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from trapeze support.
8. Constant Supports: For critical piping stress and if necessary to avoid transfer of stress from one support to another support, critical terminal, or connected equipment. Include auxiliary stops for erection, hydrostatic test, and load-adjustment capability. These supports include the following types:

    a. Horizontal (MSS Type 54): Mounted horizontally.
    b. Vertical (MSS Type 55): Mounted vertically.
    c. Trapeze (MSS Type 56): Two vertical-type supports and one trapeze member.
9. Install vibration isolation hangers or supports on all piping connected to motor driven equipment for a distance of 20’ or the first two hangers.

P. Comply with MSS SP-69 for trapeze pipe-hanger selections and applications that are not specified in piping system Sections.

Q. Comply with MFMA-103 for metal framing system selections and applications that are not specified in piping system Sections.

R. Use powder-actuated fasteners or mechanical-expansion anchors instead of building attachments where required in concrete construction.

3.7 MISCELLANEOUS:

A. Equipment bases and supports.
1. Provide housekeeping pads of concrete, minimum 4 inches thick and extending 6 inches beyond supported equipment. Champers edges all four side. Provide dowels into concrete floor for equipment that is seismically braced.
2. Provide templates, anchor bolts, and accessories for mounting and anchoring equipment. Provide for all equipment, pumps, air handling units, etc.
3. Refer to 23 0548 Vibration controls for HVAC piping and piping and equipment for vibration inertia bases.
4. Construct supports of steel members. Brace and fasten with flanges bolted to structure. Provide rigid anchors for pipes after vibration isolation components are installed.

B. Flashing;
1. Provide flexible flashing and metal counter-flashing where piping and ductwork penetrate weather or waterproofed walls, floors, and roofs.
2. Flash piping projecting above finished roof surface with prefabricated steel reinforced boot and counter flashing sleeve.

C. Sleeves;
1. Sleeves are required for all piping passing through walls and/or slabs. Sleeve diameter to be large enough to accommodate insulated piping.
2. Sleeves through interior non-fire rated walls are to have annular space between pipe and sleeve filled with materials specified in Division 1.

3. Sleeves thru fire rated walls to have annular space filled with fire stopping wrapping strips and expanding caulking applied with a caulking gun for a minimum depth of 3" or in another manner suitable for the application as recommended by the manufacturer. See Division 1.

D. Escutcheons:
   1. Provide escutcheons on all wall pipe penetrations that are visible outside MER spaces. All escutcheons shall be chrome plated.

END OF SECTION 230529

SECTION 23 05 53 IDENTIFICATION FOR HVAC PIPING EQUIPMENT

PART 1 GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
   1. Equipment labels
   2. Warning signs and labels.
   3. Pipe labels.
   4. Stencils.
   5. Valve tags.
   6. Warning tags.

1.3 SUBMITTALS

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

B. Samples: For color, letter style, and graphic representation required for each identification material and device.

C. Equipment Label Schedule: Include a listing of all equipment to be labeled with the proposed content for each label.

D. Valve numbering scheme.

E. Valve Schedules: For each piping system to include in maintenance manuals.

1.4 COORDINATION

A. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.

B. Coordinate installation of identifying devices with locations of access panels and doors.

C. Install identifying devices before installing acoustical ceilings and similar concealment.

PART 2 PRODUCTS

2.1 NAMEPLATES, TAGS, MARKERS, ETC

A. Manufacturer: W.H. Brady Co., Signmark Div

B. Acceptable manufacturers offering equivalent products

1. Atlantic Engraving Company.
2. Seton Name Plate Co.
3. MSI Services
4. Substitutions as per Contract Requirements.

C. Description: Nameplates should be as specified in Division 1.

2.3 EQUIPMENT LABELS

A. Metal Labels for Equipment:

1. Material and Thickness: Brass 0.032-inch, stainless steel 0.025-inch, aluminum, 0.032-inch or anodized aluminum, 0.032-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
2. Letter Color: Black Blue Red White Yellow. As per ANSI depending on service
3. Background Color: Black Blue Red White Yellow as per ANSI depending on service
4. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
5. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-quarters the size of principal lettering.
6. Fasteners: Stainless-steel rivets or self-tapping screws.
7. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

B. Plastic Labels for Equipment:

1. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch thick, and having predrilled holes for attachment hardware.
2. Letter Color: [Black] Blue Red White Yellow as per ANSI depending on service
3. Background Color: Black] Blue Red White Yellow ANSI depending on service
4. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
5. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
6. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-quarters the size of principal lettering.
7. Fasteners: Stainless-steel rivets or self-tapping screws.
8. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

C. Label Content: Include equipment's Drawing designation or unique equipment number, drawing numbers where equipment is indicated (plans, details, and schedules), and the Specification Section number and title where equipment is specified.

D. Equipment Label Schedule: For each item of equipment to be labeled, on 8-1/2-by-11-inch bond paper. Tabulate equipment identification number and identify Drawing numbers where equipment is indicated (plans, details, and schedules) and the Specification Section number and title where equipment is specified. Equipment schedule shall be included in operation and maintenance data.

2.4 WARNING SIGNS AND LABELS

A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch thick, and having predrilled holes for attachment hardware.
B. Letter Color: White.
C. Background Color: Black.
D. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
E. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
F. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
G. Fasteners: Stainless-steel rivets or self-tapping screws.
H. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
I. Label Content: Include caution and warning information, plus emergency notification instructions.

2.5 PIPE LABELS

A. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction.
B. Pretensioned Pipe Labels: Precoiled, semirigid plastic formed to partially cover circumference of pipe and to attach to pipe without fasteners or adhesive.
C. Self-Adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.
D. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings, pipe size, and an arrow indicating flow direction.
E. Flow-Direction Arrows: Integral with piping system service lettering to accommodate both directions, or as separate unit on each pipe label to indicate flow direction.
F. Lettering Size: At least 1-1/2 inches high.

2.6 STENCILS (not used)

A. Stencils: Prepared with letter sizes according to ASME A13.1 for piping; and minimum letter height of 3/4 inch for access panel and door labels, equipment labels, and similar operational instructions.
   1. Stencil Paint: Exterior, gloss, black unless otherwise indicated. Paint may be in pressurized spray-can form.
   2. Identification Paint: Exterior, enamel in colors according to ASME A13.1 unless otherwise indicated.

2.7 VALVE TAGS

A. Valve Tags: Stamped or engraved with 1/4-inch letters for piping system abbreviation and 1/2-inch numbers.
   1. Tag Material: Brass, 0.032-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
   2. Fasteners: Brass wire-link or beaded chain; or S-hook.

B. Valve Schedules: For each piping system, on 8-1/2-by-11-inch bond paper. Tabulate valve number, piping system, system abbreviation (as shown on valve tag), location of valve (room or space), normal-operating position (open, closed, or modulating), and variations for identification. Mark valves for emergency shutoff and similar special uses.

C. All new mechanical valves shall be tagged. All existing mechanical valves that are to remain in the MERs shall be retagged in sequence with new valves.

2.8 WARNING TAGS

A. Warning Tags: Preprinted or partially preprinted, accident-prevention tags, of plasticized card stock with matte finish suitable for writing.
   1. Size: 3 by 5-1/4 inches minimum.
   2. Fasteners: Brass grommet and wire.
   3. Nomenclature: Large-size primary caption such as "DANGER," "CAUTION," or "DO NOT OPERATE."
   4. Color: Yellow background with black lettering.

PART 3 EXECUTION

3.1 PREPARATION

A. Clean piping and equipment surfaces of substances that could impair bond of identification devices, including dirt, oil, grease, release agents, and incompatible primers, paints, and encapsulants

3.2 PIPE LABEL INSTALLATION

A. Painting of Pipe: all piping that does not receive insulation shall be painted with rust inhibiting machine enamel.
   1. Clean piping in accordance with paint manufactures recommendations. Remove all grease oil and surface rust before painting.
   2. All Fuel oil piping shall be painted yellow with black labels and flow arrow.
   3. All new and existing gas piping shall be painted yellow with black labels.
   4. Label piping as per ANSI color code

B. Locate pipe labels where piping is exposed and above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:
   1. Near each valve and control device.

2. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
3. Near penetrations through walls, floors, ceilings, and inaccessible enclosures.
4. At access doors, manholes, and similar access points that permit view of concealed piping.
5. Near major equipment items and other points of origination and termination.
6. Spaced at maximum intervals of 25' along each run. Reduce intervals to 15 feet in areas of congested piping and equipment.
7. On piping above removable acoustical ceilings. Omit intermediately spaced labels.

C. Directional Flow Arrows: provide directional flow arrows spaced at maximum intervals of 25' along each run. Reduce intervals to 15 feet in areas of congested piping and equipment.

D. All Plumbing piping including above ground storm and sanitary, domestic hot and cold-water hot water recirculation, fuel oil and gas shall be labeled. Background color and service name shall be in accordance with ANSI and industry standards.

E. Lettering shall be no less than 1" on small piping and 2" on piping 3" and larger.

3.3 VALVE-TAG INSTALLATION

A. Install tags on valves and control devices in all plumbing piping systems, except check valves; valves within factory-fabricated equipment units; shutoff valves; faucets; convenience and lawn-watering hose connections; and similar roughing-in connections of end-use fixtures and units. List tagged valves in a valve schedule.

B. All new plumbing valves shall be tagged. All existing plumbing valves that are to remain in the MER shall be retagged in sequence with new valves. This includes gas fuel oil and domestic water piping systems**.**

3.4 WARNING-TAG INSTALLATION

A. Write required message on, and attach warning tags to, equipment and other items where required.

3.5 INSTALLATION

A. Install tags, markers, etc. in conformance with Division 1.

B. Unless otherwise specified, color shall conform with ANSI/ASME A13.1

C. Install identifying devices after completion of coverings and painting.

D. Install plastic nameplates with corrosive-resistant mechanical fasteners, or adhesive.

E. Install labels with sufficient adhesive to ensure permanent adhesion and seal with clear lacquer. For unfinished cloth covering, apply paint primer before applying labels.

F. Install tags using corrosion resistant chain. Number tags consecutively by location.

G. Apply stencil painting in accordance with contract requirements.

H. Identify all equipment, including pumps, air handlers, air cooled condensers, boilers, chillers, pumps, packaged AC units, and hot water heater with nameplates. Small

devices, such as in-line pumps, may be identified with metal tags. Identify service of all air handling units, ac units split and packaged units. I.E. Ground floor offices.

I. Identify control panels and major control components outside panels with nameplates.

J. Identify valves in main and branch piping with brass tags. Main shutoff valves for boilers shall be furnished with special wording as required by ASME IV HG 710.5 "Supply or Return Valve No. X - Do Not Close Without Also Closing Supply or Return Valve No. Y".

K. Tag automatic controls, instruments, and relays. Key to control schematic.

L. Identify piping, concealed or exposed, with markers. Use tags on piping 3/4 inch diameter and smaller. Identify service, flow direction, and pressure. Install in clear view and align with axis of piping. Locate identification not to exceed 20 feet on straight runs including risers and drops, adjacent to each valve and tee, at each side of penetration of structure or enclosure, and at each obstruction. Labeling shall be in conformance with OSHA and ANSI A13.1.

M. Identify all ductwork every 20’ with flow arrows and unit or air handler served as well as service, such as SUPPLY AIR, RETURN AIR, EXHAUST AIR. Etc

N. Provide permanent labels for all controls and limits which state function of each control and control set-points.

O. Provide tags for the following: new and existing and on re-piped existing equipment including but not limited to the following.
- Hot water hydronic systems
- Natural Gas
- Cold water make-up
- Steam and steam condensate

3.3 SCHEDULE

A. Provide valve chart and schedule minimum of 8.5” x 11” in aluminum frame with clear laminate face. Install in the boiler room or at location as directed by the facilities. Indicate Valve #, size, Service and N.O. or N.C.. Included with the schedule shall be a floor plan indicating each valve location. Numbered in accordance with the schedule.

VALVE TAG SCHEDULE			
No.	size	Service	N.O./N.C.

The chart shall contain all new and existing HVAC and related systems valves, new or existing. Including heating water, steam, steam condensate, and CW make up, and drain.

END OF SECTION

SECTION 230593 - TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Balancing Hydronic Piping Systems:

    a. Constant-flow hydronic systems.
    b. Primary-secondary hydronic systems.

2. Balancing steam systems.
3. Testing, Adjusting, and Balancing Equipment:
    a. Boilers.
    b. Heat-transfer coils.

1.3 DEFINITIONS

A. AABC: Associated Air Balance Council.

B. BAS: Building automation systems.

C. NEBB: National Environmental Balancing Bureau.

D. TAB: Testing, adjusting, and balancing.

E. TABB: Testing, Adjusting, and Balancing Bureau.

F. TAB Specialist: An independent entity meeting qualifications to perform TAB work.

G. TDH: Total dynamic head.

1.4 PREINSTALLATION MEETINGS

A. TAB Conference: If requested by the engineer, conduct a TAB conference at Project site after approval of the TAB strategies and procedures plan to develop a mutual understanding of the details. Provide a minimum of 14 days' advance notice of scheduled meeting time and location.

1. Minimum Agenda Items:

    a. The Contract Documents examination report.
    b. The TAB plan.

c. Needs for coordination and cooperation of trades and subcontractors.
d. Proposed procedures for documentation and communication flow.

1.5 ACTION SUBMITTALS

1.6 INFORMATIONAL SUBMITTALS

A. Qualification Data: Within 30 days of Contractor's Notice to Proceed, submit documentation that the TAB specialist and this Project's TAB team members meet the qualifications specified in "Quality Assurance" Article.

B. Contract Documents Examination Report: Within 30 days of Contractor's Notice to Proceed, submit the Contract Documents review report as specified in Part 3.

C. Certified TAB reports.

D. Sample report forms.

E. Instrument calibration reports, to include the following:

1. Instrument type and make.
2. Serial number.
3. Application.
4. Dates of use.
5. Dates of calibration.

1.7 QUALITY ASSURANCE

A. TAB Specialists Qualifications: Certified by AABC NEBB or TABB.

1. TAB Field Supervisor: Employee of the TAB specialist and certified by AABC or NEBB.
2. TAB Technician: Employee of the TAB specialist and certified by AABC or NEBB as a TAB technician.

B. Instrumentation Type, Quantity, Accuracy, and Calibration: Comply with requirements in ASHRAE 111, Section 4, "Instrumentation."

1.8 FIELD CONDITIONS

A. Full Owner Occupancy: Owner will occupy the site and existing building during entire TAB period. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.

B. Partial Owner Occupancy: Owner may occupy completed areas of building before Substantial Completion. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine the Contract Documents to become familiar with Project requirements and to discover conditions in systems designs that may preclude proper TAB of systems and equipment.

B. Examine installed systems for balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers. Verify that locations of these balancing devices are applicable for intended purpose and are accessible.

C. Examine the approved submittals for HVAC systems and equipment.

D. Examine design data including HVAC system descriptions, statements of design assumptions for environmental conditions and systems output, and statements of philosophies and assumptions about HVAC system and equipment controls.

E. Examine ceiling plenums and underfloor air plenums used for supply, return, or relief air to verify that they are properly separated from adjacent areas. Verify that penetrations in plenum walls are sealed and fire-stopped if required.

F. Examine equipment performance data including fan and pump curves.

1. Relate performance data to Project conditions and requirements, including system effects that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.
2. Calculate system-effect factors to reduce performance ratings of HVAC equipment when installed under conditions different from the conditions used to rate equipment performance. To calculate system effects for air systems, use tables and charts found in AMCA 201, "Fans and Systems," or in SMACNA's "HVAC Systems - Duct Design." Compare results with the design data and installed conditions.

G. Examine system and equipment installations and verify that field quality-control testing, cleaning, and adjusting specified in individual Sections have been performed.

H. Examine test reports specified in individual system and equipment Sections.

I. Examine HVAC equipment and verify that bearings are greased, belts are aligned and tight, filters are clean, and equipment with functioning controls is ready for operation.

J. Examine strainers. Verify that startup screens have been replaced by permanent screens with indicated perforations.

K. Examine control valves for proper installation for their intended function of throttling, diverting, or mixing fluid flows.

L. Examine heat-transfer coils for correct piping connections and for clean and straight fins.

M. Examine system pumps to ensure absence of entrained air in the suction piping.

N. Examine operating safety interlocks and controls on HVAC equipment.

O. Report deficiencies discovered before and during performance of TAB procedures. Observe and record system reactions to changes in conditions. Record default set points if different from indicated values.

3.2 PREPARATION

A. Prepare a TAB plan that includes the following:

1. Equipment and systems to be tested.
2. Strategies and step-by-step procedures for balancing the systems.
3. Instrumentation to be used.
4. Sample forms with specific identification for all equipment.

B. Perform system-readiness checks of HVAC systems and equipment to verify system readiness for TAB work. Include, at a minimum, the following:

1. Hydronics:

a. Verify leakage and pressure tests on water distribution systems have been satisfactorily completed.
b. Piping is complete with terminals installed.
c. Water treatment is complete.
d. Systems are flushed, filled, and air purged.
e. Strainers are pulled and cleaned.
f. Control valves are functioning per the sequence of operation.
g. Shutoff and balance valves have been verified to be 100 percent open.
h. Pumps are started and proper rotation is verified.
i. Pump gage connections are installed directly at pump inlet and outlet flanges or in discharge and suction pipe prior to valves or strainers.
j. Variable-frequency controllers' startup is complete and safeties are verified.
k. Suitable access to balancing devices and equipment is provided.

3.3 GENERAL PROCEDURES FOR TESTING AND BALANCING

A. Perform testing and balancing procedures on each system according to the procedures contained in AABC's "National Standards for Total System Balance" ASHRAE 111 NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems" SMACNA's "HVAC Systems - Testing, Adjusting, and Balancing" and in this Section.

B. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary for TAB procedures.
1. Install and join new insulation that matches removed materials. Restore insulation, coverings, vapor barrier, and finish according to Section 230719 "HVAC Piping Insulation."

C. Mark equipment and balancing devices, including damper-control positions, valve position indicators, fan-speed-control levers, and similar controls and devices, with paint or other suitable, permanent identification material to show final settings.

D. Take and report testing and balancing measurements in inch-pound (IP) units.

3.4 GENERAL PROCEDURES FOR BALANCING AIR ALL SYSTEMS

A. Prepare test reports for both fans and outlets. Obtain manufacturer's outlet factors and recommended testing procedures. Cross-check the summation of required outlet volumes with required fan volumes.

B. Prepare schematic diagrams of systems' "as-built" duct layouts.

C. For variable-air-volume systems, develop a plan to simulate diversity.

D. Determine the best locations in main and branch ducts for accurate duct-airflow measurements.

E. Check airflow patterns from the outdoor-air louvers and dampers and the return- and exhaust-air dampers through the supply-fan discharge and mixing dampers.

F. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.

G. Verify that motor starters are equipped with properly sized thermal protection.

H. Check dampers for proper position to achieve desired airflow path.

I. Check for airflow blockages.

J. Check condensate drains for proper connections and functioning.

K. Check for proper sealing of air-handling-unit components.

L. Verify that air duct system is sealed as specified in Section 233113 "Metal Ducts."

3.5 GENERAL PROCEDURES FOR ALL HYDRONIC SYSTEMS

A. Prepare test reports for pumps, coils, and heat exchangers. Obtain approved submittals and manufacturer-recommended testing procedures. Crosscheck the summation of required coil and heat exchanger flow rates with pump design flow rate.

B. Prepare schematic diagrams of systems' "as-built" piping layouts.

C. In addition to requirements in "Preparation" Article, prepare hydronic systems for testing and balancing as follows:

1. Check liquid level in expansion tank.
2. Check highest vent for adequate pressure.
3. Check flow-control valves for proper position.
4. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.

5. Verify that motor starters are equipped with properly sized thermal protection.
6. Check that air has been purged from the system.

D. Code requirements:

1. Individual hydronic heating and cooling coils shall be equipped with means for balancing and measuring flow. Hydronic systems shall be proportionately balanced in a manner to first minimize throttling losses, then the pump impeller shall be trimmed or pump speed shall be adjusted to meet design flow conditions. Each hydronic system shall have the capability to measure pressure across the pumps, and test ports at each side of each pump.

2. Where throttle or balance valves are used on the discharge side of pumps balancing shall be performed by adjusting pumps speed at the variable frequency drive. The balance or throttle valves shall be used for positive shut off and as a means of reading flow across the ports.

3. Flow shall be balanced to total gpm given in the schedule for the pump and branch gpm as given on plan. Total dynamic head, (TDH), given in the plans and schedule or specifications is an estimate. The system shall be balanced such that the required flow is achieved by adjusting pump speed and branch balancing valves as well as terminal unit balancing valves. Upon balancing the actual required TDH can be established. This shall be used as the design set point used to modulate pump speed.

3.6 PROCEDURES FOR CONSTANT-FLOW HYDRONIC SYSTEMS

A. Adjust pumps to deliver total design gpm.

1. Measure total water flow.

   a. Position valves for full flow through coils.
   b. Measure flow by main flow meter, if installed.
   c. If main flow meter is not installed, determine flow by pump TDH or exchanger pressure drop.

2. Measure pump TDH as follows:

   a. Measure discharge pressure directly at the pump outlet flange or in discharge pipe prior to any valves.
   b. Measure inlet pressure directly at the pump inlet flange or in suction pipe prior to any valves or strainers.
   c. Convert pressure to head and correct for differences in gage heights.
   d. Verify pump impeller size by measuring the TDH with the discharge valve closed. Note the point on manufacturer's pump curve at zero flow, and verify that the pump has the intended impeller size.
   e. With valves open, read pump TDH. Adjust pump discharge valve until design water flow is achieved.

3. Monitor motor performance during procedures and do not operate motor in an overloaded condition.

B. Adjust flow-measuring devices installed in mains and branches to design water flows.

1. Measure flow in main and branch pipes.
2. Adjust main and branch balance valves for design flow.
3. Re-measure each main and branch after all have been adjusted.

C. Adjust flow-measuring devices installed at terminals for each space to design water flows.

1. Measure flow at terminals.
2. Adjust each terminal to design flow.
3. Re-measure each terminal after it is adjusted.
4. Position control valves to bypass the coil, and adjust the bypass valve to maintain design flow.
5. Perform temperature tests after flows have been balanced.

D. For systems with pressure-independent valves at terminals:

1. Measure differential pressure and verify that it is within manufacturer's specified range.
2. Perform temperature tests after flows have been verified.

E. For systems without pressure-independent valves or flow-measuring devices at terminals:

1. Measure and balance coils by either coil pressure drop or temperature method.
2. If balanced by coil pressure drop, perform temperature tests after flows have been verified.

F. Verify final system conditions as follows:

1. Re-measure and confirm that total water flow is within design.
2. Re-measure final pumps' operating data, TDH, volts, amps, and static profile.
3. Mark final settings.

G. Verify that memory stops have been set.

3.7 PROCEDURES FOR VARIABLE-FLOW HYDRONIC SYSTEMS

A. Balance systems with automatic two- and three-way control valves by setting systems at maximum flow through heat-exchange terminals, and proceed as specified above for hydronic systems.

B. Adjust the variable-flow hydronic system as follows:

1. Verify that the differential-pressure sensor is located as indicated.
2. Determine whether there is diversity in the system.

C. For systems with no diversity:

1. Adjust pumps to deliver total design gpm.

a. Measure total water flow.

1) Position valves for full flow through coils.

2) Measure flow by main flow meter, if installed.
3) If main flow meter is not installed, determine flow by pump TDH or exchanger pressure drop.

b. Measure pump TDH as follows:

1) Measure discharge pressure directly at the pump outlet flange or in discharge pipe prior to any valves.
2) Measure inlet pressure directly at the pump inlet flange or in suction pipe prior to any valves or strainers.
3) Convert pressure to head and correct for differences in gage heights.
4) Verify pump impeller size by measuring the TDH with the discharge valve closed. Note the point on manufacturer's pump curve at zero flow and verify that the pump has the intended impeller size.
5) With valves open, read pump TDH. Adjust pump discharge valve until design water flow is achieved.

c. Monitor motor performance during procedures and do not operate motor in an overloaded condition.

2. Adjust flow-measuring devices installed in mains and branches to design water flows.

a. Measure flow in main and branch pipes.
b. Adjust main and branch balance valves for design flow.
c. Re-measure each main and branch after all have been adjusted.

3. Adjust flow-measuring devices installed at terminals for each space to design water flows.

a. Measure flow at terminals.
b. Adjust each terminal to design flow.
c. Re-measure each terminal after it is adjusted.
d. Position control valves to bypass the coil and adjust the bypass valve to maintain design flow.
e. Perform temperature tests after flows have been balanced.

4. For systems with pressure-independent valves at terminals:

a. Measure differential pressure and verify that it is within manufacturer's specified range.
b. Perform temperature tests after flows have been verified.

5. For systems without pressure-independent valves or flow-measuring devices at terminals:

a. Measure and balance coils by either coil pressure drop or temperature method.
b. If balanced by coil pressure drop, perform temperature tests after flows have been verified.

6. Prior to verifying final system conditions, determine the system differential-pressure set point.

7. If the pump discharge valve was used to set total system flow with variable-frequency controller at 60 Hz, at completion open discharge valve 100 percent and allow variable-frequency controller to control system differential-pressure set point. Record pump data under both conditions.
8. Mark final settings and verify that all memory stops have been set.
9. Verify final system conditions as follows:

    a. Re-measure and confirm that total water flow is within design.
    b. Re-measure final pumps' operating data, TDH, volts, amps, and static profile.
    c. Mark final settings.

10. Verify that memory stops have been set.

D. For systems with diversity:

1. Determine diversity factor.
2. Simulate system diversity by closing required number of control valves, as approved by the design engineer.
3. Adjust pumps to deliver total design gpm.

    a. Measure total water flow.

        1) Position valves for full flow through coils.
        2) Measure flow by main flow meter, if installed.
        3) If main flow meter is not installed, determine flow by pump TDH or exchanger pressure drop.

    b. Measure pump TDH as follows:

        1) Measure discharge pressure directly at the pump outlet flange or in discharge pipe prior to any valves.
        2) Measure inlet pressure directly at the pump inlet flange or in suction pipe prior to any valves or strainers.
        3) Convert pressure to head and correct for differences in gage heights.
        4) Verify pump impeller size by measuring the TDH with the discharge valve closed. Note the point on manufacturer's pump curve at zero flow and verify that the pump has the intended impeller size.
        5) With valves open, read pump TDH. Adjust pump discharge valve until design water flow is achieved.

    c. Monitor motor performance during procedures and do not operate motor in an overloaded condition.

4. Adjust flow-measuring devices installed in mains and branches to design water flows.

    a. Measure flow in main and branch pipes.
    b. Adjust main and branch balance valves for design flow.
    c. Re-measure each main and branch after all have been adjusted.

5. Adjust flow-measuring devices installed at terminals for each space to design water flows.

a. Measure flow at terminals.
b. Adjust each terminal to design flow.
c. Re-measure each terminal after it is adjusted.
d. Position control valves to bypass the coil, and adjust the bypass valve to maintain design flow.
e. Perform temperature tests after flows have been balanced.

6. For systems with pressure-independent valves at terminals:

a. Measure differential pressure, and verify that it is within manufacturer's specified range.
b. Perform temperature tests after flows have been verified.

7. For systems without pressure-independent valves or flow-measuring devices at terminals:

a. Measure and balance coils by either coil pressure drop or temperature method.
b. If balanced by coil pressure drop, perform temperature tests after flows have been verified.

8. Open control valves that were shut. Close a sufficient number of control valves that were previously open to maintain diversity, and balance terminals that were just opened.
9. Prior to verifying final system conditions, determine system differential-pressure set point.
10. If the pump discharge valve was used to set total system flow with variable-frequency controller at 60 Hz, at completion open discharge valve 100 percent and allow variable-frequency controller to control system differential-pressure set point. Record pump data under both conditions.
11. Mark final settings and verify that memory stops have been set.
12. Verify final system conditions as follows:

a. Re-measure and confirm that total water flow is within design.
b. Re-measure final pumps' operating data, TDH, volts, amps, and static profile.
c. Mark final settings.

13. Verify that memory stops have been set.

3.8 PROCEDURES FOR PRIMARY-SECONDARY HYDRONIC SYSTEMS

A. Balance the primary circuit flow first.

B. Balance the secondary circuits after the primary circuits are complete.

C. Adjust pumps to deliver total design gpm.

1. Measure total water flow.

a. Position valves for full flow through coils.
b. Measure flow by main flow meter, if installed.
c. If main flow meter is not installed, determine flow by pump TDH or exchanger pressure drop.

2. Measure pump TDH as follows:

    a. Measure discharge pressure directly at the pump outlet flange or in discharge pipe prior to any valves.
    b. Measure inlet pressure directly at the pump inlet flange or in suction pipe prior to any valves or strainers.
    c. Convert pressure to head and correct for differences in gage heights.
    d. Verify pump impeller size by measuring the TDH with the discharge valve closed. Note the point on manufacturer's pump curve at zero flow and verify that the pump has the intended impeller size.
    e. With valves open, read pump TDH. Adjust pump discharge valve until design water flow is achieved.

3. Monitor motor performance during procedures and do not operate motor in an overloaded condition.

D. Adjust flow-measuring devices installed in mains and branches to design water flows.

1. Measure flow in main and branch pipes.
2. Adjust main and branch balance valves for design flow.
3. Re-measure each main and branch after all have been adjusted.

E. Adjust flow-measuring devices installed at terminals for each space to design water flows.

1. Measure flow at terminals.
2. Adjust each terminal to design flow.
3. Re-measure each terminal after it is adjusted.
4. Position control valves to bypass the coil and adjust the bypass valve to maintain design flow.
5. Perform temperature tests after flows have been balanced.

F. For systems with pressure-independent valves at terminals:

1. Measure differential pressure and verify that it is within manufacturer's specified range.
2. Perform temperature tests after flows have been verified.

G. For systems without pressure-independent valves or flow-measuring devices at terminals:

1. Measure and balance coils by either coil pressure drop or temperature method.
2. If balanced by coil pressure drop, perform temperature tests after flows have been verified.

H. Verify final system conditions as follows:

1. Re-measure and confirm that total water flow is within design.
2. Re-measure final pumps' operating data, TDH, volts, amps, and static profile.
3. Mark final settings.

I. Verify that memory stops have been set.

3.9 PROCEDURES FOR STEAM SYSTEMS

A. Measure and record upstream and downstream pressure of each piece of equipment.

B. Measure and record upstream and downstream steam pressure of pressure-reducing valves.

C. Check settings and operation of automatic temperature-control valves, self-contained control valves, and pressure-reducing valves. Record final settings.

D. Check settings and operation of each safety valve. Record settings.

E. Verify the operation of each steam trap.

3.10 PROCEDURES FOR MOTORS

A. Motors 1/2 HP and Larger: Test at final balanced conditions and record the following data:

1. Manufacturer's name, model number, and serial number.
2. Motor horsepower rating.
3. Motor rpm.
4. Phase and hertz.
5. Nameplate and measured voltage, each phase.
6. Nameplate and measured amperage, each phase.
7. Starter size and thermal-protection-element rating.
8. Service factor and frame size.

B. Motors Driven by Variable-Frequency Controllers: Test manual bypass of controller to prove proper operation.

3.11 PROCEDURES FOR BOILERS

A. Hydronic Boilers:

1. Measure and record entering- and leaving-water temperatures.
2. Measure and record water flow.
3. Record relief valve pressure setting.

B. Steam Boilers:

1. Measure and record entering-water temperature.
2. Measure and record feed water flow.
3. Measure and record leaving-steam pressure and temperature.
4. Record relief valve pressure setting.

3.12 PROCEDURES FOR HEAT-TRANSFER COILS

A. Measure, adjust, and record the following data for each water coil:

1. Entering- and leaving-water temperature.

2. Water flow rate.
3. Water pressure drop for major (more than 20 gpm) equipment coils, excluding unitary equipment such as reheat coils, unit heaters, and fan-coil units.
4. Dry-bulb temperature of entering and leaving air.
5. Wet-bulb temperature of entering and leaving air for cooling coils.
6. Airflow.

B. Measure, adjust, and record the following data for each electric heating coil:

1. Nameplate data.
2. Airflow.
3. Entering- and leaving-air temperature at full load.
4. Voltage and amperage input of each phase at full load.
5. Calculated kilowatt at full load.
6. Fuse or circuit-breaker rating for overload protection.

C. Measure, adjust, and record the following data for each steam coil:

1. Dry-bulb temperature of entering and leaving air.
2. Airflow.
3. Inlet steam pressure.

D. Measure, adjust, and record the following data for each refrigerant coil:

1. Dry-bulb temperature of entering and leaving air.
2. Wet-bulb temperature of entering and leaving air.
3. Airflow.

3.13 CONTROLS VERIFICATION

A. In conjunction with system balancing, perform the following:

1. Verify temperature control system is operating within the design limitations.
2. Confirm that the sequences of operation are in compliance with Contract Documents.
3. Verify that controllers are calibrated and function as intended.
4. Verify that controller set points are as indicated.
5. Verify the operation of lockout or interlock systems.
6. Verify the operation of valve and damper actuators.
7. Verify that controlled devices are properly installed and connected to correct controller.
8. Verify that controlled devices travel freely and are in position indicated by controller: open, closed, or modulating.
9. Verify location and installation of sensors to ensure that they sense only intended temperature, humidity, or pressure.

B. Reporting: Include a summary of verifications performed, remaining deficiencies, and variations from indicated conditions.

3.14 TOLERANCES

A. Set HVAC system's airflow rates and water flow rates within the following tolerances:

1. Supply, Return, and Exhaust Fans and Equipment with Fans: Plus, or minus 10 percent.
2. Air Outlets and Inlets: Plus, or minus 10 percent.
3. Heating-Water Flow Rate: Plus, or minus 10 percent.
4. Cooling-Water Flow Rate: Plus, or minus 10 percent.

B. Maintaining pressure relationships as designed shall have priority over the tolerances specified above.

3.15 PROGRESS REPORTING

A. Initial Construction-Phase Report: Based on examination of the Contract Documents as specified in "Examination" Article, prepare a report on the adequacy of design for systems balancing devices. Recommend changes and additions to systems balancing devices to facilitate proper performance measuring and balancing. Recommend changes and additions to HVAC systems and general construction to allow access for performance measuring and balancing devices.

B. Status Reports: Prepare progress reports to describe completed procedures, procedures in progress, and scheduled procedures. Include a list of deficiencies and problems found in systems being tested and balanced. Prepare a separate report for each system and each building floor for systems serving multiple floors.

3.16 FINAL REPORT

A. General: Prepare a certified written report; tabulate and divide the report into separate sections for tested systems and balanced systems.

1. Include a certification sheet at the front of the report's binder, signed and sealed by the certified testing and balancing engineer.
2. Include a list of instruments used for procedures, along with proof of calibration.
3. Certify validity and accuracy of field data.

B. Final Report Contents: In addition to certified field-report data, include the following:

1. Pump curves.
2. Fan curves.
3. Manufacturers' test data.
4. Field test reports prepared by system and equipment installers.
5. Other information relative to equipment performance; do not include Shop Drawings and Product Data.

C. General Report Data: In addition to form titles and entries, include the following data:

1. Title page.
2. Name and address of the TAB specialist.

3. Project name.
4. Project location.
5. Architect's name and address.
6. Engineer's name and address.
7. Contractor's name and address.
8. Report date.
9. Signature of TAB supervisor who certifies the report.
10. Table of Contents with the total number of pages defined for each section of the report. Number each page in the report.
11. Summary of contents including the following:

    a. Indicated versus final performance.
    b. Notable characteristics of systems.
    c. Description of system operation sequence if it varies from the Contract Documents.

12. Nomenclature sheets for each item of equipment.
13. Data for terminal units, including manufacturer's name, type, size, and fittings.
14. Notes to explain why certain final data in the body of reports vary from indicated values.
15. Test conditions for fans and pump performance forms including the following:

    a. Settings for outdoor-, return-, and exhaust-air dampers.
    b. Conditions of filters.
    c. Cooling coil, wet- and dry-bulb conditions.
    d. Face and bypass damper settings at coils.
    e. Fan drive settings including settings and percentage of maximum pitch diameter.
    f. Inlet vane settings for variable-air-volume systems.
    g. Settings for supply-air, static-pressure controller.
    h. Other system operating conditions that affect performance.

D. System Diagrams: Include schematic layouts of air and hydronic distribution systems. Present each system with single-line diagram and include the following:

1. Quantities of outdoor, supply, return, and exhaust airflows.
2. Water and steam flow rates.
3. Duct, outlet, and inlet sizes.
4. Pipe and valve sizes and locations.
5. Terminal units.
6. Balancing stations.
7. Position of balancing devices.

E. Apparatus-Coil Test Reports:

1. Coil Data:

    a. System identification.
    b. Location.
    c. Coil type.
    d. Number of rows.
    e. Fin spacing in fins per inch o.c.
    f. Make and model number.

g. Face area in sq. ft..
h. Tube size in NPS.
i. Tube and fin materials.
j. Circuiting arrangement.

2. Test Data (Indicated and Actual Values):

a. Airflow rate in cfm.
b. Average face velocity in fpm.
c. Air pressure drop in inches wg.
d. Outdoor-air, wet- and dry-bulb temperatures in deg F.
e. Return-air, wet- and dry-bulb temperatures in deg F.
f. Entering-air, wet- and dry-bulb temperatures in deg F.
g. Leaving-air, wet- and dry-bulb temperatures in deg F.
h. Water flow rate in gpm.
i. Water pressure differential in feet of head or psig.
j. Entering-water temperature in deg F.
k. Leaving-water temperature in deg F.
l. Inlet steam pressure in psig.

F. Gas- Fired Heat Apparatus Test Reports: In addition to manufacturer's factory startup equipment reports, include the following:

1. Unit Data:

a. System identification.
b. Location.
c. Make and type.
d. Model number and unit size.
e. Manufacturer's serial number.
f. Fuel type in input data.
g. Output capacity in Btu/h.
h. Ignition type.
i. Burner-control types.
j. Motor horsepower and rpm.
k. Motor volts, phase, and hertz.
l. Motor full-load amperage and service factor.
m. Sheave make, size in inches, and bore.
n. Center-to-center dimensions of sheave and amount of adjustments in inches.

2. Test Data (Indicated and Actual Values):

a. Total airflow rate in cfm.
b. Entering-air temperature in deg F.
c. Leaving-air temperature in deg F.
d. Air temperature differential in deg F.
e. Entering-air static pressure in inches wg.
f. Leaving-air static pressure in inches wg.
g. Air static-pressure differential in inches wg.
h. Low-fire fuel input in Btu/h.
i. High-fire fuel input in Btu/h.

j. Manifold pressure in psig.
k. High-temperature-limit setting in deg F.
l. Operating set point in Btu/h.
m. Motor voltage at each connection.
n. Motor amperage for each phase.
o. Heating value of fuel in Btu/h.

G. Pump Test Reports: Calculate impeller size by plotting the shutoff head on pump curves and include the following:

1. Unit Data:

a. Unit identification.
b. Location.
c. Service.
d. Make and size.
e. Model number and serial number.
f. Water flow rate in gpm.
g. Water pressure differential in feet of head or psig.
h. Required net positive suction head in feet of head or psig.
i. Pump rpm.
j. Impeller diameter in inches.
k. Motor make and frame size.
l. Motor horsepower and rpm.
m. Voltage at each connection.
n. Amperage for each phase.
o. Full-load amperage and service factor.
p. Seal type.

2. Test Data (Indicated and Actual Values):

a. Static head in feet of head or psig.
b. Pump shutoff pressure in feet of head or psig.
c. Actual impeller size in inches.
d. Full-open flow rate in gpm.
e. Full-open pressure in feet of head or psig.
f. Final discharge pressure in feet of head or psig.
g. Final suction pressure in feet of head or psig.
h. Final total pressure in feet of head or psig.
i. Final water flow rate in gpm.
j. Voltage at each connection.
k. Amperage for each phase.

H. Instrument Calibration Reports:

1. Report Data:

a. Instrument type and make.
b. Serial number.
c. Application.
d. Dates of use.

e. Dates of calibration.

3.17 VERIFICATION OF TAB REPORT

A. The TAB specialist's test and balance engineer shall conduct the inspection in the presence of commissioning authority.

B. Commissioning authority shall randomly select measurements, documented in the final report, to be rechecked. Rechecking shall be limited to either 10 percent of the total measurements recorded or the extent of measurements that can be accomplished in a normal 8-hour business day.

C. If rechecks yield measurements that differ from the measurements documented in the final report by more than the tolerances allowed, the measurements shall be noted as "FAILED."

D. If the number of "FAILED" measurements is greater than 10 percent of the total measurements checked during the final inspection, the testing and balancing shall be considered incomplete and shall be rejected.

E. If TAB work fails, proceed as follows:

1. TAB specialists shall recheck all measurements and make adjustments. Revise the final report and balancing device settings to include all changes; resubmit the final report and request a second final inspection.
2. If the second final inspection also fails, Owner may contract the services of another TAB specialist to complete TAB work according to the Contract Documents and deduct the cost of the services from the original TAB specialist's final payment.

F. Prepare test and inspection reports.

3.18 ADDITIONAL TESTS

A. Within 90 days of completing TAB, perform additional TAB to verify that balanced conditions are being maintained throughout and to correct unusual conditions.

B. Seasonal Periods: If initial TAB procedures were not performed during near-peak summer and winter conditions, perform additional TAB during near-peak summer and winter conditions.

END OF SECTION 230593

SECTION 23 07 19 HVAC PIPING INSULATION

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Piping insulation
B. Jackets and accessories

1.02 RELATED SECTIONS

A. Section 23 05 53 – Identification for HVAC Piping and Equipment.
B. Section 23 21 13 - Hydronic Piping.

1.03 REFERENCES

A. ASTM C177 - Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded Hot Plate Apparatus

B. ASTM C195 - Standard Specification for Mineral Fiber Thermal Insulating Cement.

C. ASTM C449/C449M - Standard Specification for Mineral Fiber Hydraulic-Setting Thermal Insulating and Finishing Cement

D. ASTM C518 - Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus

E. ASTM C533 - Standard Specification for Calcium Silicate Block and Pipe Thermal Insulation.

F. ASTM C547 - Standard Specification for Mineral Fiber Preformed Pipe Insulation

G. ASTM C552 - Standard Specification for Cellular Glass Thermal Insulation.

H. ASTM C578 - Standard Specification for Preformed, Cellular Polystyrene Thermal Insulation

I. ASTM C610 - Standard Specification for Expanded Perlite Block and Pipe Thermal Insulation

J. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials

K. NAIMA National Insulation Standards

L. NFPA 255 - Standard Method of Test of Surface Burning Characteristics of Building Materials

M. UL 723 - Standard for Test for Surface Burning Characteristics of Building Materials.

N. ASHRAE 90-75 - Insulation Standards

1.04 SUBMITTALS FOR REVIEW

A. Division 1 – Submittal Requirements.

B. Product Data: Provide product description, thermal characteristics, list of materials and thickness for each service, and locations.

C. Manufacturer's Instructions: Indicate installation procedures that ensure acceptable workmanship and installation standards will be achieved.

1.05 QUALITY ASSURANCE

A. Manufacturer Qualifications: Company specializing in manufacturing the Products specified in this section with minimum three years' experience.

1.06 REGULATORY REQUIREMENTS

A. Conform to maximum flame spread/smoke developed rating of 25/50 in accordance with NFPA 255

B. Insulation thickness shall comply with applicable Energy Conservation Codes.

PART 2 PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Pittsburgh Corning Corporation

B. CertainTeed Corporation.

C. Armstrong Corporation.

D. Manville Industrial Products.

E. Owens-Corning Fiberglass Corporation

F. Polyguard

2.02 INSULATION

A. Type A: Molded glass fiber insulation; ANSI/ASTM C547; 'k' value of 0.23 at 75º F; noncombustible. Minimum density of 3.5 lbs./cu. Ft.; temperature range 35º F to 450º F.

B. Type B: Cellular glass insulation; ASTM C552; 'K' Value of 0.53 at 75°F; non-combustible. Minimum density of 8.0 lbs./cu. ft. similar to Pittsburgh Corning Foamglass.

C. Type C: Elastomeric insulation; ASTM C518, C177; 'K' Value of 0.27 at 75°F; non-combustible. Similar to Armstrong "AP Armaflex"; temperature range -40º F to 220º F

D. Type D; Underground engineered pipe insulation system shall be as follows;
Service pipe insulation shall be spray applied .16k-factor, R141B blowing agent, nominal 2 pound per cubic foot density, polyurethane foam for straight sections and preformed polyurethane foam for all fittings. Insulation shall not be less then 2" and shall be Perma-pipe polytherm.

2.03 JACKETS

A. Interior Applications:

1. Insulation Type A - Factory applied, white, flame retardant, all service (ASJ) vapor barrier jacket of .001" aluminum foil laminated to Kraft paper with a flame retardant snuffer type adhesive reinforced with glass fibers and having a self-sealing lap. Provide 2" longitudinal lap and 4" circumferential sealing strips. Permeability .02 perm.

B. Exterior Applications:

1. Insulation Type A thickness as scheduled with ASJ vapor barrier jacket - Cover factory interior jacket with Alumaguard Cool Wrap by Polyguard, rubberized bitumen membrane designed specifically to be installed over insulation on exterior piping, tanks, vessels, and equipment. The membrane shall be 'peel and stick', self-healing if punctured, UV stable, and will expand and contract with the mechanical system. All seams shall be sealed watertight. Permeability .0053 perm

C. Piping exposed in Mechanical Rooms or any space:

1. All exposed piping and fittings shall be completely covered with white Zeston 2000 PVC insulated piping and fitting covers. Apply as per manufacturer with perma weld adhesive.

D. Underground applications: (not used)

All straight sections of the insulated piping system shall be filament wound, polyester resin/fiberglass reinforcement composite directly applied on the insulating foam. The jacket shall be either filament wind fiberglass directly onto the polyurethane foam or injected foam into a fiberglass outer casing.
Fiberglass outer casing shall be A.O. Smith Red Thread or Ameron Bondstrand 3000. Thermoplastic casing material that are not rated for temperatures above 140 degrees F will not be allowed, e.g., PVC or HDPE. The minimum thickness for FRP jacket shall be as 0.55”

2.04 ACCESSORIES

A. Insulation Bands: ¾" wide; 0.007 inch thick aluminum.

B. Metal Jacket Bands: 3/8" wide; 0.015 inch thick aluminum.

C. Insulating Cement: ANSI/ASTM C195; hydraulic setting mineral wool.

D. Finishing Cement: ASTM C449

E. Fibrous Glass Cloth: Untreated; 9 oz/sq. yd weight.

F. Adhesives: Compatible with insulation and fire retardant.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify that piping has been tested before applying insulation materials.

B. Verify that surfaces are clean and dry, with all foreign material removed. This includes but is not limited to water, oil, dirt, scale and rust.

D. Only insulation and finish materials including adhesive cements and mastic which conform to the requirements of all-governing codes and ordinances shall be used.

3.02 INSTALLATION

A. Division 1 – Quality Control: Install materials in accordance with manufacturer's instructions and the best practice of the trade.

B. Install in accordance with NAIMA National Insulation Standards.

C. Insulation on all piping shall be vapor sealed. On insulated piping with vapor barrier, insulate all fittings, valves, unions, flanges, strainers, flexible connections, and expansion joints. Vapor seal all exposed edges with jacket material and vapor barrier type adhesive.

D. Repair or replace any existing insulation and surface finish disturbed or damaged by installation of new work using materials to match existing.

E. Apply insulation to completely cover metal surface. Surface shall be applied to present a tight, smooth appearance.

F. Exposed Piping: Locate insulation and cover seams in least visible locations.

G. For hot piping conveying fluids 140 degrees F or less, and on insulated piping without vapor barrier, do not insulate flanges and unions at equipment, but bevel and seal ends of insulation.

H. For hot piping conveying fluids over 140 degrees F, insulate flanges and unions at equipment.

I. Neatly finish insulation at supports, protrusions, and interruptions.

J. Do not use staples on vapor barrier insulation.

K. Jackets:

1. Indoor, Concealed Applications: Insulated pipes conveying fluids above ambient temperature shall have standard jackets, with vapor barrier, factory-applied or field-applied. Insulate fittings, joints, and valves with insulation of like material and

thickness as adjoining pipe, and finish with glass cloth and adhesive. PVC jackets may be used

2. Indoor, Concealed Applications: Insulated dual-temperature pipes or pipes conveying fluids below ambient temperature shall have vapor barrier jackets, factory-applied. Insulate fittings, joints, and valves with molded insulation of like material and thickness as adjacent pipe, and finish with glass cloth and vapor barrier adhesive.
3. Indoor, Exposed Applications: For pipe exposed in mechanical equipment rooms or in finished spaces, insulate and jacket as for concealed applications, and finish with PVC jackets.
4. Cover factory interior jacket with Alumaguard Cool Wrap by Polyguard, rubberized bitumen membrane designed specifically to be installed over insulation on exterior piping, tanks, vessels, and equipment. The membrane shall be 'peel and stick', self-healing if punctured, UV stable, and will expand and contract with the mechanical system. All seams shall be sealed watertight. Permeability .0053 perm

L. Inserts and Shields:

1. Application: All insulated Piping 2 inches diameter or larger shall be installed with inserts and shields as follows.
2. Shields: Galvanized steel between pipe hangers or pipe hanger rolls and inserts.
3. Insert location: Between support shield and piping and under the finish jacket.
4. Insert configuration: Minimum 6 inches long, of same thickness and contour as adjoining insulation; may be factory fabricated.
5. Insert material: Hydrous calcium silicate insulation or other heavy density insulating material suitable for the planned temperature range.

M. Continue insulation through walls, sleeves, pipe hangers, and other pipe penetrations. Finish at supports, protrusions, and interruptions.

N Underground applications:
The internal pipe shall be hydrostatically tested to 150 psig or 1½ times the operating pressure, whichever is greater. Insulation shall then be poured in place into the field weld area. All field applied insulation shall be placed only in straight sections. Field insulation of fittings shall not be acceptable. The mold for the polyurethane shall be made of clear adhesive backed polyester film. The installer shall seal the field joint area with a heat shrinkable adhesive backed wrap or with wrappings of glass reinforcement fully saturated with a catalyzed resin identical in properties to the factory-applied resin. Backfilling shall not begin until the heat shrink wrap has cooled or until the FRP lay-up has cured. All insulation and coating materials for making the field joint shall be furnished by the piping system manufacture

3.3 PENETRATIONS

A. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions.

1. Comply with requirements in Division 7 Section "Through-Penetration Firestop Systems" for firestopping and fire-resistive joint sealers.

B. Insulation Installation at Floor Penetrations:

1. Pipe: Install insulation continuously through floor penetrations.
2. Seal penetrations through fire-rated assemblies. Comply with requirements in Division 7 Section "Through-Penetration Firestop Systems."

3.4 GENERAL PIPE INSULATION INSTALLATION

A. Requirements in this article generally apply to all insulation materials except where more specific requirements are specified in various pipe insulation material installation articles.

B. Insulation Installation on Fittings, Valves, Strainers, Flanges, and Unions:

1. Install insulation over fittings, valves, strainers, flanges, unions, and other specialties with continuous thermal and vapor-retarder integrity unless otherwise indicated.
2. Insulate pipe elbows using preformed fitting insulation or mitered fittings made from same material and density as adjacent pipe insulation. Each piece shall be butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.
3. Insulate tee fittings with preformed fitting insulation or sectional pipe insulation of same material and thickness as used for adjacent pipe. Cut sectional pipe insulation to fit. Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.
4. Insulate valves using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.
5. Insulate strainers using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Fill joints, seams, and irregular surfaces with insulating cement. Insulate strainers so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removable reusable insulation cover. For below-ambient services, provide a design that maintains vapor barrier.
6. Insulate flanges and unions using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker.
7. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below-ambient services and a breather mastic for above-ambient services. Reinforce the mastic with fabric-reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.
8. For services not specified to receive a field-applied jacket except for flexible elastomeric and polyolefin, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing using PVC tape.

9. Stencil or label the outside insulation jacket of each union with the word "union." Match size and color of pipe labels.

C. Insulate instrument connections for thermometers, pressure gages, pressure temperature taps, test connections, flow meters, sensors, switches, and transmitters on insulated pipes. Shape insulation at these connections by tapering it to and around the connection with insulating cement and finish with finishing cement, mastic, and flashing sealant.

D. Install removable insulation covers at locations indicated. Installation shall conform to the following:

1. Make removable flange and union insulation from sectional pipe insulation of same thickness as that on adjoining pipe. Install same insulation jacket as adjoining pipe insulation.
2. When flange and union covers are made from sectional pipe insulation, extend insulation from flanges or union long at least two times the insulation thickness over adjacent pipe insulation on each side of flange or union. Secure flange cover in place with stainless-steel or aluminum bands. Select band material compatible with insulation and jacket.
3. Construct removable valve insulation covers in same manner as for flanges, except divide the two-part section on the vertical center line of valve body.
4. When covers are made from block insulation, make two halves, each consisting of mitered blocks wired to stainless-steel fabric. Secure this wire frame, with its attached insulation, to flanges with tie wire. Extend insulation at least 2 inches (50 mm) over adjacent pipe insulation on each side of valve. Fill space between flange or union cover and pipe insulation with insulating cement. Finish cover assembly with insulating cement applied in two coats. After first coat is dry, apply and trowel second coat to a smooth finish.

3.05 INSULATION SCHEDULE

Refer to the insulation schedule below for pipe insulation thickness by system. Not all systems are necessarily included in this project

INSULATION SCHEDULE							
SERVICE	INSULATION	TEMPERATURE	NOMINAL PIPE SIZE				
	TYPE	RANGE (F°)	<1"	1" to< 1 1/2"	1 1/2" to< 4"	4" to< 8"	≥ 8"
			INSULATION THICKNESS				
Hot Water (HW)	A	> 350°	4 1/2	5	5	5	5
		251°-350°	3	4	4	4 1/2	4 1/2
		201°-250°	2 1/2	2 1/2	2 1/2	3	3
		141°-200°	1 1/2	1 1/2	2	2	2
		105°-140°	1	1	1 1/2	1 1/2	1 1/2
Buried (HW)	C	> 350°	4 1/2	5	5	5	5
		251°-350°	3	4	4	4 1/2	4 1/2
		201°-250°	2 1/2	2 1/2	2 1/2	3	3
		141°-200°	2	2	2 1/2	2 1/2	2 1/2
		105°-140°	1 1/2	1 1/2	2	2	2
Chilled Water (CHW)	A	40°- 60°	1/2	1/2	1	1	1
		< 40°	1/2	1	1	1	1
Buried (CHW)	C	40°- 60°	1	1 1/2	1 1/2	1 1/2	1 1/2
		< 40°	1	1 1/2	1 1/2	1 1/2	1 1/2
Steam & Condensate	A	Low Pressure	2 1/2	2 1/2	2 1/2	3	3
Steam Condensate	A	Low Pressure	2 1/2	2 1/2	2 1/2	3	3
Condensate Drains	A	All	1/2	1/2	1	1	1
Cold Water Make up	A	All	1/2	1/2	1	1	1
Refrigerant Hot Gas	C	All	1 1/2	1 1/2	2	2	2
Humidifier Steam	A	All	2 1/2	2 1/2	2 1/2	3	3
Refrigerant Suction	C	All	1/2	1/2	1	1	1

END OF SECTION

SECTION 230800 COMMISSIONING OF HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes commissioning process requirements for HVAC&R systems, assemblies, and equipment.

B. Related Sections:

1. Division 22, 23 and 26 Plans and specifications

1.3 DELEGATED DESIGN

1. DELEGATED-DESIGN SUBMITTAL: All mechanical systems installed under this project are to comply with performance requirements and design criteria outlined in the contract documents.
2. The contractor's responsible as a delegated design to perform all commissioning of systems as required by the NY State Energy Conservation Code. The contractor shall provide the service of a third-party commissioning agent (CA) to perform the commissioning scope of work as outlined in this specification.

1.4 SYSTEMS TO BE COMMISSIONED

A. The following Mechanical systems will be commissioned on this project:

1. Mechanical Systems
   a. Boilers (Hot Water and Steam)
   b. Boiler Primary Pumps
   c. Condensate pumps and boiler feed pumps
   d. Hot Water Secondary Pumps
   e. Heat exchanger
   f. DDC Controls
   g. Combustion Air Fan and Heater
   h. All Valves and Dampers

2. Spot checking of air balancing readings including total building space pressurization.
3. All Direct Digital Controls (DDC) shall be verified for proper operation as it relates to the above equipment including interfaces for remote monitoring.
4. Fire Alarm System: Verification of the fire alarm system as it interfaces with the HVAC system such as duct smoke detectors and fire/smoke dampers shall be verified.

1.5 SUBMITTALS

A. The CA will provide the trade contractor with a specific request for the type of submittal documentation required to facilitate the commissioning work. These requests shall be integrated into the normal submittal process and protocol of the construction team. At minimum, the request will include the manufacturer and model number, the manufacturer's printed installation and detailed start-up procedures, full sequences of operation, O&M data, performance data, any performance test procedures, control drawings and details of owner contracted tests. In addition, the installation and checkout materials that are actually shipped inside the equipment and the actual field checkout sheet forms to be used by the factory or field technicians shall be submitted to the Commissioning authority. All documentation requested by the CA will be included by the Trades in their O&M manual contributions.

B. Submit to the Engineer of record for review and approval submittals related to the commissioned equipment for conformance to the Contract Documents. Including the commissioning process, the functional performance of the equipment and adequacy for developing test procedures. This review is intended primarily to aid in the development of functional testing procedures and only secondarily to verify compliance with equipment specifications.

C. The Engineer of record may request additional design narrative from the CC, depending on the completeness of the design intent documentation and sequences provided with the Specifications.

D. These submittals do not constitute compliance for O&M manual documentation. The O&M manuals are the responsibility of the Contractor.

1.6 DOCUMENTATION REQUIREMENTS

A. Operations and Maintenance Manuals:

1. CA Review and Approval: Prior to substantial completion, the CA shall review the O&M manuals, documentation and redline as-builts for commissioned systems to verify compliance with the Specifications and field conditions. The O&M will not be accepted until all corrections are made. The CA also reviews each equipment warranty and verifies that all requirements to keep the warranty valid are clearly stated. This work does not supersede the Engineer's review of the O&M manuals.
2. The specific content and format requirements for the O&M manuals are detailed in Division 1 and shall include the following.
    a. Submittal data stating equipment size and selected options for each piece of equipment requiring maintenance.
    b. Manufacturer' s operation manuals and maintenance manuals for each piece of equipment. Required periodic maintenance, for each piece of equipment.
    c. Name and address of at least one service agency.
    d. HVAC and service hot water controls system maintenance and calibration information, including wiring diagrams, schematics and control sequence descriptions. Setpoints set points shall be permanently recorded on control drawings at control devices or, for digital controls systems and system programming instructions.

B. Documentation Of Commissioning Process:

1. The CA is responsible to compile, and organize the following commissioning data, by system, into indexed PDF Document. The Commissioning Record shall include & main sections:

   a. Commissioning Plan

   b. Preliminary Commissioning Report

   c. Final Commissioning Report

   d. Systems and Energy Management Manual

   e. Commissioning Testing Record

   f. Training Record

   g. Issues and Deficiencies Record

2. Commissioning Plan which shall include the following.
   a. A narrative description of the activities that will be accomplished during each phase of commissioning, including the personnel intended to accomplish each of the activities.
   b. A listing of the specific equipment, appliances or systems to be tested and a description of the tests to be performed.
   c. Functions to be tested including, but not limited to, calibrations and economizer controls.
   d. Conditions under which the test will be performed. Testing shall affirm winter and summer design conditions and full outside air conditions.
   e. Measurable criteria for performance.

3. A preliminary commissioning report of commissioning test procedures and results shall be completed and certified by the commissioning agent and provided to the building owner· and engineer of record. The report shall be organized with mechanical and service hot water findings in separate sections from building HVAC to allow independent review. The report shall be identified as "Preliminary Commissioning Report" and shall identify:

   a. Itemization of deficiencies found during testing required by this section that have not been corrected at the time of report preparation.
   b. Deferred tests that cannot be performed at the time of report preparation because of climatic conditions.
   c. Climatic conditions required for performance of the deferred tests.

4. Final Commissioning Report; A report of test procedures and results identified as "Final Commissioning Report" shall be delivered to the building owner and Engineer of record. The report shall be organized with mechanical systems and service hot water system findings in separate sections to allow independent review. The report shall include the following:

   a. Executive summary

   b. List of participants and roles

   c. Brief system description

d. Overview of commissioning and testing scope
e. General description of testing and verification methods.
f. Assessment of the adequacy of each system in the following areas:
    1) Meeting the equipment specifications
    2) Installation in accordance with design documents
    3) Functional performance and efficiency
    4) Meeting design intent
    5) Documentation and O&M manual content
    6) Operator training
g. Results of functional performance tests.
h. Disposition of deficiencies found during testing, including details of corrective measures used or proposed.
i. Functional performance test procedures used during the commissioning process including measurable criteria for test acceptance, provided herein for repeatability.
j. Exception: Deferred tests that cannot be performed at the time of report preparation due to climatic conditions.

5. The Commissioning Testing Record shall include:
    a. Completed Pre-functional checklists and system startup forms
    b. Completed functional performance testing forms for each system
6. The Training Record shall include:
    a. Overall Training Plan
    b. Written training plans
    c. Attendance records
    d. Video training record (if required).
7. The Issues and Deficiencies Record shall include:
    a. Open Items Listing
    b. Closed Items Listing

1.7 COMMISSIONING RESPONSIBILITIES

A. The responsibilities of various parties in the commissioning process are provided in this section.

B. Engineer – review and comment on documents submitted for review under section 1.8 Documentation of Commissioning process.

C. Trade Contractors Responsibilities
1. Construction and Acceptance Phase:
    a. Include and itemize cost of commissioning in contract price.
    b. submittal data, commissioning documentation, O&M data and training.
    c. Attend commissioning meetings necessary to facilitate commissioning process.
    d. Provide CA with normal cut sheets and shop drawing submittals of commissioned equipment.

e. Provide documentation to CA for development start-up and functional testing procedures. This data request may be made prior to normal submittals.

f. Assist in clarifying operation and control of commissioned equipment in areas where the specifications, control drawings or equipment documentation is not sufficient for writing detailed testing procedures.

g. Provide assistance to the CA in preparing the specific functional performance test procedures. Review test procedures to ensure feasibility, safety and equipment protection and provide necessary written alarm limits to be used during the tests.

h. Develop full start-up and initial checkout plan using manufacturer's start-up procedures and pre-functional checklists from CA for commissioned equipment. Submit to CA for review and approval prior to startup.

i. Perform and document pre-functional checks, startup, and initial checkout for commissioned equipment. Provide a copy of all checklists and startup forms to the CA.

j. Address punch list items before functional testing.

k. Verify that air and water testing and balancing is complete and that the discrepancies and problems have been addressed before performing functional testing of respective systems.

l. Provide skilled technicians to execute starting of equipment and functional performance tests. Ensure that they are available and present during the agreed upon schedules and for sufficient duration to complete the necessary tests, adjustments and problem solving.

m. Correct issues and deficiencies and retest equipment.

n. Prepare O&M manuals in accordance with the specifications and this section. Including clarifying and updating original sequences of operation to as-built conditions.

o. During construction, maintain as-built drawings. Update and submit after completion of commissioning.

p. Provide training of Owner's operating staff using qualified personnel familiar with the project.

q. Coordinate with equipment manufacturers to determine specific requirements to maintain warranty.

PART 2 - PRODUCTS – NOT USED

A. Provide test equipment necessary to fulfill testing requirements of Division 23, Mechanical.

B. Refer to Section 019113 and other Division 23 Sections for additional Division 23, Mechanical requirements.

PART 3 - EXECUTION

3.1 PREFUNCTIONAL CHECKLISTS AND STARTUP

A. Pre-functional tests and checklists (PFT's) are important to ensure that the equipment and systems are connected properly and are operational. PFT's ensure that functional performance testing may proceed without unnecessary delays. The Contractor shall be responsible for performing Pre-functional testing. EVERY piece of equipment to be commissioned receives a full Pre-functional checkout.

B. Division 23, Mechanical, has start-up responsibility and is required to complete systems and sub-systems so they are fully functional, meeting design objectives of Contract Documents. Commissioning procedures and functional testing do not relieve or lessen this responsibility or shift that responsibility partially to CA or Owner.

3.2 FUNCTIONAL PERFORMANCE TESTS

A. Functional testing is intended to begin upon completion of a system. Functional testing may proceed prior to completion of systems or sub-systems at discretion of CA and CM. Beginning system testing before full completion does not relieve Contractor from fully completing system as soon as possible, including pre-functional checklists.

B. Functional performance testing requirements are in addition to and do not replace any testing required by Code or listed elsewhere in Division 23.

C. Functional performance testing procedures will be performed on but not be limited to the following system types and equipment. Final functional testing requirements and procedures will be developed based on approved equipment shop drawings.

1. Steam Boiler Plants
    a. Equipment:
        1) Boiler/Burners
        2) Combustion air fans
        3) Condensate receiver tanks and pumps
        4) Boiler feed tank and pumps
        5) Draft fan and controls
        6) Heat exchanger and controls
        7) Building hot water pumps
2. Hot water Boiler Plant
    a. Equipment:
        1) Boilers and burners
        2) Primary pumps
        3) Secondary Pumps
        4) All boiler/burner safeties
3. Building Management System
    a. Equipment:

1) All safeties, alarms and controls
2) Operator workstations
3) File server(s)
4) Verification of controls front end including graphics

3.3 ISSUES AND DEFICIENCIES

1. All issues and deficiencies shall be noted in the Issues and Deficiencies Log by the CA.
2. The CA shall work with the Trade contractors to correct deficiencies identified during functional testing. It is the contractor's responsibility to solve, correct and retest problems.
3. The CA shall make reasonable efforts to expedite the testing process and minimize unnecessary delays, while not compromising the integrity of the procedures.
4. As tests progress and a deficiency is identified, the CA discusses the issue with the contractor.

3.4 TRAINING OF OWNER PERSONNEL

A. Contractor shall be responsible for training coordination and scheduling and ultimately to ensure that training is completed. Training shall include boiler plants all associated equipment and the BMS system and all controls. It shall also include starting stopping, set point adjustment and alarms. Allow (1) 8 hour session and two more (4) four-hour sessions spread out over the first year of service.

END OF SECTION 230800

SECTION 23 09 01 – DIRECT DIGITAL CONTROL EQUIPMENT

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. The work of this Section consists of providing of all materials, labor and equipment and the like necessary and/or required for the complete execution of all mechanical for this project, as required by the contract documents.

1.2 QUALIFICATIONS OF BIDDER

A. All bidders all control systems must have the minimum qualifications listed below in order to be considered for review of products or services
   1. Building automation contractors in the business of installing direct digital control building automation systems for a minimum of 10 years.
   2. Building automation contractors must have a service and installation office in the Westchester/Rockland area.
   3. Building automation contractors must be authorized distributors or branch offices of the manufacturers specified.
   4. Building automation contractors must have a trained staff of application engineers, who have been certified by the manufacturer in the configuration, programming and service of the automation system.

B. Manufacturers: Subject to review and approval by the Engineer and compliance with the contract documents, provide products by the following manufacture as per county standard:
   1. Schneider Electric, EcoStruxure Building Operation Controls

1.3 SCOPE OF WORK

A. Except as otherwise noted, the control system shall consist of all Ethernet Network Controllers, Standalone Digital Control Units, software, sensors, transducers, relays, valves, dampers, valve and damper operators, control panels, and other accessory equipment, along with a complete system of electrical interlocking wiring to fill the intent of the specification and provide for a complete and operable system. Unless otherwise specified, provide operators for equipment such as dampers and valves if the equipment manufacturer does not provide these. Coordinate requirements with the mechanical contractors.

B. The Building Automation System (BAS) contractor shall review and study all contract documents, drawings and the entire specification to familiarize himself with the equipment and system operation, and to verify the quantities and types of dampers, operators, alarms, controllers etc. to be provided. ALL NEW TEMPERATURE CONTROLS EQUIPMENT SHALL BE SCHNEIDER ELECTRIC ECOSTRUXURE BUILDING OPERATION.

C. All interlocking, wiring and installation of control devices associated with the equipment listed below shall be provided under this Contract. When the BAS system is fully installed and operational, the BAS Contractor and representatives of the Owner will review and check out the

system. At that time, the BAS contractor shall demonstrate the operation of the system and prove that it complies with the intent of the drawings and specifications.

D. The Contractor shall furnish and install a complete building automation system including all necessary hardware, network wiring, all operating applications software, and all programming necessary to perform the control sequences of operation as called for in the specifications. The scope of work shall include control over, and graphic representation all new mechanical, and plumbing equipment as well specific electrical equipment listed that are installed as part of this project.

E. At a minimum, provide controls for the following:
1. New steam boilers
2. New hot water boilers
3. Combustion fans
4. Duct heaters
5. Primary hot water pumps
6. Secondary hot water pumps
7. Motorized dampers
8. Motorized valves
9. Heat exchanger
10. Combustion air fan
11. Induced draft fan
12. Heat exchanger control valves
13. Zone heating valves

F. At a minimum, provide status monitoring of the following equipment:
1. Low water cut off
2. Boiler general fault/failure
3. Pump fault/failure
4. Condensate and boiler feed pump failure

G. Provide services and manpower necessary for commissioning of systems in coordination with the HVAC Contractor, Balancing Contractor and Owner's representative.

H. All work performed under this section of the specifications will comply with all codes, laws and governing bodies. If this specification and associated drawings exceed governing code requirements, the specification will govern. The Contractor shall obtain and pay for all necessary construction permits and licenses.

I. Provide all labor and materials to perform all programming necessary at the owner's new operator workstation to be located in the Operating Engineer's office located in the lower level of the Glenview building. GRAPHICALLY REPRESENT, (status) AND/OR CONTROL EACH AND EVERY PIECE OF EQUIPMENT IN THE LISTS ABOVE NEW AND EXISTING, ALL INPUT AND PUT STATUS POINTS, AND FUNCTIONAL POINTS. THIS SHALL INCLUDE BUT IS NOT LIMITED TO ALL EQUIPMENT LISTED IN SECTION E and F ABOVE.

1.4 SYSTEM DESCRIPTION

A. In accordance with the scope of work, the system shall also provide a graphical, web-based, operator interface that allows for instant access to any system through a standard browser. The contractor must provide PC-based programming workstations, operator workstations and

microcomputer controllers of modular design providing distributed processing capability and allowing future expansion of both input/output points and processing/control functions.

B. For this project, the system shall consist of the following components:
   1. Administration and Programming Workstation(s): The BAS Contractor shall furnish (2) Administration and Programming Workstation Computers as described in Part 2 of the specification. These workstations must be running the standard workstation software developed and tested by the manufacturer of the network server controllers and the standalone controllers. No third-party front-end workstation software will be acceptable. Workstations must conform to the B-OWS BACnet device profile.
   2. Web-Based Operator Workstations: The BAS Contractor shall furnish licenses for web connection to the BAS system. Web-based users shall have access to all system points and graphics, shall be able to receive and acknowledge alarms, and shall be able to control setpoints and other parameters. All engineering work, such as trends, reports, graphics, etc. that are accomplished from the WorkStation shall be available for viewing through the web browser interface without additional changes. The web-based interface must conform to the B-OWS BACnet device profile. There will be no need for any additional computer based hardware to support the web-based user interface.
   3. Ethernet-based Network Router and/or Network Server Controller(s): The BAS Contractor shall furnish (qty) Ethernet-based Network Server Controllers as described in Part 2 of the specification. These controllers will connect directly to the Operator Workstation over Ethernet at a minimum of 100 mbps and provide communication to the Standalone Digital Control Units and/or other Input/Output Modules. Network Server Controllers shall conform to BACnet device profile B-BC. Network controllers that utilize RS232 serial communications or ARCNET to communicate with the workstations will not be accepted.
   4. Network Controllers shall be tested and certified by the BACnet Testing Laboratory (BTL) as Network Server Controllers (B-BC).
   5. Standalone Digital Control Units (SDCUs): Provide the necessary quantity and types of SDCUs to meet the requirements of the project for mechanical equipment control including air handlers, central plant control, and terminal unit control. Each SDCU will operate completely standalone, containing all of the I/O and programs to control its associated equipment. Each BACnet protocol SDCU shall conform to the BACnet device profile B-AAC.
   6. BACnet SDCUs shall be tested and certified by the BACnet Testing Laboratory (BTL) as Advanced Application Controllers (B-AAC).

C. The Local Area Network (LAN) shall be either a 10 or 100 Mpbs Ethernet network supporting BACnet, Modbus, Java, XML, HTTP, and CORBA IIOP for maximum flexibility for integration of building data with enterprise information systems and providing support for multiple Network Server Controllers (NSCs), user workstations and a local host computer system.

D. The Enterprise Ethernet (IEEE 802.3) LAN shall utilize Carrier Sense Multiple/Access/Collision Detect (CSMA/CD), Address Resolution Protocol (ARP) and User Datagram Protocol (UDP) operating at 10 or 100 Mbps.

E. The system shall enable an open architecture that utilizes EIA standard 709.1, the LonTalk™ protocol and/or ANSI / ASHRAE™ Standard 135-2007, BACnet functionality to assure interoperability between all system components. Native support for the LonTalk™ protocol and the ANSI / ASHRAE™ Standard 135-2007, BACnet protocol are required to assure that the project is fully supported by the HVAC open protocols to reduce future building maintenance, upgrade, and expansion costs.

F. The system shall enable an architecture that utilizes a MS/TP selectable 9.6-76.8 KBaud protocol, as the common communication protocol between all controllers and integral ANSI / ASHRAE™ Standard 135-2008, BACnet functionality to assure interoperability between all system components. The AAC shall be capable of communicating as a MS/TP device or as a BACnet IP device communicating at 10/100 Mbps on a TCP/IP trunk. The ANSI / ASHRAE™ Standard 135-2008, BACnet protocol is required to assure that the project is fully supported by the leading HVAC open protocol to reduce future building maintenance, upgrade, and expansion costs.

G. The software tools required for network management of the protocol and the ANSI / ASHRAE™ Standard 135-2008, BACnet protocol must be provided with the system. Drawings are diagrammatic only. Equipment and labor not specifically referred to herein or on the plans and are required to meet the functional intent, shall be provided without additional cost to the Owner. Minimum BACnet compliance is Level 4; with the ability to support data read and write functionality. Physical connection of BACnet devices shall be via Ethernet IP or MS/TP. Physical connection of LonWorks devices shall be via Ethernet IP or FTT-10A.

H. If project is a retrofit enterprise overlay of an existing TAC Vista system, there shall be no need to re-commission any of the devices to get the system up and running.

I. If project is a retrofit enterprise overlay of an existing TAC I/NET (proprietary) HVAC system, it shall be capable of interfacing with the legacy I/NET without use of the I/NET host tool.

J. The system shall support Modbus TCP and RTU protocols natively, and not require the use of gateways.

K. The field bus shall support the use of wireless communications.

L. Complete temperature control system to be DDC with electronic sensors and electronic/electric actuation of Mechanical Equipment Room (MER) valves and dampers and electronic actuation of terminal equipment valves and actuators as specified herein. The BMS is intended to seamlessly connect devices throughout the building regardless of subsystem type, i.e. variable frequency drives, low voltage lighting systems, electrical circuit breakers, power metering and card access should easily coexist on the same network channel.
   1. The supplied system must incorporate the ability to access all data using HTML5 enabled browsers without requiring proprietary operator interface and configuration programs.
   2. Data shall reside on a supplier-installed server for all database access.
   3. A hierarchical topology is required to assure reasonable system response times and to manage the flow and sharing of data without unduly burdening the customer’s internal Intranet network.

M. All work described in this section shall be installed, wired, circuit tested and calibrated by factory certified technicians qualified for this work and in the regular employment of the approved manufacturer's local field office. The approved manufacturer's local field office shall have a minimum of 3 years of installation experience with the manufacturer and shall provide documentation in the bid and submittal package verifying longevity of the installing company's relationship with the manufacturer when requested. Supervision, hardware and software

engineering, calibration and checkout of the system shall be by the employees of the approved manufacturer's local field office and shall not be subcontracted. The control contractor shall have an in-place support facility within 100 miles of the site with factory certified technicians and engineers, spare parts inventory and all necessary test and diagnostic equipment for the installed system, and the control contractor shall have 24 hours/day, 7 days/week emergency service available.

N. Provide the Commissioning, configuration and diagnostic tool (CCDT), color display personnel computer, software, and interfaces to provide uploading/downloading of High Point Count Controllers (AAC), Unitary Equipment Controllers (UEC) and VAV controllers (VAVDDC) monitoring all BACnet objects, monitoring overrides of all controller physical input/output points, and editing of controller resident time schedules.

O. Provide a Portable Operator's Terminal (POT) color display personnel computer, software, and interfaces to provide uploading/downloading of Custom Application Controller and Application Specific Controllers databases, monitoring of all LonMark™ Standard Network Variables Types (SNVTs) including display of all bound SNVTs, monitoring and overrides of all controller physical input/output points, and editing of controller resident time schedules. POT connectivity shall be via digital wall sensor connected to controller.

P. Deployed system must satisfy system requirements to meet DIARMF (U.S. Department of Defense Information Assurance Risk Management Framework) compliance. Only exception is if system is employing a PEMS system such as described in subsection 1.6 Q. below.

Q. The system shall have the capability to provide a web-based AFDD (automated fault detection and diagnostic) system. The AFDD system shall be able to interface directly with the project BAS and energy/performance metering system to provide information on HVAC systems that are being controlled. Pricing is to be a separate line item from the BAS proposal. See specification section 25 08 01 for exact requirements.

R. The system shall have the capability to provide a web-based APEO (automated predictive energy optimization) system and enable effective participation in local utility Demand Response (DR) programs. The vendor shall provide software and ongoing services that will identify actionable energy saving and peak reduction opportunities to assist the facility in achieving its energy and sustainability objectives, and automatically and continuously operate the systems necessary to achieve the targeted savings and reductions. .

S. The system shall have the capability to provide a web-enabled PEMS (power and energy management system) monitoring system intended to monitor an entire electrical distribution infrastructure, from incoming utility feeds down to low voltage distribution points. It shall be designed to monitor and manage energy consumption throughout an enterprise, whether within a single facility or across a network of facilities, to improve energy availability and reliability, and to measure and manage energy efficiency. It shall be a standard product offering with no custom programming required. It shall provide a seamless user experience ("Single pane of glass") for managing the mechanical systems (HVAC and lighting) and monitoring the power distribution system (transformers, breakers, relays, switches, capacitors, UPS, invertors, etc.)

T. The system shall have the capability to provide an app running on a fixed or mobile device (iOS (iPad), Android (tablet), Windows) offering a consistent, aesthetic, customized graphical interface, that allows to aggregate in a graphical manner various types of services such as room temperature control, lighting control, curtain control, remote TV, etc. System shall communicate via web services and have the ability to be designed once and deployed to

multiple devices at the same time. Pricing is to be a separate line item from the BAS proposal. Provide costs for develop and deploy and tiered costs for multiple levels of device purchases.

1.5 WORK BY OTHERS

A. The BAS Contractor shall cooperate with other contractors performing work on this project necessary to achieve a complete and neat installation. To that end, each contractor shall consult the drawings and specifications for all trades to determine the nature and extent of others' work.

B. The BAS Contractor shall furnish all control valves, sensor wells, flow meters and other similar equipment for installation by the Mechanical Contractor.

C. The BAS Contractor shall provide field supervision to the designated contractor for the installation of the following as required:

1. Automatic control Dampers
2. Automatic control Valves

D. The Electrical Contractor shall provide:

1. The Electrical contractor shall provide all line voltage power required for automatic controls devices.
2. BAS contractor shall provide all low voltage wiring and transformer as required for automatic controls devices.

E. The BAS Contractor shall provide:

1. All control valves and actuators. Turn over to the mechanical contractor for installation.

1.6 CODE COMPLIANCE

A. Provide BAS components and ancillary equipment, which are UL-916 listed and labeled.

B. All equipment or piping used in conditioned air streams, spaces or return air plenums shall comply with NFPA 90A Flame/Smoke/Fuel contribution rating of 25/50/0 and all applicable building codes or requirements.

C. All wiring shall conform to the National Electrical Code.

D. All smoke dampers shall be rated in accordance with UL 555S.

E. Comply with FCC rules, Part 15 regarding Class A radiation for computing devices and low power communication equipment operating in commercial environments.

F. Comply with FCC, Part 68 rules for telephone modems and data sets.

G. New York State Building Code, New York State Mechanical Code, and the NEC- Prevailing editions

1.7 SUBMITTALS

A. All shop drawings shall be prepared in Visio Professional or AutoCAD software. And shall be provided electronically in PDF format.

B. Shop drawings shall include a riser diagram depicting locations of all controllers and workstations, with associated network wiring. Also included shall be individual schematics of each mechanical system showing all connected points with reference to their associated controller.

C. Submittal data shall contain manufacturer's data on all hardware and software products required by the specification. Valve, damper, and air flow station schedules shall indicate size, configuration, capacity and location of all equipment.

D. Submittals shall contain narrative descriptions of sequences of operation, point lists, and a complete description of the graphics, reports, alarms and configuration to be furnished with the workstation software. Information shall be provided in PDF format. All literature, descriptions, equipment spec sheets, sequences etc shall be on 8 1/2 x 11 or larger sized sheets. All details diagrams and schematics shall be on 11X17 sized sheets or larger.

E. Submit copies of submittal data and shop drawings to the Engineer for review and approval prior to ordering or fabrication of the equipment. The Contractor prior to submitting shall check all documents for accuracy.

F. The Engineer will make corrections, if required, and return to the Contractor. The Contractor will then resubmit with the corrected or additional data. This procedure shall be repeated until all corrections are made to the satisfaction of the Engineer and the submittals are fully approved.

G. Submit a training class syllabus and training manual for review with the temperature controls submittal. The training manual shall be custom made for this project. Manufactures brochures, and installation manuals will not be acceptable for this purpose. Submit a type written overview and a written summary of each topic to be covered. The document shall be suitable for a system operator to use as a quick reference guide to basic system operation as applicable for this project. Refer to section 1.9 paragraph B, for the minimum requirement of training to be included.

1.8 SYSTEM STARTUP & COMMISSIONING

A. Each point in the system shall be tested for both hardware and software functionality. In addition, each mechanical and electrical system under control of the BAS will be tested against the appropriate sequence of operation specified herein. Successful completion of the system test shall constitute the beginning of the warranty period. A written report will be submitted to the owner indicating that the installed system functions in accordance with the plans and specifications.

B. The BAS contractor shall commission and set in operating condition all major systems and equipment including boilers, chillers, pumps, cooling towers in the presence of the equipment manufacturer’s representatives, and commissioning agent as applicable, and the Owner and Architect’s representatives.

C. The BAS Contractor shall provide all manpower and engineering services required to assist the HVAC Contractor, commissioning agent and Balancing Contractor in testing, adjusting, and balancing all systems in the building. The BAS Contractor shall have a trained technician available on request during the balancing of the systems. The BAS Contractor shall coordinate all requirements to provide a complete air balance with the Balancing Contractor and shall include all labor and materials in his contract.

D. Refer to the commissioning notes on the trade drawings and the commissioning, (CX) specification sections in order to full understand CX scope of work. Provide labor and materials for pre-functional and functional testing as well as meetings and correctives measure that need to be taken regarding the controls systems.

1.9 TRAINING

A. The BAS Contractor shall provide on-site training to the Owner's representative and maintenance personnel per the following description:

B. On-site training shall consist of a minimum of (4) separate 4 - hour sessions of hands-on instruction geared at the operation and maintenance of the systems. The sessions shall be scheduled at the beginning of substantial completion and spaced out over the first year of owner use. The first session curriculum shall include

1. System Overview
2. System Software and Operation

    a. System access
    b. Software features overview
    c. Changing set-points and other attributes
    d. Scheduling
    e. Editing programmed variables
    f. Displaying color graphics
    g. Running reports
    h. Workstation maintenance
    i. Application programming

3. Operational sequences including start-up, shutdown, adjusting and changing system variables. These items shall be reviewed for all equipment installed under this project and or connected to the BMS under this project.
4. Equipment and hardware overview and maintenance. This shall include:

    a. Review of all hardware installed under this project
    b. Review of a system schematic.
    c. Review of where each controller is located in the building and what its function is. This shall include a walking, hands-on tour and demonstration of each and every controller.

1.10 OPERATING AND MAINTENANCE MANUALS

A. The operation and maintenance manuals shall contain all information necessary for the operation, maintenance, replacement, installation, and parts procurement for the entire BAS. This documentation shall include specific part numbers and software versions and dates. A complete list of recommended spare parts shall be included with the lead-time and expected frequency of use of each part clearly identified.

B. Following project completion and testing, the BAS contractor will submit as-built drawings reflecting the exact installation of the system. The as-built documentation shall also include a copy of all application software both in written form and on diskette.

1.11 WARRANTY

A. The BAS contractor shall warrant the system for 12 months after system acceptance and beneficial use by the owner. During the warranty period, the BAS contractor shall be responsible for all necessary revisions to the software as required to provide a complete and workable system consistent with the letter and intent of the Sequence of Operation section of the specification.

B. Updates to the manufacturer's software shall be provided at no charge during the warranty period.

1.12 PROGRAMMING

A. Sequence of operations: The controls contractor shall review the sequences of operation given in section 23 09 93 Sequence of Operation. "Canned", preprogrammed, or typical sequences by the manufacture may not be acceptable and shall only be used if accepted by the Engineer. Otherwise, the controls contractor shall be capable of and responsible for providing custom programming, hardware, software, and labor as required to achieve the sequences of operation as specified.

1.13 SYSTEM ARCHITECTURE

A. General

B. The Building Automation System (BAS) shall consist of all new Network Control Units (NCUs), a family of Standalone Digital Control Units (SDCUs), Input/Output Unit Modules (IOU Modules), Operator Workstations (OWs), and one File Server to support system configurations where more than one operator workstation is required. The BAS shall provide control, alarm detection, scheduling, reporting and information management for the entire building and all new and existing equipment in the building, and Wide Area Network (WAN) if applicable, from a single ODBC-compliant database

C. Level 1 Network Description

D. Level 1, the main backbone of the system, shall be an Ethernet LAN/WAN. Network Control Units, Operator Workstations, and the Central File Server shall connect directly to this network without the need for Gateway devices. The contractor shall visit the site and review the existing temperature controls equipment installed in the building and in the physical plant. Certain of these controllers may be suitable for reuse. The network shall be an extension of the existing in the building as required to achieve a complete system,

E. Level 2 Network Description

F. Level 2 of the system shall consist of one or more field buses managed by the Network Control Units. The Level 2 field buses may consist of one or both of the following types:

G. An RS485, token passing bus that supports up to 127 Standalone Digital Control Units (SDCUs) for operation of HVAC equipment and lighting, or

H. An RS485 field bus that supports up to 32 devices from a family of plug-in, IOU modules.

I. These IOU modules may be mounted within the NCU enclosure or remotely mounted via a single, twisted, shielded pair of wires.

J. The BAS shall be capable of being segmented, through software, into multiple local area networks (LANs) distributed over a wide area network (WAN), sharing a single file server. This

enables workstations to manage a single LAN (or building), and/or the entire system with all devices being assured of being updated by and sharing the most current database. In the case of a single workstation system, the workstation shall contain the entire database – with no need for a separate file server.

K. Standard Network Support

L. All NCUs, Workstation(s) and File Server shall be capable of residing directly on the owner's Ethernet TCP/IP LAN/WAN with no required gateways. Furthermore, the NCU's, Workstation(s) and File Server shall be capable of using standard, commercially available, off-the-shelf Ethernet infrastructure components such as routers, switches and hubs. With this design the owner may utilize the investment of an existing or new enterprise network or structured cabling system. This also allows the option of the maintenance of the LAN/WAN to be performed by the owner's Information Systems Department as all devices utilize standard TCP/IP components.

M. Remote Communications

N. In addition to the above LAN/WAN architecture support, the same workstation software (front end) must be capable of managing remote systems via standard dial-up phone lines as a standard component of the software. Front-end "add-on" software modules to perform remote site communication shall not be acceptable.

O. The remote system architecture shall consist of two levels providing control, alarm detection, reporting and information management for the remote facility. Level 1 shall contain the Remote Site Control Unit, communicating to the remotely located, Operator Workstation(s) through the use of a modem and a standard dial-up phone line. Level 2 shall consist of one or more field buses controlled by the RSCU. The field buses may consist of one or both of two types:

P. 1) An RS485, token passing bus that supports up to 127 Standalone Digital Control Units (SDCUs) for operation of HVAC equipment and lighting, or

Q. 2) An RS485 field bus that supports up to 32 devices from a family of plug-in, IOU modules that may be mounted within the RSCU enclosure or remotely mounted on a single, twisted, shielded pair of wires.

R. System Expansion

S. The BAS system shall be scalable and expandable at all levels of the system using the same software interface, and the same Level 1 and Level 2 controllers. Systems that require replacement of either the workstation software or field controllers in order to expand the system shall not be acceptable.

T. The BAS shall be expandable to include Security and Access Control functions at any time in the future with no additional workstations, front-end software or Level 1 controllers required. Standalone Digital Control Units or IOU modules shall be able to be added to the existing Level 1 controller's field bus(es), to perform security and card access applications. In this way, an owner's existing investment in wiring infrastructure may be leveraged and the cost and inconvenience of adding new field bus wiring will be minimized.

U. Additionally, an integrated video badging option must be able to be included with no additional workstations required. This photo ID option must share the same database as the BAS in order to eliminate the need for updating multiple databases.

V. The system shall use the same application programming language for all levels: Operator Workstation, Network Control Unit, Remote Site Control Unit and Standalone Digital Control

Unit. Furthermore, this single programming language shall be used for all applications: environmental control, card access control, intrusion detection and security, lighting control, leak detection / underground storage tank monitoring, and digital data communication interfaces to third party microprocessor-based devices.

W. Support For Open Systems Protocols

The BAS design must include solutions for the integration of the following "open systems" protocols: BACnet, LonTalk™, and digital data communication to third party microprocessors such as chiller controllers, fire panels and variable frequency drives (VFDs).

X. The system shall also provide the ability to program custom ASCII communication drivers, that will reside in the NCU, for communication to third party systems and devices. These drivers will provide real time monitoring and control of the third-party systems.

1.14 NETWORK CONTROL UNITS (NCUS)

A. Network Control Units shall be microprocessor based, multi-tasking, multi-user, and employ a real time operating system. Each NCU control panel shall consist of modular hardware including power supply, CPU board, and input/output modules. A sufficient number of NCUs shall be supplied to fully meet the requirements of this specification and the attached point list.NCUs for telephone dialup sites shall be of the same design as the Ethernet control units but without the plug-in Ethernet network interface card (NIC), i.e., NCUs, which include a NIC, shall be interchangeable whether used on a LAN/WAN or a dialup site.

B. Webserver Functionality

All NCUs on the Ethernet TCP/IP LAN/WAN shall be capable, out-of-the box, to be set up as a Web Server. The NCU shall have the ability to store HTML code and "serve" pages to a web browser. This provides the ability for any computing device utilizing a TCP/IP Ethernet connection and capable of running a standard Internet browser (Microsoft Internet Explorer™, Netscape Navigator™, etc.) to access real-time data from the entire BAS via any NCUs.

Graphics and text-based web pages shall be constructed using standard HTML code. The interface shall allow the user to choose any of the standard text or graphics-based HTML editors for page creation. It shall also allow the operator to generate custom graphical pages and forms.

The WEB server interface shall be capable of password security, including validation of the requesting PC's IP address. The WEB server interface shall allow the sharing of data or information between any controller, or process or network interface (BACnet, LonTalk and TCP/IP) that the BMS has knowledge of, regardless of where the point is connected on the BAS network or where it is acquired from.

The BAS network controller must act directly as the WEB server. It must directly generate the HTML code to the requesting user (i.e. WEB browser), eliminating the need for and reliance on any PC-based WEB server hardware or software. To simplify graphic image space allocation, HTML graphic images, if desired, shall be stored on any shared network device. The BAS WEB server shall have the ability to acquire any necessary graphics using standard pathing syntax within the HTML code mounted within the BAS WEB server. External WEB server hardware and software are not acceptable.

C. Hardware Specifications

1. Memory:

A minimum of 64MB of RAM shall be provided for NCUs with expansion up to 128 MB. The 64 MB versions shall include a floating-point math co-processor.

2. Communication Ports:

   Each NCU shall provide communication to both the Workstation(s) and the field buses. In addition, each NCU must have at least 3 other communications ports that support a telephone modem, portable service tool, serial printer and connection to third party controllers such as a chiller control panel. On a LAN/WAN system the NCU shall be provided with a 10Mbps plug-in Ethernet TCP/IP network interface card (NIC).

3. Input/Output (I/O):

   Each NCU shall support the addition of the following types of inputs and outputs:

   - Digital Inputs for status/alarm contacts
   - Counter Inputs for summing pulses from meters.
   - Thermistor inputs for measuring temperatures in space, ducts and thermowells.
   - Analog inputs for pressure, humidity, flow and position measurements.
   - Digital Outputs for on/off equipment control.
   - Analog Outputs for valve and damper position control, and capacity control of primary equipment including all air handler and fan coil control valves

4. Modular Expandability:

   The system shall employ a modular I/O design to allow easy expansion. Input and output capacity is to be provided through plug-in modules of various types or DIN-mountable IOU modules. It shall be possible to combine I/O modules as desired to meet the I/O requirements for individual control applications.

5. Hardware Override Switches:

   All digital output units shall include three position manual override switches to allow selection of the ON, OFF, or AUTO output state. These switches shall be built into the unit and shall provide feedback to the controller so that the position of the override switch can be obtained through software. In addition each analog output shall be equipped with an override potentiometer to allow manual adjustment of the analog output signal over its full range, when the 3 position manual override switch is placed in the ON position.

6. Local Status Indicator Lamps:

   Provide as a minimum LED indication of CPU status, Ethernet LAN status, and field bus status. For each output, provide LED indication of the value of the output (On/Off). For each output module provide an LED which gives a visual indication of whether any outputs on the module are manually overridden.

7. Real Time Clock (RTC):

   Each NCU shall include a battery-backed, real time clock, accurate to 10 seconds per day. The RTC shall provide the following: time of day, day, month, year, and day of week. In normal operation the system clock will be based on the frequency of the AC power. The system shall automatically correct for daylight savings time and leap years and be Year 2000 compliant.

8. Power Supply:

   The power supply for the NCUs shall be auto sensing, 120-220VAC, 60/50 Hz power, with a tolerance of +/- 20%. Line voltage below the operating range of the system shall

be considered outages. The controller shall contain over voltage surge protection and require no additional AC power signal conditioning. Optionally, if indicated on the drawings, the power supply shall accept an input voltage of (–48 VDC).

9. Automatic Restart After Power Failure:

   Upon restoration of power after an outage, the ECU shall automatically and without human intervention: update all monitored functions; resume operation based on current, synchronized time and status, and implement special start-up strategies as required.

10. Battery backup:

    Each NCU with the standard 120-220VAC power supply shall include a programmable DC power backup system rated for a minimum of 72 hours of battery backup to maintain all volatile memory or, a minimum of 2 hours of full UPS including modem power. This power backup system shall be configurable such that at the end of a settable timeframe (such as 1 hour) of running on full UPS, the unit will shut off full UPS and switch to memory retention-only mode for the remainder of the battery power. The system shall allow the simple addition of more batteries to extend the above minimum battery backup times.

D. Software Specifications

1. General.

   The NCU shall contain flash ROM as the resident operating system. Application software will be RAM resident. Application software will only be limited by the amount of RAM memory. There will be no restrictions placed on the type of application programs in the system. Each NCU shall be capable of parallel processing, executing all control programs simultaneously. Any program may affect the operation of any other program. Each program shall have the full access of all I/O facilities of the processor. This execution of control function shall not be interrupted due to normal user communications including interrogation, program entry, printout of the program for storage, etc.

2. User Programming Language:

   The application software shall be user programmable. This includes all strategies, sequences of operation, control algorithms, parameters, and setpoints. The source program shall be English language-based and programmable by the user. The language shall be structured to allow for the easy configuration of control programs, schedules, alarms, reports, telecommunications, local displays, mathematical calculations, passwords, and histories. The language shall be self-documenting. Users shall be able to place comments anywhere in the body of a program. Program listings shall be configurable by the user in logical groupings.

E. Control Software:

1. The NCU shall have the ability to perform the following pre-tested control algorithms:

   a. Proportional, Integral plus Derivative Control (PID)
   b. Self Tuning PID
   c. Two Position Control
   d. Digital Filter
   e. Ratio Calculator
   f. Equipment Cycling Protection

2. Mathematical Functions:

   a. Each controller shall be capable of performing basic mathematical functions (+, -, *, /), squares, square roots, exponential, logarithms, Boolean logic statements, or combinations of both. The controllers shall be capable of performing complex logical statements including operators such as >, <, =, and, or, exclusive or, etc. These must be able to be used in the same equations with the mathematical operators and nested up to five parentheses deep.

3. Energy Management Applications:

   a. NCUs shall have the ability to perform any or all of the following energy management routines:
   b. Time of Day Scheduling
   c. Calendar Based Scheduling
   d. Holiday Scheduling
   e. Temporary Schedule Overrides
   f. Optimal Start
   g. Optimal Stop
   h. Night Setback Control
   i. Enthalpy Switchover (Economizer)
   j. Peak Demand Limiting
   k. Temperature Compensated Duty Cycling
   l. CFM Tracking
   m. Heating/Cooling Interlock
   n. Free Cooling
   o. Hot Water Reset
   p. Chilled Water / HW water Reset
   q. Chiller / boiler Sequencing

4. History Logging:

   a. Each controller shall be capable of logging any system variable over user defined time intervals ranging from 1 second to 1440 minutes. Any system variables (inputs, outputs, math calculations, flags, etc.) can be logged in history. A maximum of 32767 values can be stored in each log. Each log can record either the instantaneous, average, minimum or maximum value of the point. Logs can be automatic or manual. Logged data shall be downloadable to the Operator Workstation for long term archiving based upon user-defined time intervals, or manual command.

5. Alarm Management:

   a. For each system point, alarms can be created based on high/low limits or conditional expressions. All alarms will be tested each scan of the NCU and can result in the display of one or more alarm messages or reports. Up to 8 alarms can be configured for each point in the controller. Messages and reports can be sent to a local terminal, to the front-end workstation(s), or via modem to a remote-computing device. Alarms will be generated based on their priority. A minimum of 255 priority levels shall be provided. If communication with the Operator Workstation is temporarily interrupted, the alarm will be buffered in the NCU.

When communications return, the alarm will be transmitted to the Operator Workstation if the point is still in the alarm condition.

6. Reporting.

a. The NCU shall be able to generate user-definable reports to a locally connected printer or terminal. The reports shall contain any combination of text and system variables. Report templates shall be able to be created by users in a word processing environment. Reports can be displayed based on any logical condition or through a user command.

1.15 STANDALONE DIGITAL CONTROL UNITS (SDCUS)

A. General:

1. Standalone Digital Control Units shall provide control of HVAC and lighting. Each controller shall have its own control programs and will continue to operate in the event of a failure or communication loss to its associated NCU.

B. Memory:

1. Control programs shall be stored in battery backed-up RAM and EPROM. Each controller shall have a minimum of 32K bytes of user RAM memory and 128K bytes of EPROM.

C. Communication Ports:

1. SDCUs shall provide a communication port to the field bus. In addition, a port shall be provided for connection of a portable service tool to support local commissioning and parameter changes with or without the NCU online. It shall be possible from a service port on any SDCU to view, enable/disable, and modify values of any point or program on any controller on the local field bus, any NCU or any SDCU on a different field bus.

D. Input/Output:

1. Each SDCU shall support the addition of the following types of inputs and outputs:

a. Digital Inputs for status/alarm contacts
b. Counter Inputs for summing pulses from meters.
c. Thermistor Inputs for measuring temperatures in space, ducts and thermowells.
d. Analog inputs for pressure, humidity, flow and position measurements.
e. Digital Outputs for on/off equipment control.
f. Analog Outputs for valve and damper position control, and capacity control of primary equipment.

Expandability:

2. Input and output capacity shall be expandable through the use of plug-in modules. A minimum of two modules shall be added to the base SDCU before additional power is required.

Networking:

3. Each SDCU will be able to exchange information on a peer-to-peer basis with other Standalone Digital Control Units during each field bus scan. Each SDCU shall be capable of storing and referencing global variables (on the LAN) with or without any workstations online. Each SDCU shall be able to have its program viewed and/or enabled/disabled either locally through a portable service tool or through a workstation connected to an NCU.

Indicator Lamps:

4. SDCUs will have as a minimum, LED indication of CPU status, and field bus status.

Real Time Clock (RTC):

5. An SDCU shall have a real time clock in either hardware or software. The accuracy shall be within 10 seconds per day. The RTC shall provide the following information: time of day, day, month, year, and day of week. Each SDCU shall receive a signal, every hour, over the network from the NCU which synchronizes all SDCU real time clocks.

Automatic Restart After Power Failure:

6. Upon restoration of power, the SDCU shall automatically and without human intervention, update all monitored functions, resume operation based on current, synchronized time and status, and implement special start-up strategies as required.

Battery Back Up:

7. Each SDCU shall have at least 3 years of battery back up to maintain all volatile memory.

Alarm Management:

8. For each system point, alarms can be created based on high/low limits or conditional expressions. All alarms will be tested each scan of the SDCU and can result in the display of one or more alarm messages or reports. Up to 8 alarms can be configured for each point in the controller enabling the escalation of the alarm priority (urgency) based upon which alarm(s) is/are triggered. Alarm messages can be sent to a local terminal or modem connected to an NCU or to the Operator's Workstation(s). Alarms will be generated based on their priority. A minimum of 255 priority levels shall be provided. If communication with the NCU is temporarily interrupted, the alarm will be buffered in the SDCU. When communications return, the alarm will be transmitted to the NCU if the point is still in the alarm condition.

9. Unitary Controllers

    a. Unitary Controllers shall support, but not be limited to, the control of the following systems as described in the Execution portion of this specification, and for future expansion:

        1) Cabinet heater and convectors
        2) Rooftop top air handling units
        3) Fan Coils
        4) Unit and cabinet heaters

    b. The I/O of each Unitary Controller shall contain the sufficient quantity and types as required to meet the sequence of operation found in the Execution portion of

this specification. In addition, each controller shall have the capability for time of day scheduling, occupancy mode control, after hour operation, lighting control, alarming, and trending.

E. Display Controllers

1. Display controllers are standalone, touch screen based operator interfaces. The controller shall be designed for flush mounting in a finished space, with a minimum display size of 9 x 9 inches. Software shall be user programmable allowing for custom graphical images that simulate floor plans, menus, equipment schematics along with associated real time point values coming from any NCU on the network. The touch screen display shall contain a minimum of 64 possible touch cells that permit user interaction for changing screens, modifying set-points or operating equipment. Systems that do not offer a display controller as specified must provide a panel mounted computer with touch screen capability as an alternative. All air handling units shall use display controllers.

Q. MP-C Controller

1. SmartX IP Controller – MP-C is a multi-purpose, fully programmable, IP based field controller. The MP-C models offer a flexible mix of I/O point types that suit a wide range of HVAC applications. MP-C can either be used as a standalone BACnet/IP field controller or as part of an EcoStruxure BMS with a SmartX AS-P or AS- B server or an Enterprise Server as the parent server. The MP-C models support an optional display that provides insight and control of the inputs and output. The MP-C has the following features:

    a. IP enabled with dual port Ethernet switch
    b. Versatile onboard I/O point mix
    c. High reliability
    d. Sensor bus for living space sensors
    e. Mobile commissioning application
    f. Full EcoStruxure Building Operation software support, providing efficient engineering tools

2. The MP Series controllers are based on open protocols that simplify interoperability, IP configuration, and device management:
    a. IP addressingBACnet/IP communications
    b. DHCP for easy network configuration
    c. The MP Series controllers have a dual-port Ethernet switch, which enables flexible network topologies:
    d. Star
    e. Daisy chain
    f. Rapid Spanning Tree Protocol (RSTP) ring

3. In a star topology, the controller and the parent EcoStruxure BMS server are individually connected to an Ethernet switch. You can reduce the installation time and cost by daisy-chaining multiple controllers together. You can use an RSTP ring topology when you want failures of a single controller to be detected and recovered quickly and efficiently.

4. MP-C comes in five models with different I/O pointcount and a versatile mix of I/O point types that match a wide variety of applications. Most of the I/O points are universal inputs/outputs, which are highly flexible and can be configured as either inputs or outputs.

5. Universal inputs/outputs
   a. The universal inputs/outputs are ideal for any mix of temperature, pressure, flow, status points, and similar point types in a building control system.
   b.
   c. As counter inputs, the universal inputs/outputs are commonly used in energy metering applications. As RTD inputs, they are ideal for temperature points in a building control system. As supervised inputs, they are used for security applications where it is critical to know whether or not a wire has been cut or shorted. These events provide a separate indication of alarms and trouble conditions to the system.
   d.
   e. For all analog inputs, maximum and minimum levels can be defined to automatically detect over-range and under-range values.
   f.
   g. The universal inputs/outputs can also be used as voltage outputs or current outputs (Uc only), without the need for external bias resistors. Therefore, the universal inputs/outputs support a wide range of devices, such
   h. as actuators.
6. Triac outputs
   a. The triac outputs can be used in many applications to switch 24 VAC on or off for external loads such as actuators, relays, or indicators. The triac outputs are isolated from the controller. Triacs are silent and do not suffer from relay contact wear.

7. Relay outputs
   a. The relay outputs support digital Form A point types. The Form A relays are designed for direct load applications.

8. High power relay output
   a. MP-C-15A and MP-C-18A have a high power relay output, which is ideal for switching loads of up to 12 A, such as electrical heating elements.

9. High reliability
   a. The MP Series controllers support local trends, schedules, and alarms, enabling local operation when the controller is offline or used in standalone applications.
   b. the battery-free power backup of the memory and real- time clock prevents data loss and ensures seamless and quick recovery after a power failure.
   c. All MP-C models can be equipped with the MP-C Display add-on module, which features an LCD display and five keys. With this module, you can manually override analog and digital outputs for testing, commissioning, and maintenance of equipment connected to the outputs. The module's dedicated processing power ensures reliable override for maintenance applications. The override status is readable through EcoStruxure Building Operation WorkStation and WebStation, enabling precise monitoring and reliable control.

R. AS-P Controller

1. At the core of a SmartStruxure solution is a SmartStruxure server device, such as AS-P. AS-P performs key functionality, such as control logic, trend logging, and alarm supervision, and supports communication and connectivity to the I/O and field buses. The distributed intelligence of the SmartStruxure solution ensures fault tolerance in the system and provides a fully featured user interface through WorkStation and WebStation.

2. AS-P is a powerful device that can act as a standalone server and also control I/O modules and monitor and manage field bus devices. In a small installation, the embedded AS-P device acts as a standalone server, mounted with its I/O modules in a small footprint. In medium and large installations, functionality is distributed over multiple SmartStruxure server devices that communicate over TCP/IP.

3. Capable of coordinating traffic from above and below its location, AS-P can deliver data directly to you or to other servers throughout the site. AS-P can run multiple control programs, manage local I/O, alarms, and users, handle scheduling and logging, and communicate using a variety of protocols. Because of this, most parts of the system function autonomously and continue to run as a whole even if communication fails or individual SmartStruxure servers or devices go offline.

4. AS-P has numerous ports that enable it to communicate witha wide range of protocols, devices, and servers.

5. AS-P has the following ports:

    a. Two 10/100 Ethernet ports
    b. Two RS-485 ports
    c. One LonWorks TP/FT port
    d. One built-in I/O bus port
    e. One USB host port
    f. One USB device port

6. The USB device port allows you to upgrade and interact with AS-P using Device Administrator. The USB host port can be used to provide power and communications for the AD touchscreen display.

7. The two Ethernet ports are connected to a built-in Ethernet switch. One port should be connected to the site network. The other port can be used to connect a single WorkStation or WebStation, a Modbus TCP unit, or a BACnet/IP device, but not another SmartStruxure server.

8. A SmartStruxure solution provides a powerful permission system that is easy to manage, flexible, and adapts to all kinds of system sizes. The permission system provides a security level to the highest standards. Authentication is done against the built-in user account management system or against Windows Active Directory Domains. The built-in account management system allows an administrator to set password policies that meet stringent CyberSecurity guidelines. When Windows Active Directory is used, the administration costs are lower because users do not have to be managed in multiple directories.

9. WorkStation/WebStation interface Through any client, the user experience is similar regardless of which SmartStruxure server the user is logged on to. The user can log directly on to AS- P to engineer, commission, supervise, and monitor AS-P as well as its attached I/O modules and field bus devices. See the WorkStation and WebStation datasheets for additional information.

10. Open building protocol support One of the cornerstones of SmartStruxure solution is support for open standards. AS-P can natively communicate with three of the most popular standards for buildings: BACnet, LonWorks, and Modbus.

11. Native BTL-listed BACnet support AS-P communicates directly to BACnet/IP and BACnet MS/TP networks. AS-P is BTL-listed as a BACnet Building Controller (B-BC),

the most advanced BACnet Device Profile. This capability provides access to an extensive range of BACnet devices from Schneider Electric and other vendors. See the BTL Product Catalog for up-to-date details on BTL listed firmware revisions on BACnet International's home page. AS-P can also serve as a BACnet Broadcast Management Device (BBMD) to facilitate BACnet systems that span multiple IP networks.

12. Native LonWorks support
13. Native Modbus support
14. Additional building protocol support AS-P also supports integration and communication with Schneider Electric supplied BMS systems and devices that use the following standards for buildings: I/NET, MicroNet, NETWORK 8000, and Andover Continuum Infinet.
15. Web Services support AS-P supports the use of Web Services based on open standards, such as SOAP and REST, to consume data into the SmartStruxure solution. Use incoming third-party data (temperature forecast, energy cost) over the Web to determine site modes, scheduling, and programming.
16. EcoStruxure Web Services support EcoStruxure Web Services, Schneider Electric's
17. Web Services standard, is natively supported in AS-
18. EcoStruxure Web Services offers extra features between compliant systems whether within Schneider Electric or other authorized systems. These features include system directory browsing, read/write of current values, alarm receipt and acknowledgement, and historical trend log data. EcoStruxure Web Services is secure. User name and password are required to log on to the system.
19. (4) GB of eMMC memory for data and backup AS-P has an available capacity of 4 GB of eMMC memory. This represents 2 GB for application and historical data and 2 GB dedicated for backup storage. This ensures that all data is safe from damage, loss, or unintended edits. Users can also manually back up or restore AS-P to a storage location on a PC or network. Through the Enterprise Server, users have the ability to perform scheduled backups of associated AS-P devices to network storage for even greater levels of protection.

1.16 ADVANCED DISPLAY V3

A. General SmartX Advanced Display v3 (AD v3) is an industrial grade Human Machine Interface (HMI) that can easily be locked to an application such as EcoStruxure Building Operation WebStation to create a dedicated tool for local operation and maintenance of an EcoStruxure BMS. Located in each boiler room

B. Features v3 provides an easy-to-use interface through which users and engineers can locally access EcoStruxure BMS servers from an HMI terminal installed on a control cabinet. The simplified user interface and the intuitive touchscreen navigation make it easy for you to operate and maintain the system.

C. Fully integrated HMI solution With AD v3, Schneider Electric offers a fully integrated HMI solution that provides benefits such as ease of use, ease of installation, and robust locking mechanism.

D. Based on an Android platform AD v3 offers an HMI that is built to last, with a battery- free power supply. The HMI is based on an Android platform with high-resolution touchscreen

display, high- quality design, leading technology, and good communications and graphics performance. The display size is 10.1 inches, which is an ideal size for many HMI solutions.

E. Protective frame and ease of installation AD v3 has an IP54 rated frame that helps protect against dust and moisture. AD v3 is quick and easy to install.

F. Preinstalled software, AD v3 is delivered with the following preinstalled software: SmartX HMI Kiosk for locking AD v3 into Kiosk mode, USBnet driver for enabling IP over USB communication

G. Dedicated HMI for operation and maintenance With SmartX HMI Kiosk, you can easily lock AD v3 into Kiosk mode and use AD v3 as a dedicated HMI for operation and maintenance. Kiosk mode enables you to select which app can be used by the end user and helps prevent the user from leaving the selected app, running other apps, interacting with the OS, and accessing the file system. The benefits of Kiosk mode include enhanced data security and easier technical support.

H. Direct access to EcoStruxure BMS serversWebStation comes built-in with every EcoStruxure BMS server and provides a web-based user interface for operation and maintenance of EcoStruxure BMS servers. With SmartX HMI Kiosk, you can easily make the embedded web browser run WebStation in Kiosk mode. For more information, see the WebStation specification sheet.

I. HMI solution for different use casesAD v3 offers an HMI solution that is suitable for different use cases and locations. With AD v3 locked to WebStation and installed on a control cabinet in a plant room, you get an excellent HMI for local maintenance.

J. Communication and power

K. The USBnet driver enables AD v3 to communicate with SmartX servers over a wired (USB) connection. AD v3 can be powered by a 24 VDC power supply through the Y-shaped cable (SXWADUSBC10002 or

L. SXWADUSBC10003). Use only the cables designed for AD v3. The required cables can be ordered from Schneider Electric.

1.17 WEB STATION

A. StruxureWare Building Operation WebStation is a web-based user interface for day-to-day operation in a SmartStruxure solution. WebStation comes built in with every SmartStruxure server, and provides easy access to the software from anywhere in the world.

B. WebStation provides a portable, fully functioning user interface to access the SmartStruxure servers using a web browser. Users can view and manage graphics, alarms, schedules, trend logs, and reports. User accounts can be created, edited, or removed.

C. A SmartStruxure solution requires each user to have an account. Access can be through an account maintained by the SmartStruxure solution or through a Windows Active Directory account. IT policies for password formatting, aging, and uniqueness are supported and enforced.

D. The software adapts the displayed language, measurement system, and date/time format to the operating system settings. Language and measurement system can easily be switched from within WebStation. Translations of WebStation are delivered as separate language packs that are easy to install and deploy.

E. The software shall have the flexibility to be fully customized to the viewing preference of each user. The main interface, called the Workspace, is a panel-based interface where users can select, position, and re-size a wide variety of components, such as alarms, graphics, and editors. WebStation supports Workspace and Panel functionality without modification.

F. The search function helps users quickly find information and navigate to wherever they need to go. By typing in all or part of the name, the user sees a list of all items that match. The software shows the current status or value for each item and users can open the item directly from the search list.

G. Through WebStation, the software can present a large number of alarms in a simple and efficient way to ensure no alarm is overlooked. Alarms can be color coded, grouped, and filtered for maximum efficiency.

H. WebStation can assign alarms to a user or a group of users by a dispatch center or manager. Using a filter, users can see only the alarms assigned to them and decide whether or not to accept the assignment.

I. In a SmartStruxure solution, the graphics can be customized to provide the user interface required to effectively run each facility. Graphics are stored locally in the SmartStruxure servers and are available to authorized users from wherever they log o

J. A SmartStruxure solution uses scalable vector graphic technology so that users can zoom in to see details without losing clarity. Graphics are built once, but can be used on any display regardless of size or resolution. Vector graphic file sizes are small so they can be stored and served directly from the SmartStruxure server device.

K. Super dynamic live updates A standard live update simply shows the displayed values as conditions change in the field. With SmartStruxure solution's super dynamic live updates, all aspects of graphical elements can change when values change.

L. Acknowledgement and response alarms can be acknowledged with varying degrees of detail, depending on the importance of the alarm. Users can be required to enter notes or choose from a standard list to explain how the issue was resolved. WebStation can present the user with instructions or a specific view of their system that shows details of the affected equipment. The alarm log records the user’s actions.

M. It is important to log more than basic activity. The software logs every action with a timestamp, the user who performed the action, and the values that were changed.

N. The software can trend data in many ways, including a periodic method (every day, hour, minute) and a change-of-value (COV) method that only records when a defined threshold has been passed. These trend logs can be shown in trend lists and charts to visualize patterns for diagnostic and optimization purposes. Multiple series can be presented in a single chart, so that data points can be easily compared.

O. WebStation is based on standard web technologies and requires no special configuration on the clientor server side. Platform-independent technologies make it run on most popular browsers. No Schneider Electric specific software has to be installed and maintained on the client computers.

P. Energy efficiency is achieved when equipment is running only when necessary. Schedules manage that process through a graphical interface that is easy-to-use. Change times with a few simple clicks of the mouse. The powerful Schedule Editor can set up recurring events (every Monday, every third Tuesday, or every January 1st) or an unlimited number of exceptions with

priority levels. Schedules go beyond the basic on and off control by enabling direct control of analog values. For example, users can set schedule events to percentages to control lighting levels without writing a program.

Q. SmartStruxure solution supports customized views of all system events, including alarms and user activity. Each view can be filtered on any event property. Fonts, colors, column sizes, and order can all be specified by the user.

R. Trend charts are easy to create. The color and weight of all lines can be specified. Display of digital data is automatically shown as high and low horizontal bars, eliminating the need for additional scaling. Log data can be presented as average, minimum, maximum, or delta in addition to the actual log value itself. Users can zoom in to see details without losing clarity. A trend chart can have two different scales on the same chart to see how different data relate to each other.

1.18 OPERATOR WORKSTATION REQUIREMENTS

A. General.

The BAS workstation software shall be configurable as a multi-workstation system where the database is located on a central file server in the physical plant. The client software on multi-workstation system shall access the file server database program via an Ethernet TCP/IP network running at either 10MBPS or 100MBPS. All Workstations shall be Pentium II based personal computers operating under the Microsoft NT operating system. The application software shall be capable of communication to all Network Control Units and Standalone Digital Control Units, feature high-resolution color graphics, alarming, reporting, and be user configurable for all data collection and data presentation functions.

For multi-workstation systems, a minimum of 256 workstations shall be allowed on the Ethernet network along with the central file server. In this client/server configuration, any changes or additions made from one workstation will automatically appear on all other workstations without the requirement for manual copying of files. Multi-workstation systems with no central database will not be acceptable. Multi-workstation systems with distributed/tiered file servers and a central (master) database will not be acceptable.

B. Workstation Requirements

The workstation shall consist of the following:

3.6 GHz Intel Core i5 processor with 12GB of RAM

Microsoft Windows operating system (latest version compatible with BMS software)

Serial port, parallel port

10/100MBPS Ethernet NIC

500 GB hard disk

CD-ROM drive

High resolution (minimum 1080 x 1920), 17” flat panel display

Mouse

Full function keyboard

Audio sound card and speakers

License agreement for all applicable software.

C. File Server Hardware Requirements.

The file server computer shall contain of the following:

3.6 GHz Intel Core 2 Duo processor with 64GB of RAM

Microsoft Windows operating system (latest version compatible with BMS software)

10/100MBPS Ethernet NIC

500 GB hard disk storage

Mouse

Full function keyboard

License agreement for all applicable software.

Provide one Windows 2000-compatible 56 Kbaud modem.

D. Printer

Provide an alarm printer and a separate report/graphics printer. The alarm printer shall be an Epson dot matrix or equivalent and the report printer shall be a HP LaserJet.

E. Monitor;

1. The monitor shall be flat screen minimum of 22" (16"x20"), LED type, 1920x1080 resolution, 16:9 aspect ratio, VGA.

F. Workstation Software

1. General Description

The software architecture must be object-oriented in design, a true 32-bit application suite utilizing Microsoft's OLE, COM, DCOM and ODBC technologies. These technologies make it easy to fully utilize the power of the operating system to share, among applications (and therefore to the users of those applications), the wealth of data available from the BAS.

The workstation functions shall include monitoring and programming of all DDC controllers. Monitoring consists of alarming, reporting, graphic displays, long term data storage, automatic data collection, and operator-initiated control actions such as schedule and setpoint adjustments.

Programming of controllers shall be capable of being done either off-line or on-line from any operator workstation. All information will be available in graphic or text displays. Graphic displays will feature animation effects to enhance the presentation of the data, to alert operators of problems, and to facilitate location of information throughout the DDC system. All operator functions shall be selectable through a mouse.

2. System Database

The files server database engine must be Microsoft SQL Server, or another ODBC-compliant, relational database program. This ODBC (Open Database Connectivity)-compliant database engine allows for an owner to utilize "their" choice of database and due to its "open" architecture, allows an owner to write custom applications and/or reports which communicate directly with the database avoiding data transfer routines to update other applications. The system database shall contain all point configurations and programs in each of the controllers that have been assigned to the network. In addition,

the database will contain all workstation files including color graphic, alarm reports, text reports, historical data logs, schedules, and polling records.

3. User Interface

   The BAS workstation software shall allow the creation of a custom, browser-style interface linked to the user that has logged into the workstation software. This interface shall support the creation of "hot-spots" that the user may link to view/edit any object in the system or run any object editor or configuration tool contained in the software. Furthermore, this interface must be able to be configured to become a user's "PC Desktop" – with all the links that a user needs to run other applications. This, along with the Windows 10 user security capabilities, will enable a system administrator to setup workstation accounts that not only limit the capabilities of the user within the BAS software but may also limit what a user can do on the PC and/or LAN/WAN. This might be used to ensure, for example, that the user of an alarm monitoring workstation is unable to shut down the active alarm viewer and/or unable to load software onto the PC.

4. User Security

   The software shall be designed so that each user of the software can have a unique username and password. This username/password combination shall be linked to a set of capabilities within the software, set by and editable only by, a system administrator. The sets of capabilities shall range from View only, acknowledge alarms, Enable/disable and change values, Program, and Administer. The system shall allow the above capabilities to be applied independently to each and every class of object in the system. The system must allow a minimum of 256 users to be configured per workstation. There shall be an inactivity timer adjustable in software that automatically logs off the current operator after the timer has expired.

5. Configuration Interface

   The workstation software shall use a familiar Windows Explorer™-style interface for an operator or programmer to view and/or edit any object (controller, point, alarm, report, schedule, etc.) in the entire system. In addition, this interface shall present a "network map" of all controllers and their associated points, programs, graphics, alarms, and reports in an easy to understand structure. All object names shall be alphanumeric and use Windows long filename conventions. Object names shall not be required to be unique throughout the system. This allows consistency in point naming. For example, each fan coil unit controller can have an input called Space Temperature and a setpoint called CFM Setpoint. The FCU controller name shall be unique such as FCU for LAB101. Systems requiring unique object names throughout the system will not be acceptable.

   The configuration interface shall also include support for template objects. These template objects shall be used as building blocks for the creation of the BAS database. The types of template objects supported shall include all data point types (input, output, string variables, setpoints, etc.), alarm algorithms, alarm notification objects, reports, graphics displays, schedules, and programs. Groups of template object types shall be able to be set up as template subsystems and systems. The template system shall prompt for data entry if necessary. The template system shall maintain a link to all "child" objects created by each template. If a user wishes to make a change to a template object, the software shall ask the user if he/she wants to update all of child objects with the change. This template system shall facilitate configuration and programming consistency and afford the user a fast and simple method to make global changes to the BAS.

6. Color Graphic Displays

The system shall allow for the creation of user defined, color graphic displays for the viewing of mechanical and electrical systems, or building schematics. These graphics shall contain point information from the database including any attributes associated with the point (engineering units, etc.). In addition operators shall be able to command equipment or change setpoints from a graphic through the use of the mouse. Requirements of the color graphic subsystem include:

a. SVGA, bit-mapped displays. The user shall have the ability to import AutoCAD generated picture files as background displays.
b. A built-in library of animated objects such as dampers, fans, pumps, buttons, knobs, gauges, ad graphs which can be "dropped" on a graphic through the use of a software configuration "wizard". These objects shall enable operators to interact with the graphic displays in a manner that mimics their mechanical equivalents found on field installed control panels. Using the mouse, operators shall be able to adjust setpoints, start or stop equipment, modify PID loop parameters, or change schedules.
c. Status changes or alarm conditions must be able to be highlighted by objects changing screen location, size, color, text, blinking or changing from one display to another.
d. Graphic panel objects shall be able to be configured with multiple "tabbed" pages allowing an operator to quickly view individual graphics of equipment, which make up a subsystem or system.
e. Ability to link graphic displays through user defined objects, alarm testing, or the result of a mathematical expression. Operators must be able to change from one graphic to another by selecting an object with a mouse - no menus will be required.
f. Automatic monitoring

   The software shall allow for the automatic collection of data and reports from any controller through either a hardwire or modem communication link. The frequency of data collection shall be completely user-configurable.

g. Alarm Management

   The software shall be capable of accepting alarms directly from controllers, or generating alarms based on evaluation of data in controllers and comparing to limits or conditional equations configured through the software. Any alarm (regardless of its origination) will be integrated into the overall alarm management system and will appear in all standard alarm reports, be available for operator acknowledgment, and have the option for displaying graphics, or reports.

   Alarm management features shall include:

   1) A minimum of 255 alarm notification levels. Each notification level will establish a unique set of parameters for controlling alarm display, acknowledgment, keyboard annunciation, alarm printout and record keeping.
   2) Automatic logging in the database of the alarm message, point name, point value, connected controller, timestamp, username and time of acknowledgement, username and time of alarm silence (soft acknowledgement)
   3) Automatic printing of the alarm information or alarm report to an alarm printer or report printer.

4) Playing an audible beep or audio (wav) file on alarm initiation or return to normal.
5) Sending an email or alphanumeric page to anyone listed in a workstation's email account address list on either the initial occurrence of an alarm and/or if the alarm is repeated because an operator has not acknowledged the alarm within a user-configurable timeframe. The ability to utilize email and alphanumeric paging of alarms shall be a standard feature of the software integrated with the operating system's mail application interface (MAPI). No special software interfaces shall be required.
6) Individual alarms shall be able to be re-routed to a workstation or workstations at user-specified times and dates. For example, a critical high temp alarm can be configured to be routed to a Facilities Dept. workstation during normal working hours (7am-6pm, Mon-Fri) and to a Central Alarming workstation at all other times.
7) An active alarm viewer shall be included which can be customized for each user or user type to hide or display any alarm attributes.
8) The font type and color, and background color for each alarm notification level as seen in the active alarm viewer shall be customizable to allow easy identification of certain alarm types or alarm states.
9) The active alarm viewer can be configured such that an operator must type in text in an alarm entry and/or pick from a drop-down list of user actions for certain alarms. This ensures accountability (audit trail) for the response to critical alarms.

h. Custom Report Generation

The software will contain a built-in custom report generator, featuring word processing tools for the creation of custom reports. These custom reports shall be able to be set up to automatically run or be generated on demand. Each workstation shall be able to associate reports with any word processing or spreadsheet program loaded on the machine. When the report is displayed, it will automatically spawn the associated report editor such as MS Word™.

1) Reports can be of any length and contain any point attributes from any controller on the network.
2) The report generator will have access to the user programming language in order to perform mathematical calculations inside the body of the report, control the display output of the report, or prompt the user for additional information needed by the report.
3) It shall be possible to run other executable programs whenever a report is initiated.
4) Report Generator activity can be tied to the alarm management system, so that any of the configured reports can be displayed in response to an alarm condition.
5) Standard reports shall include:

    a) Points in each controller.
    b) Points in alarm
    c) Disabled points
    d) Overridden points

e) Operator activity report
f) Alarm history log.
g) Program listing by controller with status.
h) Network status of each controller

i. Spreadsheet-style reports

The software shall allow the simple configuration of row/column (spreadsheet-style) reports on any class of object in the system. These reports shall be user-configurable and shall be able to extract live (controller) data and/or data from the database. The user shall be able to set up each report to display in any text font, color and background color. In addition, the report shall be able to be configured to filter data, sort data and highlight data which meets user-defined criteria.

j. HTML Reporting

The above spreadsheet-style reports shall be able to be run to an HTML template file. This feature will create an HTML "results" file in the directory of the HTML template. This directory can be shared with other computer users, which will allow those users with access to the directory to "point" their web browser at the file and view the report.

k. Scheduling- It shall be possible to configure and download from the workstation schedules for any of the controllers on the network.

1) Time of day schedules shall be in a calendar style and shall be programmable for a minimum of one year in advance. Each standard day of the week and user-defined day types shall be able to be associated with a color so that when the schedule is viewed it is very easy, at-a-glance, to determine the schedule for a particular day even from the yearly view. To change the schedule for a particular day, a user shall simply click on the day and then click on the day type.
2) Each schedule will appear on the screen viewable as the entire year, monthly, week and day. A simple mouse click shall allow switching between views. It shall also be possible to scroll from one month to the next and view or alter any of the schedule times.
3) Schedules will be assigned to specific controllers and stored in their local RAM memory. Any changes made at the workstation will be automatically updated to the corresponding schedule in the controller.

l. Programmer's Environment

The programmer's environment will include access to a superset of the same programming language supported in the controllers. Here the programmer will be able to configure application software off-line (if desired) for custom program development, write global control programs, system reports, wide area networking data collection routines, and custom alarm management software. On the same screen as the program editor, the programming environment shall include dockable debug and watch bars for program debugging and viewing updated values and point attributes during programming. In addition, a wizard tool shall be available for loading programs from a library file in the program editor.

m. Saving/Reloading

The workstation software shall have an application to save and restore field controller memory files. This application shall not be limited to saving and reloading an entire

controller – it must also be able to save/reload individual objects in the controller. This allows off-line debugging of control programs, for example, and then reloading of just the modified information.

n. Data Logging

The workstation software shall have the capability to easily configure groups of data points with trend logs and display the trend log data. A group of data points shall be created by drag-and-drop method of the points into a folder. The trend log data shall be displayed through a simple menu selection. This data shall be able to be saved to file and/or printed.

o. Audit Trail

The workstation software shall automatically log and timestamp every operation that a user performs at a workstation, from logging on and off a workstation to changing a point value, modifying a program, enabling/disabling an object, viewing a graphic display, running a report, modifying a schedule, etc.

p. Fault Tolerant File Server Operation

The system shall provide the option to provide fault tolerant operation in the event of the loss of the CPU, disk drives, or other hardware required to maintain the operational integrity of the system. Operational integrity includes all user interfaces, monitoring of alarm points and access points, and executing access control functions.

The switchover mechanism provided shall be automatic. Should the failure be caused by hardware, then the system shall immediately switch to the Backup computer. Should the system failure be caused by software (instruction or data), the system shall not pass the faulted code to the Backup computer, otherwise the Backup shall fail in the same manner of the Primary computer.

Switchover to the Backup computer shall be initiated and effective (complete) in a manner and time frame that precludes the loss of event data, and shall be transparent to the system users, except for an advisory alarm message indicating that the switchover has occurred.

When the system fails-over from the Primary to the Backup computer, no alarm or other event shall be lost, and the Backup computer shall take control of all system functions.

A single component failure in the system shall not cause the entire system to fail. All system users shall be informed of any detectable component failure via an alarm event. System users shall not be logged off as a result of a system failure or switchover.

The Primary computer shall provide continual indication that the Backup computer is unavailable until such time that the fault has been purged.

1.19 DDC SENSORS AND POINT HARDWARE

A. Temperature Sensors

1. All temperature devices shall use precision thermistors accurate to +/- 1 degree F over a range of –30 to 230 degrees F. Space temperature sensors shall be accurate to +/- .5 degrees F over a range of 40 to 100 degrees F.

2. Space sensors shall have off white enclosure and shall be mounted on a standard electrical box. Space sensors shall use surface mounted finished cast electrical box for surface mounting with metal “wire-mold” to conceal wiring for all solid masonry

partitions. For space sensors located on gypsum board partitions, wiring shall be concealed inside the walls with recessed flush mounted electrical boxes. In general, control wiring shall run from the ceiling plenum to the box which shall be wall mounted next to the door or as shown on plan. (This shall be the standard for this project)

3. The space sensor housing shall utilize buttons for adjusting the space temperature set-point, as well as a push button for selecting after hours operation, fan speed and all and other operator selectable parameters. Operators shall be able to adjust set points directly from the sensor. All space sensors, (located in public location, office), shall incorporate either an LED or LCD display for viewing the space temperature, set-point and other operator selectable parameters. Space sensors located in store rooms, MER, and unoccupied space are not required have LED or LCD display.

4. Duct temperature sensors shall incorporate a thermistor bead embedded at the tip of a stainless steel tube. Probe style duct sensors are useable in air handling applications where the coil or duct area is less than 14 square feet.

5. Averaging sensors shall be employed in ducts which are larger than 14 square feet. The averaging sensor tube must contain at least one thermistor for every 3 feet, with a minimum tube length of 12 feet.

6. Immersion sensors shall be employed for measurement of temperature in all chilled and hot water applications as well as refrigerant applications. Thermal wells shall be brass or stainless steel for non-corrosive fluids below 250 degrees F and 300 series stainless steel for all other applications. Water temperature sensors shall be accurate to +/- .5 degrees F over a range of –30 to 230 degrees F.
7. A pneumatic signal shall not be allowed for anything.

B. Humidity Sensors

1. Humidity devices shall be accurate to +/- 5% at full scale for space and +/- 3% for duct and outside air applications. Suppliers shall be able to demonstrate that accuracy is NIST traceable.
2. Provide a hand held field calibration tool that both reads the output of the sensor and contains a reference sensor for ongoing calibration.

C. Pressure Sensors

1. Air pressure measurements in the range of 0 to 10” water column will be accurate to +/- .5% using a solid-state sensing element. Acceptable manufacturers include Modus Instruments and Mamac.

2. Differential pressure measurements of liquids or gases shall be accurate to =/- 0.5% of range. The housing shall be NEMA 4 rated.

D. Current and KW Sensors

1. Current status switches shall be used to monitor fans, pumps, motors and electrical loads. Current switches shall be available in solid and split core models, and offer either a digital or an analog signal to the automation system. Acceptable manufacturer is Veris or approved equal.

2. Measurement of three phase power shall be accomplished with a kW/kWH transducer. This device shall utilize direct current transformer inputs to calculate the instantaneous

value (kW) and a pulsed output proportional to the energy usage (kWH). Provide Veris Model 6000 Power Transducer or approved equal.

E. Current Status Switches for Variable Frequency Drive Application

1. Acceptable Manufacturer: Veris Industries.
2. General: Microprocessor controlled, self-learning, self-calibrating current sensor to detect motor undercurrent and overcurrent situations such as belt loss, coupling shear, and mechanical failure on variable loads. Sensor shall store motor current as operating parameter in non-volatile memory. Push-button to clear memory and relearn.
3. Visual LED indicator for status.
4. Alarm Limits: ±20% of learned current in every 5 Hz freq. band
5. Split core sensor, induced powered from monitored load and isolated to 600 VAC rms. Sensor shall indicate status from 1.5 A to 150 A and from 12 to 115 Hz.
6. Normally open current sensor output. 0.1A at 30 VAC/DC.
7. Basis of Design: Veris Model H614.

F. Flow Sensors

1. Provide an insertion vortex flowmeter for measurement of liquid, gas or steam flows in pipe sizes above 3 inches.
2. Install the flow meter on an isolation valve to permit removal without process shutdown.
3. Sensors shall be manufactured by EMCO or approved equal.

G. Electric/Pneumatic Transducers

1. Electric to pneumatic transducers shall operate from either a PWM or analog signal. E/P transducers shall be rated for 0 - 20 psi operation and accurate to 2% of full scale. E/P transducers shall have a maximum air consumption of 100 SCIM.
2. E/P transducers may be installed at the end device (damper or valve), or mounted separately in a field interface panel, or as part of the controller. All transducers will be calibrated.

H. Electric/Pneumatic Solenoid Valves

Electric solenoid operated pneumatic valves (EP's) shall have a three-port operation: common, normally open and normally closed. They shall be rated for 50 psig when used for 25 psig or less applications, or rated for 150 psig when used for 100 psig or less applications. The coils shall be equipped with transient suppression devices to limit transients to 150 percent of the rated coil voltage.

I. Liquid Differential Pressure Transmitters:
1. Acceptable Manufacturer: Veris Industries
2. Transmitter shall be microprocessor based
3. Transmitter shall use two independent gauge pressure sensors to measure and calculate differential pressure
4. Transmitter shall have 4 switch selectable ranges
5. Transmitter shall have test mode to produce full-scale output automatically.
6. Transmitter shall have provision for zeroing by pushbutton or digital input.
7. Transmitter shall have field selectable outputs of 0-5V, 0-10V, and 4-20mA.
8. Transmitter shall have field selectable electronic surge damping

9. Transmitter shall have an electronic port swap feature
10. Transmitter shall accept 12-30 VDC or 24 VAC supply power
11. Sensor shall be 17-4 PH stainless steel where it contacts the working fluid.
12. Performance:
    a. Accuracy shall be ±1% F.S. and ±2% F.S. for lowest selectable range
    b. Long term stability shall be ±0.25%
    c. Sensor temperature operating range shall be -4° to 185°F
    d. Operating environment shall be 14° to 131°F; 10-90% RH noncondensing
    e. Proof pressure shall be 2x max. F.S. range
    f. Burst pressure shall be 5x max. F.S. range
    g. Transmitter shall be encased in a NEMA 4 enclosure
    h. Enclosure shall be white powder-coated aluminum
    i. Transmitter shall be available with a certification of NIST calibration
    j. [Transmitter shall be preinstalled on a bypass valve manifold]
    k. Basis of Design: Veris PW

1.20 CONTROL VALVES

A. Provide automatic control valves suitable for the specified controlled media (steam, water or glycol). Provide valves which mate and match the material of the connected piping. Equip control valves with the actuators of required input power type and control signal type to accurately position the flow control element and provide sufficient force to achieve required leakage specification.

B. Control valves shall meet the heating and cooling loads specified, and close off against the differential pressure conditions within the application. Valves should be sized to operate accurately and with stability from 10 to 100% of the maximum design flow.

C. Trim material shall be stainless steel for steam and high differential pressure applications.

D. Electric actuation should be provided on all terminal unit reheat applications.

1.21 DAMPERS

A. Automatic dampers, furnished by the Building Automation Contractor shall be single or multiple blade as required. Dampers are to be installed by the HVAC Contractor under the supervision of the BAS Contractor. All blank-off plates and conversions necessary to install smaller than duct size dampers are the responsibility of the Sheet Metal Contractor.

B. Damper frames are to be constructed of 13 gauge galvanized sheet steel mechanically joined with linkage concealed in the side channel to eliminate noise as friction. Compressible spring stainless steel side seals, and acetal or bronze bearings shall also be provided.

C. Damper blade width shall not exceed eight inches. Seals and 3/8 inch square steel zinc plated pins are required. Blade rotation is to be parallel or opposed as shown on the schedules.

D. For high performance applications, control dampers will meet or exceed the UL Class I leakage rating.

E. Control and smoke dampers shall be Ruskin, or approved equal.

F. Provide opposed blade dampers for modulating applications and parallel blade for two position control.

1.22 DAMPER ACTUATORS

A. Electronic Actuators – the actuator shall be direct coupled over the shaft, enabling it to be mounted directly to the damper shaft without the need for connecting linkage. The actuator shall have electronic overload circuitry to prevent damage. For power-failure/safety applications, an internal mechanical, spring return mechanism shall be built into the actuator housing. Non-spring return actuators shall have an external manual gear release to allow positioning of the damper when the actuator is not powered.

B. Pneumatic Actuators - shall be of the synthetic elastomer diaphragm piston type and shall be fully proportioning unless otherwise specified. They shall have full metal bodies and utilize replaceable diaphragms. Damper actuators on large sections of modulating dampers (>25 sq.ft.) or high face velocity applications (such as fan inlet vanes) shall be equipped with pilot positioners to provide repeatability and quick response. Also provide pilot positioners on steam valves requiring 1/3 – 2/3 operation. (Not used)

PART 3 - EXECUTION

3.1 CONTRACTOR RESPONSIBILITIES

A. General

Installation of the building automation system shall be performed by the Contractor or a subcontractor. However, all installation shall be under the personal supervision of the Contractor. The Contractor shall certify all work as proper and complete. Under no circumstances shall the design, scheduling, coordination, programming, training, and warranty requirements for the project be delegated to a subcontractor.

B. Demolition
1. Remove controls which do not remain as part of the building automation system, all associated abandoned wiring and conduit, and all associated pneumatic tubing and or wiring. The Owner will inform the Contractor of any equipment which is to be removed that will remain the property of the Owner. All other equipment which is removed will be disposed of by the Contractor.

C. Access to Site
1. Unless notified otherwise, entrance to building is restricted. No one will be permitted to enter the building unless their names have been cleared with the Owner or the Owner’s Representative.

D. Code Compliance
1. All wiring shall be installed in accordance with all applicable electrical codes and will comply with equipment manufacturer's recommendations. Should any discrepancy be found between wiring specifications in Division 17 and Division 16, wiring requirements of Division 17 will prevail for work specified in Division 17.

E. Cleanup
1. At the completion of the work, all equipment pertinent to this contract shall be checked and thoroughly cleaned, and all other areas shall be cleaned around equipment provided under this contract.

3.2 WIRING, CONDUIT, AND CABLE

A. All wire will be copper and meet the minimum wire size and insulation class listed below:

Wire Class	Wire Size	Isolation Class
Power	12 Gauge	600 Volt
Class One	14 Gauge Std.	600 Volt
Class Two	18 Gauge Std.	300 Volt
Class Three	18 Gauge Std.	300 volt
Communications	Per Mfr.	Per Mfr.

B. Power and Class One wiring may be run in the same conduit. Class Two and Three wiring and communications wiring may be run in the same conduit.

C. Where different wiring classes terminate within the same enclosure, maintain clearances and install barriers per the National Electric Code.

D. Where wiring is required to be installed in conduit, EMT shall be used. Conduit shall be minimum 1/2 inch galvanized EMT. Set screw fittings are acceptable for dry interior locations. Watertight compression fittings shall be used for exterior locations and interior locations subject to moisture. Provide conduit seal off fitting where exterior conduits enter the building or between areas of high temperature/moisture differential.

E. Flexible metallic conduit (max. 3 feet) shall be used for connections to motors, actuators, controllers, and sensors mounted on vibration producing equipment. Liquid-tight flexible conduit shall be use in exterior locations and interior locations subject to moisture.

F. Junction boxes shall be provided at all cable splices, equipment termination, and transitions from EMT to flexible conduit. Interior dry location J-boxes shall be galvanized pressed steel, nominal four-inch square with blank cover. Exterior and damp location JH-boxes shall be cast alloy FS boxes with threaded hubs and gasketed covers.

G. Where the space above the ceiling is a supply or return air plenum, the wiring shall be plenum rated. Teflon wiring can be run without conduit above suspended ceilings. EXCEPTION: Any wire run in suspended ceilings that is used to control outside air dampers or to connect the system to the fire management system shall be in conduit.

H. Coaxial cable shall conform to RG62 or RG59 rating. Provide plenum rated coaxial cable when running in return air plenums.

I. Fiber optic cable shall include the following sizes; 50/125, 62.5/125 or 100/140.

J. Only glass fiber is acceptable, no plastic.

K. Fiber optic cable shall only be installed and terminated by an experienced contractor. The BAS contractor shall submit to the Engineer the name of the intended contractor of the fiber optic cable with his submittal documents.

L. Hardware Installation

3.3 INSTALLATION PRACTICES FOR WIRING

A. All controllers are to be mounted vertically and per the manufacturer’s installation documentation.

B. The 120VAC power wiring to each Ethernet or Remote Site controller shall be a dedicated run, with a separate breaker. Each run will include a separate hot, neutral and ground wire. The ground wire will terminate at the breaker panel ground. This circuit will not feed any other circuit or device.

C. A true earth ground must be available in the building. Do not use a corroded or galvanized pipe, or structural steel.

D. Wires are to be attached to the building proper at regular intervals such that wiring does not droop. Wires are not to be affixed to or supported by pipes, conduit, etc.

E. Conduit in finished areas, will be concealed in ceiling cavity spaces, plenums, furred spaces and wall construction. Exception; metallic surface raceway may be used in finished areas on masonry walls. All surface raceway in finished areas must be color matched to the existing finish within the limitations of standard manufactured colors.

F. Conduit, in non-finished areas where possible, will be concealed in ceiling cavity spaces, plenums, furred spaces, and wall construction. Exposed conduit will run parallel to or at right angles to the building structure.

G. Wires are to be kept a minimum of three (3) inches from hot water, steam, or condensate piping.

H. Where sensor wires leave the conduit system, they are to be protected by a plastic insert.

I. Wire will not be allowed to run across telephone equipment areas.

3.4 INSTALLATION PRACTICES FOR FIELD DEVICES

A. Well-mounted sensors will include thermal conducting compound within the well to insure good heat transfer to the sensor.

B. Actuators will be firmly mounted to give positive movement and linkage will be adjusted to give smooth continuous movement throughout 100 percent of the stroke.

C. Relay outputs will include transient suppression across all coils. Suppression devices shall limit transients to 150% of the rated coil voltage.

D. Water line mounted sensors shall be removable without shutting down the system in which they are installed.

E. For duct static pressure sensors, the high pressure port shall be connected to a metal static pressure probe inserted into the duct pointing upstream. The low pressure port shall be left open to the plenum area at the point that the high pressure port is tapped into the ductwork.

F. For building static pressure sensors, the high pressure port shall be inserted into the space via a metal tube. Pipe the low pressure port to the outside of the building.

3.5 ENCLOSURES

A. For all I/O requiring field interface devices, these devices where practical will be mounted in a field interface panel (FIP). The Contractor shall provide an enclosure which protects the device(s) from dust, moisture, conceals integral wiring and moving parts.

B. FIPs shall contain power supplies for sensors, interface relays and contactors, safety circuits, and I/P transducers.

C. The FIP enclosure shall be of steel construction with baked enamel finish, NEMA 1 rated with a hinged door and keyed lock. The enclosure will be sized for twenty percent spare mounting space. All locks will be keyed identically.

D. All wiring to and from the FIP will be to screw type terminals. Analog or communications wiring may use the FIP as a raceway without terminating. The use of wire nuts within the FIP is prohibited.

E. All outside mounted enclosures shall meet the NEMA-4 rating.

F. The wiring within all enclosures shall be run in plastic track. Wiring within controllers shall be wrapped and secured.

3.6 IDENTIFICATION

A. Identify all control wires with labeling tape or sleeves using either words, letters, or numbers that can be exactly cross-referenced with as-built drawings.

B. All field enclosures, other than controllers, shall be identified with a bakelite nameplate. The lettering shall be in white against a black or blue background.

C. Junction box covers will be marked to indicate that they are a part of the BAS system.

D. All I/O field devices (except space sensors) that are not mounted within FIP's shall be identified with name plates.

E. All I/O field devices inside FIP's shall be labeled.

3.7 EXISTING CONTROLS.

A. Existing controls which are to be reused must each be tested and calibrated for proper operation. Existing controls which are to be reused and are found to be defective requiring replacement, will be noted to the Owner. (Not applicable. Existing controls shall not be reused)

B. All existing controllers, thermostats, pneumatic tubing, actuators, panels gauges and any device associated with equipment is to be removed completely. Remove pneumatic lines back to wall or floor and cap airtight.

C. The existing compressors shall remain in place and operational to service devices other than in the plant.

3.8 CONTROL SYSTEM SWITCH-OVER

A. Demolition of the existing control system will occur after the new temperature control system is in place including new sensors and new field interface devices.

B. Switch-over from the existing control system to the new system will be fully coordinated with the Owner. A representative of the Owner will be on site during switch-over.

C. The Contractor shall minimize control system downtime during switch-over. Sufficient installation mechanics will be on site so that the entire switch-over can be accomplished in a reasonable time frame.

D. Provide temporary controls as necessary and as required to operate equipment as equipment is phased into operations.

3.9 LOCATION

A. The location of sensors is per mechanical and architectural drawings.

B. Space humidity or temperature sensors will be mounted away from machinery generating heat, direct light and diffuser air streams.

C. Outdoor air sensors will be mounted on the north building face directly in the outside air. Install these sensors such that the effects of heat radiated from the building or sunlight is minimized.

D. Field enclosures shall be located immediately adjacent to the controller panel(s) to which it is being interfaced.

E. The new operator work station shall be located in the operating engineers office near the boiler room.

3.10 SOFTWARE INSTALLATION

A. General.

The Contractor shall provide all labor necessary to install, initialize, start-up and debug all system software as described in this section. This includes any operating system software or other third party software necessary for successful operation of the system.

B. Database Configuration.

The Contractor will provide all labor to configure those portions of the database that are required by the points list and sequence of operation.

C. Color Graphic Slides.

Unless otherwise directed by the owner, the Contractor will provide color graphic displays as depicted in the mechanical drawings for each system and floor plan. For each system or floor plan, the display shall contain the associated points identified in the point list and allow for setpoint changes as required by the owner. Graphically represent each and every piece of equipment in the building, new and existing, all input and put status point, and functional points. This shall include the new fans, chillers, and convectors, existing boilers, water, fuel, and ejection pumps, fan coil units, convectors, air handlers and fans.

D. Reports.

The Contractor will configure a minimum of 6 reports for the owner as listed below:

1. Boiler status
2. Hot water pump report
3. Combustion air fan status
4. Hot water supply and return water temp at the primary loop and secondary loop

E. Documentation

As built software documentation will include the following:

1. Descriptive point lists
2. Application program listing
3. Application programs with comments.
4. Printouts of all reports.
5. Alarm list.

6. Printouts of all graphics

F. Commissioning and System Startup

G. Point to Point Checkout.

Each I/O device (both field mounted as well as those located in FIPs) shall be inspected and verified for proper installation and functionality. A checkout sheet itemizing each device shall be filled out, dated and approved by the Project Manager for submission to the owner or owner's representative.

H. Controller and Workstation Checkout.

A field checkout of all controllers and front-end equipment (computers, printers, modems, etc.) shall be conducted to verify proper operation of both hardware and software. A checkout sheet itemizing each device and a description of the associated tests shall be prepared and submitted to the owner or owner's representative by the completion of the project.

I. System Acceptance Testing

All application software will be verified and compared against the sequences of operation. Control loops will be exercised by inducing a setpoint shift of at least 10% and observing whether the system successfully returns the process variable to setpoint. Record all test results and attach to the Test Results Sheet.

J. Test each alarm in the system and validate that the system generates the appropriate alarm message, that the message appears at all prescribed destinations (workstations or printers), and that any other related actions occur as defined (i.e., graphic panels are invoked, reports are generated, etc.). Submit a Test Results Sheet to the owner.

K. Perform an operational test of each unique graphic display and report to verify that the item exists, that the appearance and content are correct, and that any special features work as intended. Submit a Test Results Sheet to the owner.

L. Perform an operational test of each third-party interface that has been included as part of the automation system. Verify that all points are properly polled, that alarms have been configured, and that any associated graphics and reports have been completed. If the interface involves a file transfer over Ethernet, test any logic that controls the transmission of the file, and verify the content of the specified information.

END OF SECTION 23 09 01.12

SECTION 230923.11 CONTROL VALVES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes control valves and actuators for DDC systems.

1.3 DEFINITIONS

A. Cv: Design valve coefficient.

B. DDC: Direct-digital control.

C. NBR: Nitrile butadiene rubber.

D. PTFE: Polytetrafluoroethylene

E. RMS: Root-mean-square value of alternating voltage, which is the square root of the mean value of the square of the voltage values during a complete cycle.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product, including the following:

1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes.
2. Operating characteristics, electrical characteristics, and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.
3. Product description with complete technical data, performance curves, and product specification sheets.
4. Installation, operation, and maintenance instructions, including factors affecting performance.

B. Shop Drawings:

1. Include plans, elevations, sections, and mounting details.

2. Include details of product assemblies. Indicate dimensions, weights, loads, and required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.
4. Include diagrams for pneumatic signal and main air tubing.

C. Delegated-Design Submittal:

1. Schedule and design calculations for control valves and actuators, including the following:

a. Flow at project design and minimum flow conditions.
b. Pressure differential drop across valve at project design flow condition.
c. Maximum system pressure differential drop (pump close-off pressure) across valve at project minimum flow condition.
d. Design and minimum control valve coefficient with corresponding valve position.
e. Maximum close-off pressure.
f. Leakage flow at maximum system pressure differential.
g. Torque required at worst case condition for sizing actuator.
h. Actuator selection indicating torque provided.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plan drawings and corresponding product installation details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Control valve installation location shown in relationship to room, duct, pipe, and equipment.
2. Size and location of wall access panels for control valves installed behind walls.
3. Size and location of ceiling access panels for control valves installed above inaccessible ceilings.

1.6 CLOSEOUT SUBMITTALS

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

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. ASME Compliance: Fabricate and label products to comply with ASME Boiler and Pressure Vessel Code where required by authorities having jurisdiction.

C. Delegated Design: Engage a qualified professional, to size products where indicated as delegated design.

D. Ground Fault: Products shall not fail due to ground fault condition when suitably grounded.

E. Backup Power Source: Systems and equipment served by a backup power source shall have associated control valve actuators served from a backup power source.

F. Environmental Conditions:

1. Provide electric control valve actuators, with protective enclosures satisfying the following minimum requirements unless more stringent requirements are indicated. Electric control valve actuators not available with integral enclosures, complying with requirements indicated, shall be housed in protective secondary enclosures.

    a. Hazardous Locations: Explosion-proof rating for condition.

G. Body & Trim. Body and trim style and materials shall be in accordance with the manufacturer's recommendations for design conditions and service shown in compliance with the following at a minimum:
1. Valve pattern, three-way or straight through, shall be as indicated on Drawings.
2. Modulating two-way pattern control valves shall have equal percentage flow-throttling characteristics unless otherwise indicated.
3. Modulating three-way pattern water valves shall have linear flow-throttling characteristics. The total flow through the valve shall remain constant regardless of the valve's position
4. Valve bodies shall meet or exceed pressure and temperature class rating based upon design operating temperature and 150% design operating pressure. Unless otherwise specified or scheduled, minimum body rating for any valve is 125 psi and a maximum fluid temperature of 350˚F.
5. Valves shall have stainless-steel stems and stuffing boxes with extended necks to clear the piping insulation.
6. Globe valves shall have replaceable seats.
7. Steam control valves shall have an end switch.

H. Determine control valve sizes and flow coefficients by ISA 75.01.01.
1. Water Valves. Unless otherwise specified or scheduled, water valves shall follow the following criteria:
    a. Two-position service: Line size.
    b. Two-way modulating service: Pressure drop shall be equal to twice the pressure drop through the heat exchanger (coil, load, etc.), 50% of the pressure difference between the supply and return mains, or 5 psi (Maximum).
    c. Three-way modulating service: Pressure drop shall be equal to twice the pressure drop through the heat exchanger (coil, load, etc.), (5 psi) maximum.
    d. Valves 1/2" through 2" shall be bronze or cast brass body ANSI Class 250, spring-loaded, PTFE packing quick opening for two-position service.
    e. Valves larger than 2 ½" and shall be cast iron ANSI Class 125 with guided plug and PTFE packing.
    f. Valves 1/2" through 2" shall be ANSI/ASME B1.20.1 (NPT) threaded connections.
    g. Valves 2 ½"to 3" shall use flanged connections.

2. Steam Valves. Body and trim style and materials shall be in accordance with the manufacturer's recommendations for design conditions and service shown in compliance with the following at a minimum:
   a. Linear percentage ports for modulating service.
   b. Two-position service: Pressure drop 10% to 20% of inlet pressure.
   c. Modulating service: 15 psig or less; pressure drop 80% of inlet pressure.
   d. Modulating service: 16-50 psig or less; pressure drop 50% of inlet pressure.
   e. Modulating service: Greater than 50 psig; pressure drop as scheduled

I. Control valve characteristics and rangeability of 50;1 and shall comply with ISA 75.11.01.

J. Control valve shutoff classifications shall be FCI 70-2, Class IV. Close-Off/Differential Pressure Rating. All valves shall be guaranteed to have not more than 1% leakage of design flow rate at the pump shut-off pressure. All valve actuators and trim shall be furnished to provide the following minimum close-off pressure ratings unless otherwise specified or scheduled:
   1. Two-way water valves: 150% of total system (pump) head.
   2. Three-way water valves: 300% of pressure differential between ports A and B at design flow or 100% of total system (pump) head (whichever is greater).
   3. Steam valves: 150% of operating (inlet) pressure.

K. Fail positions unless otherwise indicated:
   1. Chilled Water: close
   2. Condenser Water: close
   3. Heating Hot Water: Open.
   4. Steam: Open.
   5. Valves for steam and hot water service between 210F and 250F shall have all internal trim (including seats, rings, modulating plugs and springs) of Type 316 Stainless Steel
   6. Valves for hot water service below 210F shall have all internal trim (including seats, rings, modulating plugs and springs) of Brass, Bronze or Type 316 Stainless Steel

2.2 BALL-STYLE CONTROL VALVES

A. General:
   1. All control ball valves shall feature characterized flow guides when used for modulating applications.

B. Ball Valves with Single Port and Characterized Disk:

   1. Manufacturers: Subject to compliance with requirements, provide products by the following:
      a. Belimo Aircontrols (USA), Inc
      b. Nibco
      c. Bray
      d. Jflow

   2. Pressure Rating for NPS 1 and Smaller: Nominal 600 WOG.
   3. Pressure Rating for NPS 1-1/2 through NPS 2: Nominal 400 WOG.
   4. Close-off Pressure: 200 psig.
   5. Process Temperature Range: Zero to 212 deg F.

6. Body and Tail Piece: Cast bronze ASTM B 61, ASTM B 62, ASTM B 584, or forged brass with nickel plating.
7. End Connections: Threaded (NPT) ends.
8. Ball: Chrome-plated brass or bronze or 300 series stainless steel.
9. Stem and Stem Extension:

    a. Material to match ball.
    b. Blowout-proof design.
    c. Sleeve or other approved means to allow valve to be opened and closed without damaging the insulation or the vapor barrier seal.

10. Ball Seats: Reinforced PTFE.
11. Stem Seal: Reinforced PTFE packing ring with a threaded packing ring follower to retain the packing ring under design pressure with the linkage removed. Alternative means, such as EPDM O-rings, are acceptable if an equivalent cycle endurance can be demonstrated by testing.
12. Flow Characteristic: Equal percentage.

C. Ball Valves with Two Ports and Characterized Disk:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:
    a. Belimo Aircontrols (USA), Inc.
    b. Nibco
    c. Bray
    d. Jflow

2. Pressure Rating for NPS 1 and Smaller: Nominal 600 WOG.
3. Pressure Rating for NPS 1-1/2 through NPS 2: Nominal 400 WOG.
4. Close-off Pressure: 200 psig.
5. Process Temperature Range: Zero to 212 deg F.
6. Body and Tail Piece: Cast bronze ASTM B 61, ASTM B 62, ASTM B 584, or forged brass with nickel plating.
7. End Connections: Threaded (NPT) ends.
8. Ball: Chrome-plated brass or bronze or 300 series stainless steel].
9. Stem and Stem Extension:

    a. Material to match ball.
    b. Blowout-proof design.
    c. Sleeve or other approved means to allow valve to be opened and closed without damaging the insulation or the vapor barrier seal.

10. Ball Seats: Reinforced PTFE.
11. Stem Seal: Reinforced PTFE packing ring with a threaded packing ring follower to retain the packing ring under design pressure with the linkage removed. Alternative means, such as EPDM O-rings, are acceptable if an equivalent cycle endurance can be demonstrated by testing.
12. Flow Characteristics for A-Port: Equal percentage.
13. Flow Characteristics for B-Port: Modified for constant common port flow.

D. Ball Valves with Single Port and Segmented Ball:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:
    a. Valve Solutions, Inc.
    b. Nibco
    c. Bray
    d. Jflow
2. ASME B16.10 face-to-face dimensions.
3. Valves NPS 2 and Smaller: Threaded (NPT) ends.
4. Valves NPS 2-1/2 through NPS 6: Flanged ends suitable for mating to ASME B16.5 flanges.
5. Body: Carbon or stainless steel.
6. Ball and Shaft: Stainless steel.
7. Shaft and Segmented Ball: Pinned and welded.
8. Ball Seat: Graphite.
9. Packing: PTFE V-rings and graphite packing follower.
10. Replaceable seat, ball, and shaft packing.
11. Label each valve with following:
    a. Manufacturer's name, model number, and serial number.
    b. Body size.
    c. Flow directional arrow.

E. Ball Valves with Full Ball and Characterized V-Notch:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:
    a. Flow-Tek, Inc.
    b. Nibco
    c. Bray
    d. Jflow
2. Performance:
    a. Process Temperature Rating: Minus 20 to plus 500 deg F.
    b. ASME B16.34, Class 600 for NPS 2 and smaller; Class 150 or Class 300 for larger than NPS 2.
    c. Leakage: FCI 70-2, Class VI, bi-directional.
    d. Rangeability: Varies from 200 to 1 up to 800 to 1 based on notch pattern of ball.
    e. Rotation: Zero to 90 degrees.
    f. Equal percentage flow characteristic.
    g. Full port.
3. Face-to-Face Dimension: ASME B16.10 long pattern.
4. Valves NPS 2 and Smaller: ASME B1.20.1 threaded (NPT) ends and three-piece body.
5. Valves NPS 2-1/2 through NPS 12: Flanged ends suitable for mating to ASME B16.5 flanges and two-piece body.
6. Hole in the stem slot of each ball equalizes pressure between the body cavity and the line media flow.
7. Replaceable seat, ball, and shaft packing.

8. Body: Carbon or stainless steel.
9. Ball and Shaft: Stainless steel.
10. Ball Seat: RPTFE.
11. Stem Seals for Valves NPS 2 and Smaller: Live-loaded, self-adjusting, primary and secondary sealing using belleville washers.

    a. Primary Seal: Combination of thrust washer and thrust washer protector.
    b. Secondary Seal: Adjustable stem packing composed of RPTFE V-rings.

12. Stem Seals for Valves Larger than NPS 2: Independent packing gland, adjusted without removing mounting hardware or operator, and contoured to uniformly distribute load across packing.

    a. Primary Seal: Combination of thrust washer and thrust washer protector.
    b. Secondary Seal: Adjustable stem packing composed of RPTFE V-rings.

13. Label each valve with following:

    a. Manufacturer's name, model number, and serial number.
    b. Body size.
    c. Flow directional arrow.

F. Pressure-Independent Ball Valves NPS 2 and Smaller:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Belimo Aircontrols (USA), Inc.
    b. HCI; Hydronics Components Inc.
    c. Nibco
    d. Bray
    e. Jflow

2. Integral Pressure Regulator: Located upstream of ball to regulate pressure, to maintain a constant pressure differential while operating within a pressure differential range of 5 to 50 psig.
3. Body: Forged brass, nickel plated, and with threaded ends.
4. Ball: Chrome-plated brass.
5. Stem and Stem Extension: Chrome-plated brass, blowout-proof design.
6. Stem sleeve or other approved means to allow valve to be opened and closed without damaging field-applied insulation and insulation vapor barrier seal.
7. Ball Seats: Reinforced PTFE.
8. Stem Seal: Reinforced PTFE packing ring stem seal with threaded packing ring follower to retain the packing ring under design pressure with the linkage removed. Alternative means, such as EPDM O-rings, are acceptable if equivalent cycle endurance can be achieved.
9. Flow Characteristic: Equal percentage.

2.3 GLOBE-STYLE CONTROL VALVES

A. General Globe-Style Valve Requirements:

1. Globe-style control valve body dimensions shall comply with ISA 75.08.01.
2. Construct the valves to be serviceable from the top.
3. For cage guided valves, trim shall be field interchangeable for different valve flow characteristics, such as equal percentage, linear, and quick opening.
4. Reduced trim for one nominal size smaller shall be available for industrial valves NPS 1 and larger.
5. Replaceable seats and plugs.
6. Furnish each control valve with a corrosion-resistant nameplate indicating the following:

    a. Manufacturer's name, model number, and serial number.
    b. Body and trim size.
    c. Arrow indicating direction of flow.

B. Two-Way Globe Valves NPS 2 and Smaller:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:

    a. Johnson Controls, Inc.
    b. Belimo Aircontrols (USA), Inc.
    c. Nibco
    d. Bray
    e. Jflow

2. Globe Style: Single port.
3. Body: Cast bronze or forged brass with ASME B16.5, Class 250 rating.
4. End Connections: Threaded.
5. Bonnet: Screwed.
6. Packing: PTFE V-ring.
7. Plug: Top guided.
8. Plug, Seat, and Stem: Brass or stainless steel.
9. Process Temperature Range: 35 to 248 deg F.
10. Ambient Operating Temperature: 35 to 150 deg F.
11. Leakage: FCI 70-2, Class IV.
12. Rangeability: 25 to 1.
13. Equal percentage flow characteristic.

C. Two-Way Globe Valves NPS 2-1/2 to NPS 6:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:

    a. Johnson Controls, Inc.
    b. Belimo Aircontrols (USA), Inc.
    c. HCI; Hydronics Components Inc.
    d. Nibco
    e. Bray

f. Jflow

2. Globe Style: Single port.
3. Body: Cast iron complying with ASME B61.1, Class 125.
4. End Connections: Flanged, suitable for mating to ASME B16.5, Class 150 flanges.
5. Bonnet: Bolted.
6. Packing: PTFE cone-ring.
7. Plug: Top or bottom guided.
8. Plug, Seat, and Stem: Brass or stainless steel.
9. Process Temperature Rating: 35 to 281 deg F.
10. Leakage: 0.1 percent of maximum flow.
11. Rangeability: Varies with valve size between 6 and 10 to 1.
12. Modified linear flow characteristic.

2.4 SOLENOID VALVES

A. Manufacturers: Subject to compliance with requirements, provide products by the following:

1. ASCO Valve, Inc.

B. Description:

1. Action: Either normally open or normally closed in the event of electrical power failure as required by the application.
2. Size to close against the system pressure.
3. Manual override capable.
4. Heavy-duty assembly.
5. Body: Brass or stainless steel.
6. Seats and Discs: NBR or PTFE.
7. Solenoid Enclosure: NEMA 250, Type 4.

2.5 SELF-CONTAINED TEMPERATURE REGULATING VALVE

A. Manufacturers: Subject to compliance with requirements, provide products by the following:

1. Jordan Valve; Richards Industries Company.
2. Danfoss Valve
3. Spartan Valves

B. Description:

1. Self-contained and self-operated temperature regulating valve. Direct acting or reverse acting as required by application.
2. Direct Acting: A rise in temperature at the sensing bulb vaporizes some of the liquid in the bulb, forcing the remaining liquid through a capillary to apply pressure at the diaphragm, in turn closing the valve. The valve shall fail open.
3. Reverse Acting: A rise in temperature at the sensing bulb vaporizes some of the liquid in the bulb, forcing the remaining liquid through a capillary to apply pressure at the diaphragm, in turn opening the valve. The valve shall fail close.

4. Body: Carbon steel.
5. Trim and Seats: 300 series stainless steel.
6. Yoke: Cast iron.
7. Actuator: 300 series stainless steel.
8. End Connections: Threaded.
9. Capillary, Bulb, and Armor: 300 series stainless steel.
10. Thermal Fill Material: Match to the temperature range.
11. Thermowell: Type 316 stainless-steel thermowell sized to fit the bulb and pipe.

C. Operational Characteristics: Control flow from between 5 to 100 percent of rated capacity.

D. Interchangeable trim for one size smaller.

E. Valve Leakage: Comply with FCI 70-2, Class IV.

F. Temperature Range: Match application.

1. Drains from Hot Equipment to Sanitary Sewer System: 105 to 165 deg F.

G. Valve Size: Size to pass the design flow required with not more than 95 percent of the stem lift while operating at design pressure.

2.6 ELECTRIC AND ELECTRONIC CONTROL VALVE ACTUATORS

A. Actuators for Hydronic Control Valves: Capable of closing valve against system pump shutoff head.

B. Actuators for Steam Control Valves: Shutoff against 1.5 times steam design pressure.

C. Position indicator and graduated scale on each actuator.

D. Type: Motor operated, with or without gears, electric and electronic.

E. Voltage: 24-V ac.

F. Deliver torque required for continuous uniform movement of controlled device from limit to limit when operated at rated voltage.

G. Function properly within a range of 85 to 120 percent of nameplate voltage.

H. Construction:

1. For Actuators Less Than 100 W: Fiber or reinforced nylon gears with steel shaft, copper alloy or nylon bearings, and pressed steel enclosures.
2. For Actuators from 100 to 400 W: Gears ground steel, oil immersed, shaft hardened steel running in bronze, copper alloy or ball bearings. Operator and gear trains shall be totally enclosed in dustproof cast-iron, cast-steel or cast-aluminum housing.
3. For Actuators Larger Than 400 W: Totally enclosed reversible induction motors with auxiliary hand crank and permanently lubricated bearings.

4. All control valves shall have a visual position indicator.
5. All non-spring return actuators shall have an external clutch/manual gear release to allow manual positioning of the valve when the actuator is not powered. Spring return actuators with more than 60-in-LB torque capacity shall have a manual crank for this purpose. In lieu of a manual positioning device, it will be acceptable for the contractor to provide a full line size bypass around the control valve. Three bypass shut off valves shall be provided to allow the control valve to be isolated while the open stop valve in the bypass allows flow around the control valve.

I. Field Adjustment:

1. Spring Return Actuators: Easily switchable from fail open to fail closed in the field without replacement.
2. Gear Type Actuators: External manual adjustment mechanism to allow manual positioning when the actuator is not powered.

J. Two-Position Actuators: Single direction, spring return or reversing type.

K. Modulating Actuators:

1. Operation: Capable of stopping at all points across full range, and starting in either direction from any point in range.
2. Control Input Signal:

    a. Three Point, Tristate, or Floating Point: Clockwise and counter-clockwise inputs. One input drives actuator to open position and other input drives actuator to close position. No signal of either input remains in last position.
    b. Proportional: Actuator drives proportional to input signal and modulates throughout its angle of rotation. Suitable for zero- to 10- or 2- to 10-V dc 4- to 20-mA signals.
    c. Pulse Width Modulation (PWM): Actuator drives to a specified position according to pulse duration (length) of signal from a dry contact closure, triac sink, or source controller.
    d. Programmable Multi-Function:

        1) Control Input, Position Feedback, and Running Time: Factory or field programmable.
        2) Diagnostic: Feedback of hunting or oscillation, mechanical overload, mechanical travel, and mechanical load limit.
        3) Service Data: Include, at a minimum, number of hours powered and number of hours in motion.
3. All modulating actuators shall have an external, built-in switch to allow the reversing of direction of rotation

L. Position Feedback:

1. Equip where indicated two-position actuators with limits switches or other positive means of a position indication signal for remote monitoring of open and close position.
2. Equip where indicated, equip modulating actuators with a position feedback through current or voltage signal for remote monitoring.

3. Provide a position indicator and graduated scale on each actuator indicating open and closed travel limits.

M. Fail-Safe:

1. Where indicated, provide actuator to fail to an end position.
2. Internal spring return mechanism to drive controlled device to an end position (open or close) on loss of power.
3. Batteries, capacitors, and other non-mechanical forms of fail-safe operation are acceptable only where uniquely indicated.
4. Any mechanical equipment with direct introduction of outside air shall require fail-safe spring return valve actuators. Terminal equipment (VAV ATU, &c.) without direct introduction of outside air are permitted to have actuators that maintain their last commanded position when power is lost to the actuator. Equipment isolation and differential or temperature pressure bypass valves shall not be required to be provided with a spring return actuator provided that a failure of the valve to return to its “fail-safe” position will not incur damage to property or the system it serves.

N. Integral Overload Protection:

1. Provide against overload throughout the entire operating range in both directions.
2. Electronic overload, digital rotation sensing circuitry, mechanical end switches, or magnetic clutches are acceptable methods of protection.

O. Valve Attachment:

1. Unless otherwise required for valve interface, provide an actuator designed to be directly coupled to valve shaft without the need for connecting linkages.
2. Attach actuator to valve drive shaft in a way that ensures maximum transfer of power and torque without slippage.
3. Bolt and set screw method of attachment is acceptable only if provided with at least two points of attachment.

P. Temperature and Humidity:

1. Temperature: Suitable for operating temperature range encountered by application with minimum operating temperature range of minus 20 to plus 120 deg F.
2. Humidity: Suitable for humidity range encountered by application; minimum operating range shall be from 5 to 95 percent relative humidity, non-condensing.

Q. Enclosure:

1. Suitable for ambient conditions encountered by application.
2. NEMA 250, Type 2 for indoor and protected applications.
3. NEMA 250, Type 4 or Type 4X for outdoor and unprotected applications.
4. Provide actuator enclosure with heater and control where required by application.
5. Actuators used in wet conditions and/or in or near outdoor air streams shall have NEMA 2 housings.

R. Stroke Time:

1. Operate valve from fully closed to fully open within 60 75 90 150 Insert number seconds.
2. Operate valve from fully open to fully closed within 60 seconds.
3. Move valve to failed position within 15 seconds.
4. Select operating speed to be compatible with equipment and system operation.

S. Sound:

1. Spring Return: 62 dBA.
2. Non-Spring Return: 45 dBA.

2.7 POWER SUPPLIES AND LINE FILTERING

A. Power Supplies & Control Transformers. Control transformers and power supplies shall be UL-Listed. Provide Class 2 current-limiting type or over-current protection in both primary and secondary circuits for Class 2 service not to exceed 100 VA in accordance with the applicable following requirements or as directed by the AHJ.
1. NEC 2011 (NFPA 70) Chapter 7 Article 725 – Class 1, Class 2 and Class 3 Remote-Control, Signaling and Power-Limited Circuits.
2. NEC 2011 (NFPA 70) Chapter 9 Table 11(A) and Table 11(B).
3. Canadian Electrical Code, Part 1 (CSA C22.1-12) Rule 16-200.

B. DC Power Supplies. DC power supply output shall match output current and voltage requirements. Power supply shall be half-wave rectified type with the following minimum specifications:
1. Output ripple: 5.0 mV maximum peak-to-peak.
2. Regulation: 1.0% line and load combined.
3. Response: 100 ms for 50% load changes.
4. Built-in overvoltage and overcurrent protection and able to withstand a 150% current overload for a minimum of three (3) seconds without tripping or failure.

C. Power Line Filtering. Provide transient voltage and surge suppression for all workstations and controllers either internally or as an external component.

D. Valve Actuators shall be modulating, floating (tri-state) with feedback signal, two-position and spring return fail safe as called out in the control sequence of operation or indicated on the drawings. All modulating valves shall be positive positioning, and respond to a [0-10VDC] [2-10 VDC] [4-20 mA with a load resistor] with the exception that terminal unit zone valves may use an actuator that responds to a floating or tri-state with feedback signal.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for valves installed in piping to verify actual locations of piping connections before installation.

C. Prepare written report, endorsed by Installer, listing conditions detrimental to performance.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 CONTROL VALVE APPLICATIONS

A. Unless otherwise noted, controls valves shall be globe pattern or ball valves. Use globe for steam and globe or ball for hydronic applications.

B. Do not use butterfly valves for steam service or modulating applications.

3.3 INSTALLATION, GENERAL

A. Furnish and install products required to satisfy most stringent requirements indicated.

B. Install products level, plumb, parallel, and perpendicular with building construction.

C. Properly support instruments, tubing, piping, wiring, and conduits to comply with requirements indicated. Brace all products to prevent lateral movement and sway or a break in attachment when subjected to a force.

D. Provide ceiling, floor, roof, and wall openings and sleeves required by installation. Before proceeding with drilling, punching, or cutting, check location first for concealed products that could potentially be damaged. Patch, flash, grout, seal, and refinish openings to match adjacent condition.

E. Firestop penetrations made in fire-rated assemblies and seal penetrations made in acoustically rated assemblies.

F. Fastening Hardware:

1. Stillson wrenches, pliers, and other tools that will cause injury to or mar surfaces of rods, nuts, and other parts are prohibited for assembling and tightening nuts.
2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by excessive force or by oversized wrenches.
3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.

G. Install products in locations that are accessible and that will permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.

H. Corrosive Environments:

1. Use products that are suitable for environment to which they will be subjected.
2. If possible, avoid or limit use of materials in corrosive environments, including. but not limited to, the following:

    a. Laboratory exhaust airstreams.
    b. Process exhaust airstreams.

3. Use Type 316 stainless-steel tubing and fittings when in contact with a corrosive environment.
4. When conduit is in contact with a corrosive environment, use Type 316 stainless-steel conduit and fittings or conduit and fittings that are coated with a corrosive-resistant coating that is suitable for environment.
5. Where control devices are located in a corrosive environment and are not corrosive resistant from manufacturer, field install products in a NEMA 250, Type 4X enclosure constructed of Type 316L stainless steel.

3.4 ELECTRIC POWER

A. Furnish and install electrical power to products requiring electrical connections.

B. Furnish and install circuit breakers. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers."

C. Furnish and install power wiring, as per electrical specifications

D. Furnish and install raceways as per electrical specifications.

E. Electrical subcontractor shall provide all required line voltage. The mechanical subcontractor shall provide all low voltage wiring and power supply transformers in coordination with the controls subcontractor and control actuator requirements.

3.5 CONTROL VALVES

A. Install pipe reducers for valves smaller than line size. Position reducers as close to valve as possible but at distance to avoid interference and impact to performance. Install with manufacturer-recommended clearance.

B. Install flanges or unions to allow drop-in and -out valve installation.

C. Where indicated, install control valve with three-valve bypass manifold to allow for control valve isolation and removal without interrupting system flow by providing manual throttling valve in bypass pipe.

D. Install drain valves in piping upstream and downstream of each control valve installed in a three-valve manifold and for each control valve larger than NPS 4.

E. Install pressure temperature taps in piping upstream and downstream of each control valve larger than NPS 2.

F. Valve Orientation:

1. Where possible, install globe and ball valves installed in horizontal piping with stems upright and not more than 15 degrees off of vertical, not inverted.
2. Install valves in a position to allow full stem movement.
3. Where possible, install butterfly valves that are installed in horizontal piping with stems in horizontal position and with low point of disc opening with direction of flow.

G. Clearance:

1. Locate valves for easy access and provide separate support of valves that cannot be handled by service personnel without hoisting mechanism.
2. Install valves with at least 12 inches of clear space around valve and between valves and adjacent surfaces.

H. Threaded Valves:

1. Note internal length of threads in valve ends, and proximity of valve internal seat or wall, to determine how far pipe should be threaded into valve.
2. Align threads at point of assembly.
3. Apply thread compound to external pipe threads, except where dry seal threading is specified.
4. Assemble joint, wrench tight. Apply wrench on valve end as pipe is being threaded.

I. Flanged Valves:

1. Align flange surfaces parallel.
2. Assemble joints by sequencing bolt tightening to make initial contact of flanges and gaskets as flat and parallel as possible. Use suitable lubricants on bolt threads. Tighten bolts gradually and uniformly with a torque wrench.

3.6 CONNECTIONS

A. Connect electrical devices and components to electrical grounding system. Comply with electrical specifications

3.7 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Each piece of wire, cable, and tubing shall have the same designation at each end for operators to determine continuity at points of connection. Comply with requirements for identification specified in Section 230553.

B. Install engraved phenolic nameplate with valve identification on valve.

3.8 CLEANING

A. Remove grease, mastic, adhesives, dust, dirt, stains, fingerprints, labels, and other foreign materials from exposed interior and exterior surfaces.

B. Wash and shine glazing.

C. Polish glossy surfaces to a clean shine.

3.9 CHECKOUT PROCEDURES

A. Control Valve Checkout:

1. Check installed products before continuity tests, leak tests, and calibration.
2. Check valves for proper location and accessibility.
3. Check valves for proper installation for direction of flow, elevation, orientation, insertion depth, or other applicable considerations that will impact performance.
4. For pneumatic products, verify air supply for each product is properly installed.
5. For pneumatic valves, verify that pressure gauges are provided in each air line to valve actuator and positioner.
6. Verify that control valves are installed correctly for flow direction.
7. Verify that valve body attachment is properly secured and sealed.
8. Verify that valve actuator and linkage attachment are secure.
9. Verify that actuator wiring is complete, enclosed, and connected to correct power source.
10. Verify that valve ball, disc, and plug travel are unobstructed.
11. After piping systems have been tested and put into service, but before insulating and balancing, inspect each valve for leaks. Adjust or replace packing to stop leaks. Replace the valve if leaks persist.

3.10 ADJUSTMENT, CALIBRATION, AND TESTING

A. Stroke and adjust control valves following manufacturer's recommended procedure, from 100 percent open to 100 percent closed back to 100 percent open.

B. Stroke control valves with pilot positioners. Adjust valve and positioner following manufacturer's recommended procedure, so valve is 100 percent closed, 50 percent closed, and 100 percent open at proper air pressures.

C. Check and document open and close cycle times for applications with a cycle time of less than 30 seconds.

D. For control valves equipped with positive position indication, check feedback signal at multiple positions to confirm proper position indication.

END OF SECTION 230923.11

SECTION 230993 SEQUENCE OF OPERATION

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
1. Summer winter change over
2. Boiler Plant General
3. Hot Water Boiler Plant
4. Steam Boilers
5. Primary pumps
6. Secondary Pumps
7. Cabinet and Unit Heater
8. Cabinet Convectors
9. Heat Exchanger
10. Combustion air fan
11. Induced draft fan
12. Steam zone control valves
13. Miscellaneous

B. Related Sections:

1. Section 230901 “Direct Digital Controls" for automatic temperature controls

1.3 DEFINITIONS

A. BMS; Building Management System

B. ATC; Automatic temperature controls

C. Cx; Commissioning Agent

D. SDCU; Standalone Digital Control Units.

1.4 PERFORMANCE REQUIREMENTS

A. Delegated Design: the installation of the temperature controls system is a delegated design. The sequence of operation is a performance specification that defines the intent of equipment operation.

1.5 ACTION SUBMITTALS

A. Product Data: submit automatic temperature and sequence of operations for review and approval.

B. Shop Drawings: Indicate mechanical system controlled and control system components.

C. Label with settings, adjustable range of control and limits. Include written description of control sequence.

D. Include flow diagrams for each control system, graphically depicting control logic.

E. Include draft copies of graphic displays indicating mechanical system components, control system components, and controlled function status and value.

F. Submit a complete written sequence of operation for each and every controlled piece of equipment.

1.6 SUBMITTALS AT PROJECT CLOSEOUT

A. Operation and Maintenance Data.

B. Project Record Documents: Record actual locations of components and set-points of controls, including changes to sequences made after submission of shop drawings.

1.7 QUALITY ASSURANCE

A. Vender Qualifications: Company specializing in the installation and programming of ATC systems specified in these bid document with minimum of five years in experience. Design system under direct supervision of a Professional Engineer experienced in design of this Work and licensed in the **State of New York.**

PART 2 – PRODUCTS

2.1 SYSTEM DESCRIPTION

A. This Section defines the manner and method by which controls function. Requirements for each type of control system operation are specified. Equipment, devices, and system components required for control systems are specified in other Sections.

B. Provide DDC based electronic controls, panels, wiring and all accessories required to achieve the specified control sequences and establish a complete independent system for all new equipment and existing equipment. In general, the equipment shall be controlled through Standalone Digital Control Units.

C. Provide the necessary quantity and types of SDCU to meet the requirements of the project for mechanical equipment control including air handlers, central plant control, and terminal unit control. Each SDCU will operate completely standalone, containing all of the I/O and programs to control its associated equipment.

D. Certain controls are specified to be furnished with the equipment. This contractor shall provide all components to communicate with factory furnished controls and connect them to the building automation control system. This contractor shall be responsible to review equipment submittals and review and review the controls provided with all packaged equipment to ensure that the equipment is ordered with eh appropriate gateways and MPTP controllers for integration to the BMS system. The contractor shall also provide all controls, wiring and auxiliaries required to operate equipment not furnished with factory controls. Work required includes, but is not limited to the following:

1. Control wiring between factory mounted unit panels and factory supplied remote panels.
2. Installation and wiring for factory supplied devices requiring field installation.

3. Panel mounted transformers and control power wiring for all controllers and control devices.
4. Control wiring to each remote device (room thermostats, outdoor air sensors, static pressure controllers, control actuators, control panels, etc.).
5. All control valves, motorized dampers thermostats, relays, sensors, etc. unless furnished as an integral part of the equipment.
6. All interlock control wiring (24 volt and 120 volt) between units, fans, etc.

E. All control and interlock wiring shall be run in EMT for indoor locations and in galvanized conduit for outdoor locations.

F. All new controllers, hardware and accessories shall be **Schneider Electric, Eco-Struxure.**

PART 3 - EXECUTION

A. SUMMER/WINTER CHANGE OVER

The Building Management System (BMS) shall index the heating system equipment into either summer or winter control based upon outdoor air temperature.
This shall apply to both the hot water and steam systems.
Above 55F, (adjustable), outside air temperature the heating systems shall disable

G. BOILER PLANTS GENERAL:

Boilers shall be operated through an application specific unitary controller that will sequence boilers, pumps dampers, valves and fans. Refer to section 235216 and 235223 for all safeties and combustion control sequences for hot water and steam systems. The controller shall be a microprocessor-based system engineered and programmed exclusively for the operation of multiple hot water boilers.

The communications protocol for the boiler controls shall be based on ASHRA/ANSI BACNET Standard 135-1995. Provide required modules to allow open communication, integration and interoperability with other DDC system. The BMS contractor and boiler manufacturer shall coordinate their work to insure compatibility prior to installation.

H. HOT WATER BOILERS

The BMS system shall enable the hot water system and change the system from cooling to heating operation based on outdoor air temperature. Set point shall be 55 degrees, adjustable for heating. The hot water primary, (BP-1 AND BP-2) circulation pumps shall be interlocked to run continuously when the respective boiler is started. Furnish a flow switch in each of the primary supply water headers and the secondary loop arranged to prevent boiler operation if flow is not proved.

The pump speed shall modulate in proportion to firing rate. 100% firing rate shall correspond to maximum pump speed. Minimum firing rate shall correspond to minimum min pump speed. Typically, 30% of rated max.

The BMS shall sequence the hot water boilers to maintain the secondary hot water loop temperature set-point. The set-point shall be reset based on the outdoor air temperature sensor.

Reset schedule to be 180 F to 130 F hot water supply temperature as outside air varies from 10 F to 55 F. adjustable). Lead boiler selection shall be made by the BMS according to a rotating seven-day schedule.

Alarms
Hot water temperature out of bounds
primary pumps fail
boiler common alarm
low gas pressure
low water level

I. STEAM BOILERS

The BMS system shall change the system from cooling to heating operation based on outdoor air temperature enable the steam system. Set point shall be 55 degrees, adjustable for heating.

1. The burner(s) switch is in the "On" position
2. The outside air temperature is less than 55°F during occupied mode (adjustable) and 45°F during unoccupied mode (adjustable)
3. The BMS shall enable boilers to satisfy and maintain steam supply header set point of less than 3 to 5 psi. (Adjustable).
4. The boilers will be disabled based on a lockout OAT set point of 55°F (adjustable)
5. The BMS will send a stream pressure set point to the boilers based on an OAT reset schedule. With one or two boilers running as needed to maintain set point.
6. The main heating boilers shall be rotated for equal running time in a lead /Lag arrangement.
7. Low water cut off switch shall prevent the burner from firing if the water level in the boiler falls below the low water cut off switch set point. Provide a second low water cut off switch arranged similarly with manual reset.

Boiler feed pumps -

The pumps shall be controlled through a new pump packaged controller and arranged to run in a lead lag arrangement. If the lead pump fails to operate the lag pump will start and an alarm will be generated at the pump control panel and the BMS. Furnish a flow switch in the header of each pump, or a current switch for each motor with adjustable time delay. The pump controller shall rotate the lead and lag pumps for equal running time on a weekly or daily basis, (adjustable). The pumps shall be started and stopped by new water level controller on the new boiler. On a call for feed water the lead pump shall start and the respective solenoid valve for the boiler shall open.

Each boiler feed pump shall be interlocked to run when the respective boiler water level control calls for boiler feed. The pumps shall be run through the boiler feed system manufactures control panel. The standby pump shall be manually selected at the pump controller. Low water cut off switch shall prevent the burner from firing if the water level in the boiler falls below the low water cut off switch set point. Provide a second low water cut off switch arranged similarly with manual reset.

Combustion Air Fan –
The combustion fans shall be interlocked with the new steam boilers. Upon startup of any boiler the fans shall be energized to run. Furnish an air flow switch "sail switch" in the supply duct or a current sensor on the supply fan motor to prove fan operation. The boilers shall be prevented from

firing if the combustion air fan fails to start. After proof of air flow, the boiler's packaged safety and operating controls shall enable them to fire.
An electric duct heater shall maintain combustion air at a set point temperature of 45 degrees adjustable.

1. Alarms
2. pressure out of bounds
3. boiler feed pumps fail
4. boiler common alarm
5. low gas pressure
6. low water level
7. combustion air fan fail

J. HOT WATER SECONDARY PUMPS (SECONDARY HWP-1, HWP-2)

The building secondary pumps shall be utilized as constant volume pumps. The set up and installation will resemble variable speed pumps so that the pumps can be utilized in that way in the future. Variable frequency drives will be provided for each pump. The VFDs will be utilized for final pump balancing in conjunction with balance valves installed at each existing air handling unit. The final pump speed shall be established during the balancing when design flow is achieved at the lowest available pump speed.

When the heating is enabled the lead, pump will be enabled to operate at its design speed setting. If the lead pump fails to operate the lag pump will start and an alarm will be generated at the pump control panel and the BMS. Furnish a flow switch in the header of each secondary pump with adjustable time delay. The BMS system shall rotate the lead and lag pumps for equal running time on a weekly or daily basis, (adjustable).

K. CABINET HEATERS AND UNIT HEATERS (HOT WATER):

Provide a space thermostat set at 72°F adjustable for each hot water cabinet and unit heater. Upon a drop in space temperature below set-point the unit fan shall cycle on and the hot water (or steam) control valve shall open (*or the electric heating element shall be energized*). On a rise in space temperature above set point the reverse shall take place. Provide a strap-on-aquastat to prevent fan and valve operation when hot water is not detected. In summer mode the control valve shall be closed. All control valves positions shall be monitored and indicated on the BMS

L. CABINET CONVECTORS:

Provide a control valve for all units and room thermostats where indicated on plan set at 72°F for each convector Upon a drop-in space temperature below set-point the CV valve shall cycle open. On a rise in space temperature above set point the reverse shall take place. For those zones served by VAV boxes with reheat coils and convectors the controls shall be arranged to operate the VAV box CV and convector CV in sequence. All control valves positions shall be monitored and indicated on the BMS

M. HEAT EXCHANGERS -HX

Heating water HX provide two steam controls valves size for 1/3 and 2/3 of the full HX load to operate in parallel. Provide a temperature sensor in the hot water supply piping from the HX

to the building. The BMS shall be arranged to modulate the controls valves in sequence to maintain HW supply temperature set point. The set point shall be reset based on an outdoor reset schedule. When the OA temp is 10 °F the HWS temp shall be 180°F. when the OA temp is 55°F the HWS temp shall be 140 °F

N. DRAFT INDUCING FAN.

The fan shall be arranged to operate when either of the two steam boilers is energized to run. The fan shall modulate speed to maintain .01" sp negative draft in the stack.

O. STEAM ZONE CONTROL VALVES

The two new steam controls valves shall be operated by two new zone thermostats located on the second floor as per the plans. On a call for heat zone valves shall modulate open period of time. The BMS shall open the valves for a predetermined period of time designed to allow adequate steaming. The valve shall close after that period and be prevented form short cycling through PID programming. Steam control valves shall end switches.

P. MISCELLANEOUS

All safety devices shall be interlocked with "hand" and "Automatic" positions in series with motor controller holding coil circuit. Interlocking with other fans and equipment of system shall be through "Automatic" position "Hand" position shall be for maintenance only. Remote starting shall be from through "automatic" position only.

SECTION 232113 - HYDRONIC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes pipe and fitting materials and joining methods for the following:

1. Hot-water heating piping.
2. Makeup-water piping.
3. Condensate-drain piping.
4. Blowdown-drain piping.
5. Air-vent piping.
6. Safety-valve-inlet and -outlet piping.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of the following:

1. Plastic pipe and fittings with solvent cement.
2. RTRP and RTRF with adhesive.
3. Pressure-seal fittings.
4. Chemical treatment.

B. Delegated-Design Submittal:

1. Design calculations and detailed fabrication and assembly of pipe anchors and alignment guides, hangers and supports for multiple pipes, expansion joints and loops, and attachments of the same to the building structure.
2. Locations of pipe anchors and alignment guides and expansion joints and loops.
3. Locations of and details for penetrations, including sleeves and sleeve seals for exterior walls, floors, basement, and foundation walls.
4. Locations of and details for penetration and firestopping for fire- and smoke-rated wall and floor and ceiling assemblies.
5. For underground piping provide size and quantity of pipe expansion loops and thrust blocks.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Piping layout, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Suspended ceiling components.
2. Other building services.
3. Structural members.

B. Qualification Data: For Installer.

C. Welding certificates.

D. Field quality-control reports.

E. Water Analysis: Submit a copy of the water analysis to illustrate water quality available at Project site.

1.5 QUALITY ASSURANCE

A. Installer Qualifications:

1. Installers of Pressure-Sealed Joints: Installers shall be certified by pressure-seal joint manufacturer as having been trained and qualified to join piping with pressure-seal pipe couplings and fittings.

B. Steel Support Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

C. Pipe Welding: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code: Section IX.

1. Comply with ASME B31.9, "Building Services Piping," for materials, products, and installation.
2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Hydronic piping components and installation shall be capable of withstanding the following minimum working pressure and temperature unless otherwise indicated:

1. Hot-Water Heating Piping: 150 psig at 200 deg F.
2. Makeup-Water Piping: 60 psig at 150 deg F.
3. Condensate-Drain Piping: 150 deg F.
4. Blowdown-Drain Piping: 200 deg F.
5. Air-Vent Piping: 200 deg F.
6. Safety-Valve-Inlet and -Outlet Piping: Equal to the pressure of the piping system to which it is attached.

2.2 COPPER TUBE AND FITTINGS

A. Drawn-Temper Copper Tubing: ASTM B 88, Type L.

B. Annealed-Temper Copper Tubing: ASTM B 88, Type K.

C. DWV Copper Tubing: ASTM B 306, Type DWV.

D. Wrought-Copper Unions: ASME B16.22.

2.3 STEEL PIPE AND FITTINGS

A. Steel Pipe: ASTM A 53/A 53M, black steel with plain ends; welded and seamless, Grade B, and wall thickness as indicated in "Piping Applications" Article.

B. Cast-Iron Threaded Fittings: ASME B16.4; Classes 125 and 250 as indicated in "Piping Applications" Article.

C. Malleable-Iron Threaded Fittings: ASME B16.3, Classes 150 and 300 as indicated in "Piping Applications" Article.

D. Malleable-Iron Unions: ASME B16.39; Classes 150, 250, and 300 as indicated in "Piping Applications" Article.

E. Cast-Iron Pipe Flanges and Flanged Fittings: ASME B16.1, Classes 25, 125, and 250; raised ground face, and bolt holes spot faced as indicated in "Piping Applications" Article.

F. Wrought-Steel Fittings: ASTM A 234/A 234M, wall thickness to match adjoining pipe.

G. Wrought Cast- and Forged-Steel Flanges and Flanged Fittings: ASME B16.5, including bolts, nuts, and gaskets of the following material group, end connections, and facings:

1. Material Group: 1.1.
2. End Connections: Butt welding.
3. Facings: Raised face.

H. Steel Pipe Nipples: ASTM A 733, made of same materials and wall thicknesses as pipe in which they are installed.

2.4 PLASTIC PIPE AND FITTINGS (Condensing Boiler Condensate Drains Only)

A. CPVC Plastic Pipe: ASTM F 441/F 441M, with wall thickness as indicated in "Piping Applications" Article.

1. CPVC Plastic Pipe Fittings: Socket-type pipe fittings, ASTM F 438 for Schedule 40 pipe; ASTM F 439 for Schedule 80 pipe.

B. PVC Plastic Pipe: ASTM D 1785, with wall thickness as indicated in "Piping Applications" Article.

1. PVC Plastic Pipe Fittings: Socket-type pipe fittings, ASTM D 2466 for Schedule 40 pipe; ASTM D 2467 for Schedule 80 pipe.

2.5 JOINING MATERIALS

A. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.

1. ASME B16.21, nonmetallic, flat, asbestos free, 1/8-inch maximum thickness unless otherwise indicated.

a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.

B. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.

C. Plastic, Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer unless otherwise indicated.

D. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.

E. Brazing Filler Metals: AWS A5.8/A5.8M, BCuP Series, copper-phosphorus alloys for joining copper with copper; or BAg-1, silver alloy for joining copper with bronze or steel.

F. Welding Filler Metals: Comply with AWS D10.12M/D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

G. Solvent Cements for Joining Plastic Piping:

1. CPVC Piping: ASTM F 493.

a. CPVC solvent cement shall have a VOC content of 490 g/L or less.
b. Adhesive primer shall have a VOC content of 550 g/L or less.
c. Solvent cement and adhesive primer shall comply with the testing and product requirements of the California Department of Public Health's (formerly, the California Health Services') "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

2. PVC Piping: ASTM D 2564. Include primer according to ASTM F 656.

a. PVC solvent cement shall have a VOC content of 510 g/L or less.
b. Adhesive primer shall have a VOC content of 550 g/L or less.
c. Solvent cement and adhesive primer shall comply with the testing and product requirements of the California Department of Public Health's (formerly, the California Health Services') "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

H. Gasket Material: Thickness, material, and type suitable for fluid to be handled and working temperatures and pressures.

2.6 TRANSITION FITTINGS

A. Plastic-to-Metal Transition Fittings:
1. One-piece fitting with one threaded brass or copper insert and one solvent-cement-joint end of material and wall thickness to match plastic pipe material.

B. Plastic-to-Metal Transition Unions:
1. Brass or copper end, solvent-cement-joint end of material and wall thickness to match plastic pipe material, rubber gasket, and threaded union.

2.7 DIELECTRIC FITTINGS

A. General Requirements: Assembly of copper alloy and ferrous materials with separating nonconductive insulating material. Include end connections compatible with pipes to be joined.

B. Dielectric Unions:
1. Description:

a. Standard: ASSE 1079.
b. Pressure Rating: 150 psig 250 psig.
c. End Connections: Solder-joint copper alloy and threaded ferrous.

C. Dielectric Flanges:
1. Description:

a. Standard: ASSE 1079.
b. Factory-fabricated, bolted, companion-flange assembly.
c. Pressure Rating: 150 psig minimum at 250 deg F.
d. End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.

D. Dielectric-Flange Insulating Kits:
1. Description:

a. Nonconducting materials for field assembly of companion flanges.
b. Pressure Rating: 150 psig.
c. Gasket: Neoprene or phenolic.
d. Bolt Sleeves: Phenolic or polyethylene.
e. Washers: Phenolic with steel backing washers.

E. Dielectric Nipples:
1. Description:

a. Standard: IAPMO PS 66.
b. Electroplated steel nipple, complying with ASTM F 1545.
c. Pressure Rating: 300 psig at 225 deg F.

d. End Connections: Male threaded or grooved.
e. Lining: Inert and noncorrosive, propylene.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS

A. Hot-water heating, piping aboveground; NPS 2 1/2 and smaller, shall be any of the following:

1. Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered, brazed.
2. Schedule 40, Grade B, Type 96 steel pipe; Class 150, malleable-iron fittings; cast-iron flanges and flange fittings; and threaded joints.

B. Hot-water heating, Piping above ground; NPS 3 and larger, shall be any of the following:

1. Type L, drawn-temper copper tubing, wrought-copper fittings, brazed joints.
2. Schedule 40 steel pipe, wrought-steel fittings and wrought-cast or forged-steel flanges and flange fittings, and welded and flanged joints.

C. Makeup-water piping installed aboveground shall be either of the following:

1. Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered joints.

D. Makeup-Water Piping Installed Belowground and within Slabs: Type K, annealed-temper copper tubing, wrought-copper fittings, and soldered joints. Use the fewest possible joints.

E. Condensate-Drain Piping: Type M, Type DWV, drawn-temper copper tubing, wrought-copper fittings, and soldered joints or Schedule 40 PVC plastic pipe and fittings and solvent-welded joints. (down stream of acid neutralizer only)

F. Condensate-Drain Piping: Schedule 40 PVC plastic pipe and fittings and solvent-welded joints.

G. Blowdown-Drain Piping: Same materials and joining methods as for piping specified for the service in which blowdown drain is installed.

H. Air-Vent Piping:

1. Inlet: Same as service where installed with metal-to-plastic transition fittings for plastic piping systems according to piping manufacturer's written instructions.
2. Outlet: Type K, annealed-temper copper tubing with soldered or flared joints.

I. Safety-Valve-Inlet and -Outlet Piping for Hot-Water Piping: Same materials and joining methods as for piping specified for the service in which safety valve is installed.

3.2 PIPING INSTALLATIONS

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

B. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.

C. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

D. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

E. Install piping to permit valve servicing.

F. Install piping at indicated slopes.

G. Install piping free of sags and bends.

H. Install fittings for changes in direction and branch connections.

I. Install piping to allow application of insulation.

J. Select system components with pressure rating equal to or greater than system operating pressure.

K. Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.

L. Install drains, consisting of a tee fitting, NPS 3/4 ball valve, and short NPS 3/4 threaded nipple with cap, at low points in piping system mains and elsewhere as required for system drainage.

M. Install piping at a uniform grade of 0.2 percent upward in direction of flow.

N. Reduce pipe sizes using eccentric reducer fitting installed with level side up.

O. Install branch connections to mains using tee fittings in main pipe, with the branch connected to the bottom of the main pipe. For up-feed risers, connect the branch to the top of the main pipe.

P. Install valves according to Section 230523.10 " Valves for HVAC Piping.

Q. Install unions in piping, NPS 2 and smaller, adjacent to valves, at final connections of equipment, and elsewhere as indicated.

R. Install flanges in piping, NPS 2-1/2 and larger, at final connections of equipment and elsewhere as indicated.

S. Install shutoff valve immediately upstream of each dielectric fitting.

T. Comply with requirements in Section 230553 "Identification for HVAC Piping and Equipment" for identifying piping.

U. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 230517.5 "Sleeves and Sleeve Seals for HVAC Piping."

V. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."

W. For piping passing through equipment room walls to occupied spaces provide split seals for sound and vibration attenuation between rooms. Comply with section 23 21 16.

X. Install packless expansion fitting in all hydronic piping sections that are 75’ long or over.

3.3 DIELECTRIC FITTING INSTALLATION

A. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.

B. Dielectric Fittings for NPS 2 and Smaller: Use dielectric nipples, or unions.

C. Dielectric Fittings for NPS 2-1/2 to NPS 4: Use dielectric flanges, or nipples.

D. Dielectric Fittings for NPS 5 and Larger: Use dielectric flange kits.

3.4 HANGERS AND SUPPORTS

A. Comply with requirements in Section 230529 "Hangers and Supports for HVAC Piping and Equipment" for hanger, support, and anchor devices. Comply with the following requirements for maximum spacing of supports and hanger rod size.

B. Install the following pipe attachments:

1. Adjustable steel clevis hangers for individual horizontal piping less than 20 feet long.
2. Adjustable roller hangers and spring hangers for individual horizontal piping 20 feet or longer.
3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet or longer, supported on a trapeze.
4. Spring hangers to support vertical runs.
5. Provide copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.
6. On plastic pipe, install pads or cushions on bearing surfaces to prevent hanger from scratching pipe.

C. Install hangers for drawn-temper copper piping with the following maximum spacing and minimum rod sizes:

1. NPS 3/4: Maximum span, 6 feet; minimum rod size, 1/4 inch.
2. NPS 1: Maximum span, 6 feet; minimum rod size, 1/4 inch.
3. NPS 1-1/4Maximum span, 7 feet; minimum rod size, 3/8 inch.
4. NPS 1-1/2: Maximum span, 8 feet; minimum rod size, 3/8 inch.
5. NPS 2: Maximum span, 8 feet; minimum rod size, 3/8 inch.
6. NPS 2-1/2: Maximum span, 9 feet; minimum rod size, 3/8 inch.
7. NPS 3 and Larger: Maximum span, 10 feet; minimum rod size, 3/8 inch.

D. Plastic Piping Hanger Spacing: Space hangers according to pipe manufacturer's written instructions for service conditions. Avoid point loading. Space and install hangers with the fewest practical rigid anchor points.

E. Fiberglass Piping Hanger Spacing: Space hangers according to pipe manufacturer's written instructions for service conditions. Avoid point loading. Space and install hangers with the fewest practical rigid anchor points.

F. Support vertical runs at roof, at each floor, and at 10-foot intervals between floors.

3.5 PIPE JOINT CONSTRUCTION

A. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

C. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B 32.

D. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8/A5.8M.

E. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

F. Welded Joints: Construct joints according to AWS D10.12M/D10.12, using qualified processes and welding operators according to "Quality Assurance" Article.

G. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

H. Plastic Piping Solvent-Cemented Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:

1. Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements.
2. CPVC Piping: Join according to ASTM D 2846/D 2846M Appendix.
3. PVC Pressure Piping: Join ASTM D 1785 schedule number, PVC pipe and PVC socket fittings according to ASTM D 2672. Join other-than-schedule number PVC pipe and socket fittings according to ASTM D 2855.
4. PVC Nonpressure Piping: Join according to ASTM D 2855.

I. Fiberglass Bonded Joints: Prepare pipe ends and fittings, apply adhesive, and join according to pipe manufacturer's written instructions.

J. Grooved Joints: Assemble joints with coupling and gasket, lubricant, and bolts. Cut or roll grooves in ends of pipe based on pipe and coupling manufacturer's written instructions for pipe wall thickness. Use grooved-end fittings and rigid, grooved-end-pipe couplings.

K. Mechanically Formed, Copper-Tube-Outlet Joints: Use manufacturer-recommended tool and procedure, and brazed joints.

L. Pressure-Sealed Joints: Use manufacturer-recommended tool and procedure. Leave insertion marks on pipe after assembly.

3.6 TERMINAL EQUIPMENT CONNECTIONS

A. Sizes for supply and return piping connections shall be the same as or larger than equipment connections.

B. Install control valves in accessible locations close to connected equipment.

C. Install bypass piping with globe valve around control valve. If parallel control valves are installed, only one bypass is required.

D. Install ports for pressure gages and thermometers at coil inlet and outlet connections. Comply with requirements in Section 230519 "Meters and Gages for HVAC Piping."

3.7 CHEMICAL TREATMENT

A. Perform an analysis of makeup water to determine type and quantities of chemical treatment needed to keep system free of scale, corrosion, and fouling, and to sustain the following water characteristics:

1. pH: 9.0 to 10.5.
2. "P" Alkalinity: 100 to 500 ppm.
3. Boron: 100 to 200 ppm.
4. Chemical Oxygen Demand: Maximum of 100 ppm. Revise this value if closed system contains glycol.
5. Corrosion Inhibitor:

    a. Sodium Nitrate: 1000 to 1500 ppm.
    b. Molybdate: 200 to 300 ppm.
    c. Chromate: 200 to 300 ppm.
    d. Sodium Nitrate Plus Molybdate: 100 to 200 ppm each.
    e. Chromate Plus Molybdate: 50 to 100 ppm each.

6. Soluble Copper: Maximum of 0.20 ppm.
7. Tolyiriazole Copper and Yellow Metal Corrosion Inhibitor: Minimum of 10 ppm.
8. Total Suspended Solids: Maximum of 10 ppm.
9. Ammonia: Maximum of 20 ppm.

10. Free Caustic Alkalinity: Maximum of 20 ppm.
11. Microbiological Limits:

    a. Total Aerobic Plate Count: Maximum of 1000 organisms/mL.
    b. Total Anaerobic Plate Count: Maximum of 100 organisms/mL.
    c. Nitrate Reducers: 100 organisms/mL.
    d. Sulfate Reducers: Maximum of zero organisms/mL.
    e. Iron Bacteria: Maximum of zero organisms/mL.

B. Install bypass chemical feeders in each hydronic system where indicated.

1. Install in upright position with top of funnel not more than 48 inches above the floor.
2. Install feeder in minimum NPS 3/4 bypass line, from main with full-size, full-port, ball valve in the main between bypass connections.
3. Install NPS 3/4 pipe from chemical feeder drain to nearest equipment drain and include a full-size, full-port, ball valve.

C. Fill system with fresh water and add liquid alkaline compound with emulsifying agents and detergents to remove grease and petroleum products from piping. Circulate solution for a minimum of 24 hours, drain, clean strainer screens, and refill with fresh water.

D. Add initial chemical treatment and maintain water quality in ranges noted above for the first year of operation.

3.8 FIELD QUALITY CONTROL

A. Prepare hydronic piping according to ASME B31.9 and as follows:

1. Leave joints, including welds, uninsulated and exposed for examination during test.
2. Provide temporary restraints for expansion joints that cannot sustain reactions due to test pressure. If temporary restraints are impractical, isolate expansion joints from testing.
3. Flush hydronic piping systems with clean water; then remove and clean or replace strainer screens.
4. Isolate equipment from piping. If a valve is used to isolate equipment, its closure shall be capable of sealing against test pressure without damage to valve. Install blinds in flanged joints to isolate equipment.
5. Install safety valve, set at a pressure no more than one-third higher than test pressure, to protect against damage by expanding liquid or other source of overpressure during test.

B. Perform the following tests on hydronic piping:

1. Use ambient temperature water as a testing medium unless there is risk of damage due to freezing. Another liquid that is safe for workers and compatible with piping may be used.
2. While filling system, use vents installed at high points of system to release air. Use drains installed at low points for complete draining of test liquid.
3. Isolate expansion tanks and determine that hydronic system is full of water.
4. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the system's working pressure. Test pressure shall not exceed maximum pressure for any vessel, pump, valve, or other component in system under test. Verify that stress due to pressure at bottom of vertical runs does not exceed 90 percent of specified minimum

yield strength or 1.7 times the "SE" value in Appendix A in ASME B31.9, "Building Services Piping."

5. After hydrostatic test pressure has been applied for at least 10 minutes, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components, and repeat hydrostatic test until there are no leaks.
6. Prepare written report of testing.

C. Perform the following before operating the system:

1. Open manual valves fully.
2. Inspect pumps for proper rotation.
3. Set makeup pressure-reducing valves for required system pressure.
4. Inspect air vents at high points of system and determine if all are installed and operating freely (automatic type), or bleed air completely (manual type).
5. Set temperature controls so all coils are calling for full flow.
6. Inspect and set operating temperatures of hydronic equipment, such as boilers, chillers, cooling towers, to specified values.
7. Verify lubrication of motors and bearings.

END OF SECTION 232113

SECTION 232116 - HYDRONIC PIPING SPECIALTIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes special-duty valves and specialties for the following:

1. Hot-water heating piping.
2. Makeup-water piping.
3. Condensate-drain piping.
4. Blowdown-drain piping.
5. Air-vent piping.
6. Safety-valve-inlet and -outlet piping.
7. Vibration Isolation
8. Expansion fittings for hydronic piping
9. Pipe guides and anchors
10. Chemical shot feeder

1.3 ACTION SUBMITTALS

A. Product Data: For each type of the following:

1. Valves: Include flow and pressure drop curves based on manufacturer's testing for calibrated-orifice balancing valves and automatic flow-control valves.
2. Air-control devices.
3. Hydronic specialties.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For air-control devices, hydronic specialties, and special-duty valves to include in emergency, operation, and maintenance manuals.

1.5 MAINTENANCE MATERIAL SUBMITTALS

A. Differential Pressure Meter: For each type of balancing valve and automatic flow control valve, include flowmeter, probes, hoses, flow charts, and carrying case.

1.6 QUALITY ASSURANCE

A. Pipe Welding: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code: Section IX.

1. Safety valves and pressure vessels shall bear the appropriate ASME label. Fabricate and stamp air separators and expansion tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Hydronic piping components and installation shall be capable of withstanding the following minimum working pressure and temperature unless otherwise indicated:

1. Hot-Water Heating Piping: 150 psig at 200 deg F
2. Glycol Cooling-Water Piping: 150 psig at 150 deg F
3. Makeup-Water Piping: 80 psig at 150 deg F
4. Condensate-Drain Piping: 150 deg F.
5. Blowdown-Drain Piping: 200 deg F
6. Air-Vent Piping: 200 deg F.
7. Safety-Valve-Inlet and -Outlet Piping: Equal to the pressure of the piping system to which it is attached.

2.2 VALVES

A. Gate, Globe, Check, Ball, and Butterfly Valves: Comply with requirements specified in Section 230523.10 "Valves for HVAC Piping,"

B. Automatic Temperature-Control Valves, Actuators, and Sensors: Comply with requirements specified in Section 230923.11 "Control Valves."

C. Bronze, Calibrated-Orifice, Balancing Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Armstrong Pumps, Inc.
b. Bell & Gossett; a Xylem brand.
c. Nexus Valve, Inc.
d. TACO Comfort Solutions, Inc.
e. Tour & Andersson; available through Victaulic Company.
f. Victaulic Company.

2. Body: Bronze, ball or globe type with calibrated orifice or venturi.

3. Ball: Brass or stainless steel.
4. Seat: PTFE.
5. End Connections: Threaded or socket.
6. Pressure Gage Connections: Integral seals for portable differential pressure meter.
7. Handle Style: Lever, with memory stop to retain set position.
8. CWP Rating: Minimum 125 psig
9. Maximum Operating Temperature: 250 deg F

D. Cast-Iron or Steel, Calibrated-Orifice, Balancing Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Armstrong Pumps, Inc.
    b. Bell & Gossett; a Xylem brand.
    c. Nexus Valve, Inc.
    d. Tour & Andersson; available through Victaulic Company.

2. Body: Cast-iron or steel body, globe pattern with calibrated orifice or venturi.

3. Ball: Brass or stainless steel.
4. Stem Seals: EPDM O-rings.
5. Disc: Glass and carbon-filled PTFE.
6. Seat: PTFE.
7. End Connections: Flanged or grooved.
8. Pressure Gage Connections: Integral seals for portable differential pressure meter.
9. Handle Style: Lever, with memory stop to retain set position.
10. CWP Rating: Minimum 125 psig
11. Maximum Operating Temperature: 250 deg F

E. Diaphragm-Operated, Pressure-Reducing Valves: ASME labeled.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. AMTROL, Inc.
    b. Armstrong Pumps, Inc.
    c. Bell & Gossett; a Xylem brand.
    d. Spence Engineering Company, Inc.
    e. Watts; a Watts Water Technologies company.

2. Body: Bronze or brass.
3. Disc: Glass and carbon-filled PTFE.
4. Seat: Brass.
5. Stem Seals: EPDM O-rings.
6. Diaphragm: EPT.
7. Low inlet-pressure check valve.
8. Inlet Strainer: stainless steel, removable without system shutdown.
9. Valve Seat and Stem: Noncorrosive.
10. Valve Size, Capacity, and Operating Pressure: Selected to suit system in which installed, with operating pressure and capacity factory set and field adjustable.

F. Diaphragm-Operated Safety Valves: ASME labeled.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. AMTROL, Inc.
    b. Armstrong Pumps, Inc.

c. Bell & Gossett; a Xylem brand.
d. Spence Engineering Company, Inc.
e. Watts; a Watts Water Technologies company.

2. Body: Bronze or brass.
3. Disc: Glass and carbon-filled PTFE.
4. Seat: Brass.
5. Stem Seals: EPDM O-rings.
6. Diaphragm: EPT.
7. Wetted, Internal Work Parts: Brass and rubber.
8. Inlet Strainer: stainless steel, removable without system shutdown.
9. Valve Seat and Stem: Noncorrosive.
10. Valve Size, Capacity, and Operating Pressure: Comply with ASME Boiler and Pressure Vessel Code: Section IV, and selected to suit system in which installed, with operating pressure and capacity factory set and field adjustable.

G. Automatic Flow-Control Valves: (NOT USED)

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Flow Design, Inc.
b. Griswold Controls.
c. Nexus Valve, Inc.
d. NuTech Hydronic Specialty Products.

2. Body: Brass or ferrous metal.
3. Piston and Spring Assembly: Stainless steel, tamper proof, self-cleaning, and removable.
4. Combination Assemblies: Include bronze or brass-alloy ball valve.
5. Identification Tag: Marked with zone identification, valve number, and flow rate.
6. Size: Same as pipe in which installed.
7. Performance: Maintain constant flow, plus or minus 5 percent over system pressure fluctuations.
8. Minimum CWP Rating: 175 psig
9. Maximum Operating Temperature: 200 deg F

2.3 AIR-CONTROL DEVICES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. AMTROL, Inc.
b. Armstrong Pumps, Inc.
c. Bell & Gossett; a Xylem brand.
d. TACO Comfort Solutions, Inc.
e. John Wood

B. Manual Air Vents:

1. Body: Bronze.

2. Internal Parts: Nonferrous.
3. Operator: Screwdriver or thumbscrew.
4. Inlet Connection: NPS 1/2
5. Discharge Connection: NPS 1/8.
6. CWP Rating: 150 psig
7. Maximum Operating Temperature: 225 deg F

C. Automatic Air Vents:
1. Body: Bronze or cast iron.
2. Internal Parts: Nonferrous.
3. Operator: Noncorrosive metal float.
4. Inlet Connection: NPS 1/2
5. Discharge Connection: NPS 1/4
6. CWP Rating: 150 psig
7. Maximum Operating Temperature: 240 deg F

D. Expansion Tanks:

1. Tank: Welded steel, rated for 125-psig working pressure and 375 deg F maximum operating temperature, with taps in bottom of tank for tank fitting and taps in end of tank for gage glass. Tanks shall be factory tested after taps are fabricated and shall be labeled according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

2. Air-Control Tank Fitting: Cast-iron body, copper-plated tube, brass vent tube plug, and stainless-steel ball check, 100-gal. unit only; sized for compression-tank diameter. Provide tank fittings for 125-psig working pressure and 250 deg F maximum operating temperature.

3. Tank Drain Fitting: Brass body, nonferrous internal parts; 125-psig working pressure and 240 deg F maximum operating temperature; constructed to admit air to compression tank, drain water, and close off system.
4. Gage Glass: Full height with dual manual shutoff valves, 3/4-inch- diameter gage glass, and slotted-metal glass guard.

E. Diaphragm or Bladder-Type Expansion Tanks as scheduled or noted on plans:
1. Tank: Welded steel, rated for 125-psig working pressure and 375 deg F maximum operating temperature. Factory test after taps are fabricated and supports installed and are labeled according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
2. Diaphragm or Bladder: Securely sealed into tank to separate air charge from system water to maintain required expansion capacity.
3. Air-Charge Fittings: Schrader valve, stainless steel with EPDM seats.

F. Tangential-Type Air Separators:
1. Tank: Welded steel; ASME constructed and labeled for 125-psig minimum working pressure and 375 deg F maximum operating temperature.
2. Air Collector Tube: Perforated stainless steel, constructed to direct released air into expansion tank.
3. Tangential Inlet and Outlet Connections: Threaded for NPS 2 and smaller; flanged connections for NPS 2-1/2 and larger.
4. Blowdown Connection: Threaded.
5. Size: Match system flow capacity.

G. In-Line Air Separators:
1. Tank: One-piece cast iron with an integral weir constructed to decelerate system flow to maximize air separation.
2. Maximum Working Pressure: Up to 175 psig
3. Maximum Operating Temperature: Up to 300 deg F

H. Air Purgers:
1. Body: Cast iron with internal baffles that slow the water velocity to separate the air from solution and divert it to the vent for quick removal.
2. Maximum Working Pressure: 150 psig
3. Maximum Operating Temperature: 250 deg F

2.4 HYDRONIC PIPING SPECIALTIES

A. Y-Pattern Strainers:

1. Body: ASTM A 126, Class B, cast iron with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for NPS 2 and smaller; flanged ends for NPS 2-1/2 and larger.
3. Strainer Screen: Stainless-steel, 20-mesh strainer, or perforated stainless-steel basket.
4. CWP Rating: 125 psig

B. Basket Strainers:

1. Body: ASTM A 126, Class B, high-tensile cast iron with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for NPS 2 and smaller; flanged ends for NPS 2-1/2 and larger.
3. Strainer Screen: 40-mesh startup strainer, and perforated stainless-steel basket with 50 percent free area.
4. CWP Rating: 125 psig

C. T-Pattern Strainers:

1. Body: Ductile or malleable iron with removable access coupling and end cap for strainer maintenance.
2. End Connections: Grooved ends.
3. Strainer Screen: 40-mesh startup strainer, and perforated stainless-steel basket with 57 percent free area.
4. CWP Rating: 150 psig

D. Stainless-Steel Bellow, Flexible Connectors:

1. Body: Stainless-steel bellows with woven, flexible, bronze, wire-reinforcing protective jacket.
2. End Connections: Threaded or flanged to match equipment connected.
3. Performance: Capable of 3/4-inch misalignment.
4. CWP Rating: 150 psig
5. Maximum Operating Temperature: 250 deg F

E. Spherical, Rubber, Flexible Connectors:

1. Rubber flexible connections shall be peroxide cured EPDM throughout with Kevlar tire cord reinforcement. The raised face rubber flanges must encase solid steel rings to prevent pull out. Flexible cable wire is not acceptable. Sizes 1-1/2" through 14" shall have a ductile iron external ring between the two spheres. Sizes 3/4" through 2" may have one sphere, bolted threaded flange assemblies and cable retention.

2. Minimum ratings shall be 250 psi at 170°F and 215 psi at 250°F. Higher published rated connectors may be used where required.

3. Safety factors shall be a minimum of 3/1. All flexible connections must be factory tested to 150% of maximum pressure for 12 minutes before shipment. The piping gap shall be equal to the length of the expansion joint under pressure. Control rods passing through 1/2" thick Neoprene washer bushings large enough to take the thrust at 1000psi of surface area may be used on unanchored piping where the manufacturer determines the condition exceeds the expansion joint rating without them.

4. All flexible joints shall be installed on the equipment side of the shut off valves. Expansion joints shall be SAFEFLEX SFDEJ, SFEJ, SFDCR or SFU and Control Rods CR as manufactured by Mason Industries, Inc
   a. Body: Fiber-reinforced rubber body.
   b. End Connections: Steel flanges drilled to align with Classes 150 and 300 steel flanges.
   c. Performance: Capable of misalignment.
   d. CWP Rating: 150 psig
   e. Maximum Operating Temperature: 250 deg F

F. Braided Pipe Flexible Connection;
   1. Flexible stainless steel hose shall have stainless steel braid and carbon steel fittings. Sizes 3"and larger shall be flanged. Smaller sizes may have male nipples. Minimum sizes listed below.

Flanged (Pipe Dia x Flexible Pipe Length)		
3" x 12"	6" x 18"	12" x 24"
4" x 12"	8" x 18"	14" x 30"
5" x 18"	10" x 18"	16" x 32"

Male Nipples (Pipe Dia x Flexible Pipe Length)		
1/2" x 12"	1-1/4" x 12"	2" x 12"
3/4" x 12"	1-1/2"x 12"	2-1/2" x 18"
1" x 12"		

   2. At equipment connections, hoses shall be installed on the equipment side of the shut-off valves horizontal and parallel to the equipment shafts wherever possible. Hoses shall be type FFL or type MN as manufactured by Mason Industries, Inc

G. Vibration isolation pipe hangers; pre-compressed and locked at the rated deflection by means of a resilient up-stop to keep the piping or equipment at a fixed elevation during installation. The hangers shall be designed with a release mechanism to free the spring after the installation is

complete and the hanger is subjected to its full load. Deflection shall be clearly indicated by means of a scale. Submittals shall include a drawing of the hanger showing the 30° capability. Hangers shall be type PC30N as manufactured by Mason Industries, Inc

H. Acoustic Split Seals; consist of pipe halves with minimum 3/4" thick neoprene sponge cemented to the inner faces. The seal shall be tightened around the pipe to eliminate clearance between the inner sponge face and the piping. Grout seals to make it integral with the floor, wall or ceiling in masonry construction. Seals shall project a minimum of 1" past either face of the wall. Where temperatures exceed 240F, 10 lb. density fiberglass may be used in lieu of the sponge. Seals shall be Type SPS or SWS as manufactured by Mason Industries, Inc.

2.5 PACKLESS EXPANSION JOINTS

A. Metal, Compensator Packless Expansion Joints: Metraflex Model HPFF – for copper, Model HP for steel pipe

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Flexicraft Industries.
   b. Mason Industries, Inc.
   c. Metraflex Company (The).

2. Minimum Pressure Rating: 175 psig unless otherwise indicated.

3. Description: Totally enclosed, externally pressurized, multi-ply bellows isolated from fluid flow by an internal pipe sleeve and external housing.
4. Joint Axial Movement: 2 inches of compression and 1/2 inch of extension.
5. Configuration for Copper Tubing: Multi-ply, phosphor-bronze bellows with copper pipe ends.

   a. End Connections for Copper Tubing NPS 2 and Smaller: Solder joint or threaded.
   b. End Connections for Copper Tubing NPS 2-1/2 to NPS 4: Threaded.

6. Configuration for Steel Piping: Multi-ply, stainless-steel bellows; steel-pipe end connections; and carbon-steel shroud.

   a. End Connections for Steel Pipe NPS 2 and Smaller: Threaded.
   b. End Connections for Steel Pipe NPS 2-1/2 to NPS 4: Threaded Welded.

2.6 ALIGNMENT GUIDES AND ANCHORS

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Advanced Thermal Systems, Inc.
   b. Flexicraft Industries.
   c. Mason Industries, Inc.
   d. Metraflex Company (The).

2. Description: Steel, factory-fabricated alignment guide, with bolted two-section outer cylinder and base for attaching to structure; with two-section guiding slider for bolting to pipe.

3. Steel Shapes and Plates: ASTM A 36/A 36M.
4. Bolts and Nuts: ASME B18.10 or ASTM A 183, steel hex head.
5. Washers: ASTM F 844, steel, plain, flat washers.
6. Mechanical Fasteners: Insert-wedge-type stud with expansion plug anchor for use in hardened concrete, with tension and shear capacities appropriate for application. Threaded stud, expansion plug, nuts and washers shall be zink-coated carbon steel.

7. Chemical Fasteners: Insert-type stud, bonding-system anchor for use with hardened concrete, with tension and shear capacities appropriate for application.

    a. Bonding Material: ASTM C 881/C 881M, Type IV, Grade 3, two-component epoxy resin suitable for surface temperature of hardened concrete where fastener is to be installed.
    b. Stud: threaded stud washers and nuts shall be ASTM A 307, zinc-coated carbon steel.
    c. Alignment Guides
        1) Horizontal split spider type guide – Metraflex – Style IV
        2) Slide guide – Metraflex – model PTFE
        3) Pre-insulated guide – Metraflex – model PG PRE
        4) Vertical glide riser – Metraflex – model PGQ
    d. Anchors
        1) Anchor clamp – Metraflex – model PA
        2) Structural I Beam Anchors – Metraflex
        3) Pre-insulated Anchor – Metraflex – model PAPI
        4) Modular riser guide – Metraflex – modular riser with EPDM insert

2.7 BYPASS CHEMICAL FEEDER

A. Description: Welded steel construction; 150-psig working pressure; 5-gal. capacity min; with fill funnel and inlet, outlet, and drain valves.

1. Chemicals: Specially formulated, based on analysis of makeup water, to prevent accumulation of scale and corrosion in piping and connected equipment.

PART 3 - EXECUTION

3.1 VALVE APPLICATIONS

A. Install shut off-duty valves at each branch connection to supply mains and at supply connection to each piece of equipment.

B. Install calibrated-orifice, balancing valves at each branch connection to return main.

C. Install calibrated-orifice, balancing valves in the return pipe of each heating or cooling terminal.

D. Install check valves at each pump discharge and elsewhere as required to control flow direction.

E. Install safety valves at hot-water generators and elsewhere as required by ASME Boiler and Pressure Vessel Code. Install drip-pan elbow on safety-valve outlet and pipe without valves to the outdoors; pipe drain to nearest floor drain or as indicated on Drawings. Comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1, for installation requirements.

F. Install pressure-reducing valves at makeup-water connection to regulate system fill pressure.

G. All valves and specialties installed in the system shall have a pressure rating that exceeds the system working pressure.

3.2 HYDRONIC SPECIALTIES INSTALLATION

A. All valves and specialties installed in the system shall have a pressure rating that exceeds the system working pressure.

B. Install manual air vents at high points in piping, at heat-transfer coils, and elsewhere as required for system air venting.

C. Install automatic air vents at high points of system piping in mechanical equipment rooms only. Install manual vents at heat-transfer coils and elsewhere as required for air venting.

D. Install piping from boiler air outlet, air separator, or air purger to expansion tank with a 2 percent upward slope toward tank.

E. Install in-line air separators in pump suction. Install drain valve on air separators NPS 2 and larger.

F. Install tangential air separator in pump suction. Install blowdown piping with gate or full-port ball valve; extend full size to nearest floor drain.

G. Install steel braided flexible pipe connections at all coil connections and at all piping connections to motor driven equipment except for pumps.

H. Isolate piping from base mounted pumps with spherical rubber flexible connections

I. Install vibration isolation hangers or supports on all piping connected to motor driven equipment for a distance of 20’ or the first two hangers.

J. Install expansion tanks above the air separator. Install tank fitting in tank bottom and charge tank. Use manual vent for initial fill to establish proper water level in tank.

1. Install tank fittings that are shipped loose.
2. Support tank from floor or structure above with sufficient strength to carry weight of tank, piping connections, fittings, plus tank full of water. Do not overload building components and structural members.

K. Install expansion tanks on the floor. Vent and purge air from hydronic system, and ensure that tank is properly charged with air to suit system Project requirements. System pressure shall be 5psi minimum residual at the top of the system.

L. Install Acoustic split seals on all hydronic piping 3” and over, penetrating mechanical equipment room walls.

M. Install Packless expansion fittings in all hydronic pipe sections, regardless of service, that is over 75’ long straight run. Alternative pipe “expansion loop” may be used if space permits. Piping layout submittal shall indicate guide and ridged mount locations.

3.3 EXPANSION JOINT INSTALLATION

A. Install expansion joints of sizes matching sizes of piping in which they are installed.

B. Install grooved-joint expansion joints to grooved-end steel piping.

C. Grooved end pipe applications can use multiple grooved coupling installed in an arrangement as approved by the manufacture for the specific application. The manufacture shall recommend the number, placement and arrangement in the piping systems. Submit to the engineer for review and approval.

3.4 PIPE LOOP AND SWING CONNECTION INSTALLATION

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

B. Connect risers and branch connections to terminal units with at least four pipe fittings, including tee in riser.

C. Connect mains and branch connections to terminal units with at least four pipe fittings, including tee in main.

3.5 ALIGNMENT-GUIDE AND ANCHOR INSTALLATION

A. Install alignment guides to guide expansion and to avoid end-loading and torsional stress.

B. Install one guide(s) on each side of pipe expansion fittings and loops. Install guides nearest to expansion joint or loop not more than three pipe diameters from expansion joint.

C. Attach guides to pipe, and secure guides to building structure.

D. Install anchors at locations to prevent stresses from exceeding those permitted by ASME B31.9 and to prevent transfer of loading and stresses to connected equipment.

E. Anchor Attachments:

1. Anchor Attachment to Steel Pipe: Attach by welding. Comply with ASME B31.9 and ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
2. Anchor Attachment to Copper Tubing: Attach with pipe hangers. Use MSS SP-69, Type 24; U bolts bolted to anchor.

F. Fabricate and install steel anchors by welding steel shapes, plates, and bars. Comply with ASME B31.9 and AWS D1.1/D1.1M.

1. Anchor Attachment to Steel Structural Members: Attach by welding.
2. Anchor Attachment to Concrete Structural Members: Attach by fasteners. Follow fastener manufacturer's written instructions.

G. Use grout to form flat bearing surfaces for guides and anchors attached to concrete.

END OF SECTION 232116

SECTION 232213 - STEAM AND CONDENSATE HEATING PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes pipe and fittings for LP steam and condensate piping:

1. Steel pipe and fittings.
2. Fiberglass pipe and fittings.
3. Joining materials.

B. Related Requirements:

1. Section 232216 "Steam and Condensate Heating Piping Specialties" for strainers, flash tanks, special-duty valves, steam traps, thermostatic air vents and vacuum breakers, and steam and condensate meters.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of the following:

1. Steel pipe and fitting.
2. Joining material.

B. Delegated-Design Submittal:

1. Design calculations and detailed fabrication and assembly of pipe anchors and alignment guides, hangers and supports for multiple pipes, expansion joints and loops, and attachments of the same to the building structure.
2. Locations of pipe anchors and alignment guides and expansion joints and loops.
3. Locations of and details for penetrations, including sleeves and sleeve seals for exterior walls, floors, basement, and foundation walls.
4. Locations of and details for penetration and fire stopping for fire- and smoke-rated wall and floor and ceiling assemblies.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Piping layout, drawn to 3/8 = 1’-0” scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Suspended ceiling components.
2. Other building services.
3. Structural members
4. Steam and condensate equipment.

B. Qualification Data: For Installer.

C. Welding certificates.

D. Field quality-control reports.

1.5 QUALITY ASSURANCE

A. Installer Qualifications:

1. Fiberglass Pipe and Fitting Installers: Installers of fiberglass pipe and fittings shall be certified by the manufacturer of pipes and fittings as having been trained and qualified to join fiberglass piping with manufacturer-recommended adhesive.

B. Steel Support Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

C. Pipe Welding: Qualify procedures and operators according to the following:

1. ASME Compliance: Comply with ASME B31.1, "Power Piping," and ASME B31.9, "Building Services Piping," for materials, products, and installation.
2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Components and installation shall be capable of withstanding the following minimum working pressures and temperatures unless otherwise indicated:

1. LP Steam Piping: up to 15psig.
2. HP Steam Piping: over 15 psig.
3. Condensate Piping: 15 psig at 250 deg F.
4. Makeup-Water Piping: 150 psig at 150 deg F.
5. Blowdown-Drain Piping: Equal to pressure of the piping system to which it is attached.
6. Air-Vent and Vacuum-Breaker Piping: Equal to pressure of the piping system to which it is attached.
7. Safety-Valve-Inlet and -Outlet Piping: Equal to pressure of the piping system to which it is attached.

2.2 STEEL PIPE AND FITTINGS

A. Steel Pipe: ASTM A 53/A 53M, black steel, plain ends, welded and seamless, Grade B, and Schedule as indicated in piping applications articles.

B. Cast-Iron Threaded Fittings: ASME B16.4; Classes 300 as indicated in piping applications articles.

C. Malleable-Iron Threaded Fittings: ASME B16.3; Classes 300 as indicated in piping applications articles.

D. Malleable-Iron Unions: ASME B16.39; Classes 300 as indicated in piping applications articles.

E. Cast-Iron Threaded Flanges and Flanged Fittings: ASME B16.1, Classes 125 and 250 as indicated in piping applications articles; raised ground face, and bolt holes spot faced.

F. Wrought-Steel Fittings: ASTM A 234/A 234M, wall thickness to match adjoining pipe.

G. Wrought-Steel Flanges and Flanged Fittings: ASME B16.5, including bolts, nuts, and gaskets of the following material group, end connections, and facings:

1. Material Group: 1.1.
2. End Connections: Butt welding.
3. Facings: Raised face.

H. Steel Pipe Nipples: ASTM A 733, made of ASTM A 53/A 53M, black steel of same Type, Grade, and Schedule as pipe in which installed.

2.3 JOINING MATERIALS

A. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.

1. ASME B16.21, nonmetallic, flat, asbestos free, 1/8-inch maximum thickness unless otherwise indicated.

a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.

B. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.

C. Welding Filler Metals: Comply with AWS D10.12M/D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

D. Welding Materials: Comply with Section II, Part C, of ASME Boiler and Pressure Vessel Code for welding materials appropriate for wall thickness and for chemical analysis of pipe being welded.

E. Fiberglass Pipe Adhesive: As furnished or recommended by pipe manufacturer.

PART 3 - EXECUTION

3.1 LP STEAM PIPING APPLICATIONS

A. LP Steam Piping, NPS 2 and Smaller: Schedule 40, Type S, Grade B, steel pipe; Class 125 cast-iron fittings; and threaded joints.

B. LP Steam Piping, NPS 2-1/2 through NPS 12: Schedule 40, Type E, Grade B, steel pipe; Class 150 wrought-steel fittings, flanges, and flange fittings; and welded and flanged joints.

C. Condensate piping above grade, NPS 2 and smaller, shall be the following:

1. Schedule 80, Type S, Grade B, steel pipe; Class 125 cast-iron fittings; and threaded joints.

D. Condensate piping above grade, NPS 2-1/2 and larger, shall be the following:

1. Schedule 80, Type E, Grade B, steel pipe; Class 150 wrought-steel fittings, flanges, and flange fittings; and welded and flanged joints.

E. Condensate piping below grade, NPS 2 and smaller, shall be the following:

1. Schedule 80, Type S, Grade B, steel pipe; Class 125 cast-iron fittings; and threaded joints.

F. Condensate piping below grade, NPS 2-1/2 and larger, shall be the following:

1. Schedule 80, Type E, Grade B, steel pipe; Class 150 wrought-steel fittings, flanges, and flange fittings; and welded and flanged joints.

3.2 ANCILLARY PIPING APPLICATIONS

A. Blowdown-Drain Piping: Same materials and joining methods as for piping specified for the service in which blowdown drain is installed.

B. Vacuum-Breaker Piping: Outlet, same as service where installed.

C. Safety-Valve-Inlet and -Outlet Piping: Same materials and joining methods as for piping specified for the service in which safety valve is installed.

3.3 PIPING INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

B. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.

C. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless otherwise indicated.

D. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

E. Install piping to permit valve servicing.

F. Install piping free of sags and bends.

G. Install fittings for changes in direction and branch connections.

H. Install piping to allow application of insulation.

I. Select system components with pressure rating equal to or greater than system operating pressure.

J. Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.

K. Install drains, consisting of a tee fitting, NPS 3/4 full port-ball valve, and short NPS 3/4 threaded nipple with cap, at low points in piping system mains and elsewhere as required for system drainage.

L. Install steam supply piping at a minimum uniform grade of 0.2 percent downward in direction of steam flow.

M. Install condensate return piping at a minimum uniform grade of 0.4 percent downward in direction of condensate flow.

N. Reduce pipe sizes using eccentric reducer fitting installed with level side down.

O. Install branch connections to mains using tee fittings in main pipe, with the branch connected to top of main pipe.

P. Install valves according to the following Sections or other Sections as needed: Do not use butterfly valves in steam or condensate lines or services or steam equipment.

1. Section 230523.10 " Valves for HVAC Piping."

Q. Install unions in piping, NPS 2 and smaller, adjacent to valves, at final connections of equipment, and elsewhere as indicated.

R. Install flanges in piping, NPS 2-1/2 and larger, at final connections of equipment and elsewhere as indicated.

S. Install shutoff valve immediately upstream of each dielectric fitting.

T. Install strainers on supply side of control valves, pressure-reducing valves, traps, and elsewhere as indicated. Install NPS 3/4 nipple and full port ball valve in blowdown connection of strainers NPS 2 and larger. Match size of strainer blowoff connection for strainers smaller than NPS 2.

U. Comply with requirements in Section 230553 "Identification for HVAC Piping and Equipment" for identifying piping.

V. Install drip legs at low points and natural drainage points such as ends of mains, bottoms of all risers, and ahead of pressure regulators, and control valves.

1. On straight runs with no natural drainage points, install drip legs at intervals not exceeding 300 feet.
2. Size drip legs same size as main. In steam mains NPS 6 and larger, drip leg size can be reduced, but to no less than NPS 4.

W. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."

X. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."

Y. For piping passing through equipment room walls to occupied spaces provide split seals for sound and vibration attenuation between rooms. Comply with section 23 21 16.

Z. Install piping to allow for expansion and contraction.

3.4 STEAM AND CONDENSATE PIPING SPECIALTIES INSTALLATION

A. Comply with requirements in Section 232216 "Steam and Condensate Heating Piping Specialties" for installation requirements for strainers, flash tanks, special-duty valves, steam traps, thermostatic air vents and vacuum breakers, and steam and condensate meters.

3.5 HANGERS AND SUPPORTS

A. Comply with requirements in Section 230529 "Hangers and Supports for HVAC Piping and Equipment" for hanger, support, and anchor devices. Comply with the following requirements for maximum spacing of supports and hanger rod size.

B. Install the following pipe attachments:

1. Adjustable steel clevis hangers for individual horizontal piping less than 20 feet long.
2. Adjustable roller hangers and spring hangers for individual horizontal piping 20 feet or longer.
3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet or longer, supported on a trapeze.
4. Spring hangers to support vertical runs.

C. Install hangers for steel steam supply piping with the following maximum spacing:

1. NPS 3/4: Maximum span, 9 feet.
2. NPS 1: Maximum span, 9 feet.
3. NPS 1-1/2: Maximum span, 12 feet.

4. NPS 2: Maximum span, 13 feet.
5. NPS 2-1/2: Maximum span, 14 feet.
6. NPS 3 and Larger: Maximum span, 15 feet.

D. Install hangers for steel steam condensate piping with the following maximum spacing:

1. NPS 3/4: Maximum span, 7 feet.
2. NPS 1: Maximum span, 7 feet.
3. NPS 1-1/2: Maximum span, 9 feet.
4. NPS 2: Maximum span, 10 feet.
5. NPS 2-1/2: Maximum span, 11 feet.
6. NPS 3 and Larger: Maximum span, 12 feet

E. Support vertical runs at roof, at each floor, and at 10-foot intervals between floors.

F. Fiberglass Piping Hanger Spacing: Space hangers according to pipe manufacturer's written instructions for service conditions. Avoid point loading. Space and install hangers with the fewest practical rigid anchor points.

3.6 PIPE JOINT CONSTRUCTION

A. Ream ends of pipes and remove burrs. Bevel plain ends of steel pipe.

B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

C. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

D. Welded Joints: Construct joints according to AWS D10.12M/D10.12, using qualified processes and welding operators according to "Quality Assurance" Article.

E. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

3.7 TERMINAL EQUIPMENT CONNECTIONS

A. Size for supply and return piping connections shall be the same as or larger than equipment connections.

B. Install traps and control valves in accessible locations close to connected equipment.

C. Install bypass piping with globe valve around control valve. If parallel control valves are installed, only one bypass is required.

D. Install vacuum breakers downstream from control valve, close to coil inlet connection.

E. Install a drip leg at coil outlet.

3.8 FIELD QUALITY CONTROL

A. Prepare steam and condensate piping according to ASME B31.1, "Power Piping," and ASME B31.9, "Building Services Piping," and as follows:

1. Leave joints, including welds, uninsulated and exposed for examination during test.
2. Provide temporary restraints for expansion joints that cannot sustain reactions due to test pressure. If temporary restraints are impractical, isolate expansion joints from testing.
3. Flush system with clean water. Clean strainers.
4. Isolate equipment from piping. If a valve is used to isolate equipment, its closure shall be capable of sealing against test pressure without damage to valve. Install blinds in flanged joints to isolate equipment.

B. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

C. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

D. Perform the following tests and inspections:

1. Use ambient temperature water as a testing medium unless there is risk of damage due to freezing. Another liquid that is safe for workers and compatible with piping may be used.
2. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the working pressure. Test pressure shall not exceed maximum pressure for any vessel, pump, valve, or other component in system under test. Verify that stress due to pressure at bottom of vertical runs does not exceed 90 percent of specified minimum yield strength.
3. After hydrostatic test pressure has been applied for at least 10 minutes, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components, and repeat hydrostatic test until there are no leaks.

E. Prepare test and inspection reports.

END OF SECTION 232213

SECTION 232216 - STEAM AND CONDENSATE HEATING PIPING SPECIALTIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes the following piping specialties for steam and condensate piping:

1. Strainers.
2. Flash tanks.
3. Stop-check valves.
4. Safety valves.
5. Pressure-reducing valves.
6. Steam traps.
7. Thermostatic air vents and vacuum breakers.
8. Flexible connectors.
9. Steam meters
10. Condensate meters.
11. Vibration isolators for hangers
12. Expansion Fittings
13. Alignment guides and anchors

B. Related Requirements:

1. Section 232213 "Steam and Condensate Heating Piping" for expansion fittings and loops.
2. Section 230523.10 "Valves for HVAC Piping" for specification and installation requirements for globe valves common to most piping systems.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Strainer.
2. Flash tank.
3. Valve.
4. Steam trap.
5. Air vent and vacuum breaker.
6. Connector.
7. Meter.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For valves, safety valves, pressure-reducing valves, steam traps, air vents, vacuum breakers, and meters to include in emergency, operation, and maintenance manuals.

1.5 QUALITY ASSURANCE

A. Pipe Welding: Qualify procedures and operators according to the following:

1. ASME Compliance: Safety valves and pressure vessels shall bear the appropriate ASME label. Fabricate and stamp flash tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Components and installation shall be capable of withstanding the following minimum working pressures and temperatures unless otherwise indicated:

1. HP Steam Piping: over 15 psig.
2. LP Steam Piping: up to 15 psig.
3. Condensate Piping: 15 psig at 250 deg F.
4. Makeup-Water Piping: 150 psig at 73 deg F.
5. Blowdown-Drain Piping: Equal to pressure of the piping system to which it is attached.
6. Air-Vent and Vacuum-Breaker Piping: Equal to pressure of the piping system to which it is attached.
7. Safety-Valve-Inlet and -Outlet Piping: Equal to pressure of the piping system to which it is attached.

2.2 STRAINERS

A. Y-Pattern Strainers:

1. Body: ASTM A 126, Class B cast iron, with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for strainers NPS 2 and smaller; flanged ends for strainers NPS 2-1/2 and larger.
3. Strainer Screen: Stainless-steel, 20-mesh strainer or perforated stainless-steel basket.
4. Tapped blowoff plug.
5. CWP Rating: 250-psig working steam pressure.

B. Basket Strainers:

1. Body: ASTM A 126, Class B cast iron, with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for strainers NPS 2 and smaller; flanged ends for strainers NPS 2-1/2 and larger.
3. Strainer Screen: Stainless-steel, 20-mesh strainer and perforated stainless-steel basket with 50 percent free area.
4. CWP Rating: 250-psig working steam pressure.

2.3 FLASH TANKS

A. Shop or factory fabricated of welded steel according to ASME Boiler and Pressure Vessel Code for 150-psig rating, and bearing ASME label. Fabricate with tappings for low-pressure steam and condensate outlets, high-pressure condensate inlet, air vent, safety valve, and legs.

2.4 STOP-CHECK VALVES

A. Stop-Check Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. A.Y. McDonald Mfg. Co.
    b. Crane; Crane Energy Flow Solutions.
    c. Jenkins Valves.
    d. Lunkenheimer Valves.

2. Body and Bonnet: Malleable iron.
3. End Connections: Flanged.
4. Disc: Cylindrical with removable liner and machined seat.
5. Stem: Brass alloy.
6. Operator: Outside screw and yoke with cast-iron handwheel.
7. Packing: PTFE-impregnated packing with two-piece packing gland assembly.
8. Pressure Class: 250.

2.5 STEAM SAFETY VALVES

A. Bronze or Brass Steam Safety Valves: ASME labeled, NPS 1/2 through NPS 2-1/2

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Apollo Valves; Conbraco Industries, Inc.
    b. Armstrong International, Inc.
    c. Spirax Sarco, Inc.
    d. Watts; a Watts Water Technologies company.

2. Disc Material: Forged copper alloy.
3. End Connections: Threaded inlet and outlet.
4. Spring: Fully enclosed steel spring with adjustable pressure range and positive shutoff; factory set and sealed.
5. Pressure Class: 250.
6. Drip-Pan Elbow: Cast iron and having threaded inlet and outlet, with threads complying with ASME B1.20.1.
7. Size and Capacity: As required for equipment according to ASME Boiler and Pressure Vessel Code.

B. Cast-Iron Steam Safety Valves: ASME labeled NPS 1-1/2 through NPS 6.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Apollo Valves; Conbraco Industries, Inc.
    b. Armstrong International, Inc.
    c. Spirax Sarco, Inc.
    d. Watts; a Watts Water Technologies company.
    e. Spence

2. Disc Material: Forged copper alloy with bronze nozzle.
3. End Connections: Raised-face flanged inlet and threaded or flanged outlet connections.
4. Spring: Fully enclosed cadmium-plated steel spring with adjustable pressure range and positive shutoff, factory set and sealed.
5. Pressure Class: 250.
6. Drip-Pan Elbow: Cast iron and having threaded inlet, outlet, and drain, with threads complying with ASME B1.20.1.
7. Exhaust Head: Cast iron and having threaded inlet and drain, with threads complying with ASME B1.20.1.
8. Size and Capacity: As required for equipment according to ASME Boiler and Pressure Vessel Code.

2.6 PRESSURE-REDUCING VALVES (Not Used)

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Apollo Valves; Conbraco Industries, Inc.
    b. Armstrong International, Inc.
    c. Spirax Sarco, Inc.
    d. Watts; a Watts Water Technologies company.
    e. Spence

B. Capacities and Characteristics:

1. Steam Flow Rate:
2. Inlet Pressure:
3. Outlet Set Pressure:
4. Pressure Loss (Wide Open):

C. ASME labeled.

D. Size, Capacity, and Pressure Rating: Factory set for inlet and outlet pressures indicated.

E. Description: Pilot-actuated diaphragm type, with adjustable pressure range and positive shutoff.

F. Body: Cast iron.

G. End Connections: Threaded connections for valves NPS 2 and smaller and flanged connections for valves NPS 2-1/2 and larger.

H. Trim: Hardened stainless steel.

I. Head and Seat: Replaceable, main head stem guide fitted with flushing and pressure-arresting device cover over pilot diaphragm.

J. Gaskets: Non-asbestos materials.

2.7 STEAM TRAPS

A. Thermostatic Steam Traps:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Armstrong International, Inc.
b. Dunham-Bush, Inc.
c. Hoffman Specialty.
d. Spirax Sarco, Inc.
e. Sterling.
f. Tunstall Corporation.

2. Body: Bronze angle-pattern body with integral union tailpiece and screw-in cap.
3. Trap Type: Balanced pressure.
4. Bellows: Stainless steel or monel.
5. Head and Seat: Replaceable, hardened stainless steel.
6. Pressure Class: 125.

B. Thermodynamic Steam Traps:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Armstrong International, Inc.
b. Dunham-Bush, Inc.
c. Hoffman Specialty.
d. Spirax Sarco, Inc.

2. Body: Stainless steel with screw-in cap.
3. End Connections: Threaded.
4. Disc and Seat: Stainless steel.
5. Maximum Operating Pressure: 600 psig.

C. Float and Thermostatic Steam Traps:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Armstrong International, Inc.
b. Dunham-Bush, Inc.
c. Hoffman Specialty.
d. Spirax Sarco, Inc.

2. Body and Bolted Cap: ASTM A 126 cast iron.

3. End Connections: Threaded.
4. Float Mechanism: Replaceable, stainless steel.
5. Head and Seat: Hardened stainless steel.
6. Trap Type: Balanced pressure.
7. Thermostatic Bellows: Stainless steel or monel.
8. Thermostatic air vent capable of withstanding 45 deg F of superheat and resisting water hammer without sustaining damage.
9. Vacuum Breaker: Thermostatic with phosphor bronze bellows, and stainless-steel cage, valve, and seat.
10. Maximum Operating Pressure: 125 psig.

D. Inverted Bucket Steam Traps:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Armstrong International, Inc.
    b. Dunham-Bush, Inc.
    c. Hoffman Specialty.
    d. Spirax Sarco, Inc.

2. Body and Cap: Cast iron.
3. End Connections: Threaded.
4. Head and Seat: Stainless steel.
5. Valve Retainer, Lever, and Guide Pin Assembly: Stainless steel.
6. Bucket: Brass or stainless steel.
7. Strainer: Integral stainless-steel inlet strainer within the trap body.
8. Air Vent: Stainless-steel thermostatic vent.
9. Pressure Rating: 250 psig.

2.8 THERMOSTATIC AIR VENTS AND VACUUM BREAKERS

A. Thermostatic Air Vents:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Armstrong International, Inc.
    b. Dunham-Bush, Inc.
    c. Hoffman Specialty.
    d. Spirax Sarco, Inc.

2. Body: Cast iron, bronze, or stainless steel.
3. End Connections: Threaded.
4. Float, Valve, and Seat: Stainless steel.
5. Thermostatic Element: Phosphor bronze bellows in a stainless-steel cage.
6. Pressure Rating: 300 psig.
7. Maximum Temperature Rating: 350 deg F.

B. Vacuum Breakers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Armstrong International, Inc.
    b. Dunham-Bush, Inc.
    c. Hoffman Specialty.
    d. Spirax Sarco, Inc.

2. Body: Cast iron, bronze, or stainless steel.
3. End Connections: Threaded.
4. Sealing Ball, Retainer, Spring, and Screen: Stainless steel.
5. O-Ring Seal: Ethylene propylene rubber.
6. Pressure Rating: 300 psig.
7. Maximum Temperature Rating: 350 deg F.

2.9 VIBRATION ISOLATION PIPE HANGERS

A. Vibration isolation pipe hangers; pre-compressed and locked at the rated deflection by means of a resilient up-stop to keep the piping or equipment at a fixed elevation during installation. The hangers shall be designed with a release mechanism to free the spring after the installation is complete and the hanger is subjected to its full load. Deflection shall be clearly indicated by means of a scale. Submittals shall include a drawing of the hanger showing the 30° capability. Hangers shall be type PC30N as manufactured by Mason Industries, Inc

2.10 ALIGNMENT GUIDES AND ANCHORS

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Advanced Thermal Systems, Inc.
    b. Flexicraft Industries.
    c. Mason Industries, Inc.
    d. Metraflex Company (The).

2. Description: Steel, factory-fabricated alignment guide, with bolted two-section outer cylinder and base for attaching to structure; with two-section guiding slider for bolting to pipe.
3. Steel Shapes and Plates: ASTM A 36/A 36M.
4. Bolts and Nuts: ASME B18.10 or ASTM A 183, steel hex head.
5. Washers: ASTM F 844, steel, plain, flat washers.
6. Mechanical Fasteners: Insert-wedge-type stud with expansion plug anchor for use in hardened concrete, with tension and shear capacities appropriate for application. Threaded stud, expansion plug, nuts and washers shall be zink-coated carbon steel.

7. Chemical Fasteners: Insert-type stud, bonding-system anchor for use with hardened concrete, with tension and shear capacities appropriate for application.

    a. Bonding Material: ASTM C 881/C 881M, Type IV, Grade 3, two-component epoxy resin suitable for surface temperature of hardened concrete where fastener is to be installed.

b. Stud: threaded stud washers and nuts shall be ASTM A 307, zinc-coated carbon steel.
c. Alignment Guides
    1) Horizontal split spider type guide – Metra flex – Style IV
    2) Slide guide – Metra flex – model PTFE
    3) Pre-insulated guide – Metra flex – model PG PRE
    4) Vertical glide riser – Metra flex – model PGQ
d. Anchors
    1) Anchor clamp – Metra flex – model PA
    2) Structural I Beam Anchors – Metra flex
    3) Pre-insulated Anchor – Metra flex – model PAPI
    4) Modular riser guide – Metra flex – modular riser with EPDM insert

PART 3 - EXECUTION

3.1 VALVE APPLICATIONS

A. Install shutoff duty valves at branch connections to steam supply mains, at steam supply connections to equipment, and at the outlet of steam traps.

B. Install safety valves on pressure-reducing stations and elsewhere as required by ASME Boiler and Pressure Vessel Code. Install safety-valve discharge piping, without valves, to nearest floor drain or as indicated on Drawings. Comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1, for installation requirements.

3.2 PIPING INSTALLATION

A. Install piping to permit valve servicing.

B. Install drains, consisting of a tee fitting, NPS 3/4 full-port ball valve, and short NPS 3/4 threaded nipple with cap, at low points in piping system mains and elsewhere as required for system drainage.

C. Install valves according to Section 230523.10 "Valves for HVAC Piping,"

D. Install unions in piping, NPS 2 and smaller, adjacent to valves, at final connections of equipment and elsewhere as indicated.

E. Install flanges in piping, NPS 2-1/2 and larger, at final connections of equipment and elsewhere as indicated.

F. Install shutoff valve immediately upstream of each dielectric fitting.

G. Install strainers on supply side of control valves, pressure-reducing valves, traps, and elsewhere as indicated. Install NPS 3/4 nipple and full-port ball valve in blowdown connection of strainers NPS 2 and larger. Match size of strainer blowoff connection for strainers smaller than NPS 2.

H. Install vibration isolation hangers or supports on all piping connected to motor driven equipment for a distance of 20’ or the first two hangers.

I. Flash Tank:

1. Pitch condensate piping down toward flash tank.
2. If more than one condensate pipe discharges into flash tank, install a check valve in each line.
3. Install thermostatic air vent at tank top.
4. Install safety valve at tank top.
5. Install full-port ball valve, and swing check valve on condensate outlet.
6. Install inverted bucket or float and thermostatic trap at low-pressure condensate outlet, sized for 3 times the calculated heat load.
7. Install pressure gage on low-pressure steam outlet according to Section 230519 "Meters and Gages for HVAC Piping."

3.3 STEAM-TRAP INSTALLATION

A. Install steam traps in accessible locations as close as possible to connected equipment.

B. Install full-port ball valve, strainer, and union upstream from trap; install union, check valve, and full-port ball valve downstream from trap unless otherwise indicated.

C. All radiator traps and main drips shall be float and thermostatic traps.

3.4 SAFETY VALVE INSTALLATION

A. Install safety valves according to ASME B31.1, "Power Piping." ASME B31.9, "Building Services Piping." ASME B31.1, "Power Piping," and ASME B31.9, "Building Services Piping."

B. Pipe safety-valve discharge without valves to atmosphere outside the building.

C. Install drip-pan elbow fitting adjacent to safety valve and pipe drain connection to nearest floor drain.

D. Install exhaust head with drain to waste, on vents equal to or larger than NPS 2-1/2.

3.5 TERMINAL EQUIPMENT CONNECTIONS

A. Install traps and control valves in accessible locations close to connected equipment.

B. Install bypass piping with globe valve around control valve. If parallel control valves are installed, only one bypass is required.

C. Install vacuum breakers downstream from control valve, close to coil inlet connection.

3.6 EXPANSION JOINT INSTALLATION

A. Install expansion joints of sizes matching sizes of piping in which they are installed.

B. Install grooved-joint expansion joints to grooved-end steel piping.

3.7 PIPE LOOP AND SWING CONNECTION INSTALLATION

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

B. Connect risers and branch connections to terminal units with at least four pipe fittings, including tee in riser.

C. Connect mains and branch connections to terminal units with at least four pipe fittings, including tee in main.

3.8 ALIGNMENT-GUIDE AND ANCHOR INSTALLATION

A. Install alignment guides to guide expansion and to avoid end-loading and torsional stress.

B. Install one guide(s) on each side of pipe expansion fittings and loops. Install guides nearest to expansion joint or loop not more than three pipe diameters from expansion joint.

C. Attach guides to pipe, and secure guides to building structure.

D. Install anchors at locations to prevent stresses from exceeding those permitted by ASME B31.9 and to prevent transfer of loading and stresses to connected equipment.

E. Anchor Attachments:

1. Anchor Attachment to Steel Pipe: Attach by welding. Comply with ASME B31.9 and ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
2. Anchor Attachment to Copper Tubing: Attach with pipe hangers. Use MSS SP-69, Type 24; U bolts bolted to anchor.

F. Fabricate and install steel anchors by welding steel shapes, plates, and bars. Comply with ASME B31.9 and AWS D1.1/D1.1M.

1. Anchor Attachment to Steel Structural Members: Attach by welding.
2. Anchor Attachment to Concrete Structural Members: Attach by fasteners. Follow fastener manufacturer's written instructions.

G. Use grout to form flat bearing surfaces for guides and anchors attached to concrete.

END OF SECTION 232216

SECTION 232223 - STEAM CONDENSATE PUMPS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes steam condensate pumps.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product. Include certified performance curves and rated capacities, operating characteristics, furnished specialties, and accessories for each type of product indicated. Indicate pump's operating point on curves. Include receiver capacity and material.

B. Shop Drawings: For each pump.

1. Show pump layout and connections.
2. Include setting drawings with templates for installing foundation and anchor bolts and other anchorages.
3. Include diagrams for power, signal, and control wiring.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For pumps to include in emergency, operation, and maintenance manuals.

PART 2 - PRODUCTS

2.1 SINGLE-STAGE, CENTRIFUGAL PUMPS WITH FLOOR-MOUNTED RECEIVER

A. Basis-of-Design Product: The basis of design manufacturer shall be Sterlco. Subject to review and approval by the engineer and compliance with the contract documents, provide the product indicated on plan or a comparable product by one of the following alternate manufactures:
1. ITT Corporation.
2. Skidmore Pump.
3. Spence Engineering Company, Inc.
4. Spirax Sarco, Inc.
5. Shipco

B. Description: Factory-fabricated, packaged, electric-driven pumps; with receiver, pumps, controls, and accessories suitable for operation with steam condensate.

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. ASME Compliance: Fabricate and label steam condensate receivers to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

C. Configuration: Simplex floor-mounted pump with receiver and float switches; rated to pump 200 deg F steam condensate.

D. Receiver:

1. Floor mounted.
2. Heavy duty 3/16” welded steel.
3. Externally adjustable float switches.
4. Float switch shall two pole drip proof, stainless steel float and rod
5. Flanges for pump mounting.
6. Water-level gage glass and dial thermometer.
7. Pressure gage at pump discharge.
8. Bronze fitting isolation valve between pump and receiver.
9. Lifting eyebolts.
10. Inlet vent and an overflow.
11. Cast-iron inlet strainer with vertical self-cleaning bronze screen and large dirt pocket.

E. Pumps:

1. Centrifugal, close coupled, vertical design.
2. Permanently aligned.
3. Bronze fitted.
4. Replaceable bronze case ring.
5. Ceramic seals rated at 300 deg F.
6. Mounted on receiver flange.
7. Magnetic HOA starter
8. 3400 rpm

F. Motor:

1. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
2. Enclosure: Open, drip proof Totally enclosed, fan cooled Totally enclosed, air over Open, externally ventilated Totally enclosed, nonventilated Severe duty Explosion proof Dust-ignition-proof machine.
3. Enclosure Materials: Rolled steel.
4. Motor Bearings: Permanently lubricated ball bearings up through 5 HP
5. Motor Bearings Grease lubricated ball bearings over 5 HP
6. Unusual Service Conditions:

a. Ambient Temperature: **40 deg C 104 F.**
b. Altitude: 100 above sea level.

c. High humidity.

7. Efficiency: Premium efficient.
8. NEMA Design: B or C .
9. Service Factor: 1.15.

G. Control Panel:

1. Factory wired between pumps and float switches, for single external electrical connection.
2. Provide fused, control-power transformer if voltage exceeds 230 V ac.
3. NEMA 250, Type 1 enclosure with hinged door and grounding lug, mounted on pump.
4. Motor controller for each pump.
5. Electrical pump alternator to operate pumps in lead-lag sequence and allow both pumps to operate on receiver high level.
6. Manual lead-lag control to override electrical pump alternator and manually select the lead pump.
7. Momentary-contact "TEST" push button on cover for each pump.
8. Numbered terminal strip.
9. Disconnect switch.

H. Capacities and Characteristics: REFER TO PLANS AND SCHEDULES

2.2 SINGLE-STAGE, CENTRIFUGAL BOILER FEED PUMPS WITH FLOOR-MOUNTED RECEIVER

A. Basis-of-Design Product: The basis of design manufacture shall be Sterlco. Subject to review and approval by the engineer and compliance with the contract documents, provide the product indicated on plan or a comparable product by one of the following alternate manufactures:
1. ITT Corporation.
2. Skidmore Pump.
3. Spence Engineering Company, Inc.
4. Spirax Sarco, Inc.
5. Shipco

B. Description: Factory-fabricated, packaged, electric-driven pumps; with receiver, pumps, controls, and accessories suitable for operation with steam condensate.

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. ASME Compliance: Fabricate and label steam condensate receivers to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

C. Configuration: Duplex floor-mounted pump with receiver and float switches; rated to pump 200 deg F steam condensate.

D. Receiver:

1. Floor mounted.
2. Heavy duty 3/16” welded steel tank

3. Externally adjustable float switches.
4. Float switch shall two pole drip proof, stainless steel float and rod
5. Flanges for pump mounting.
6. Water-level gage glass and dial thermometer.
7. Pressure gage at pump discharge.
8. Bronze fitting isolation valve between pump and receiver.
9. Lifting eyebolts.
10. Inlet vent and an overflow.
11. Cast-iron inlet strainer with vertical self-cleaning bronze screen and large dirt pocket.
12. Make up water valve

E. Pumps:

1. Centrifugal, close coupled, vertical design.
2. Permanently aligned.
3. Bronze fitted.
4. Replaceable bronze case ring.
5. Ceramic seals rated at 300 deg F.
6. Mounted on receiver flange.
7. Magnetic HOA starter
8. 3400 rpm

F. Motor:

1. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
2. Enclosure: Open, drip proof Totally enclosed, fan cooled Totally enclosed, air over Open, externally ventilated Totally enclosed, nonventilated Severe duty Explosion proof Dust-ignition-proof machine.
3. Enclosure Materials: Rolled steel.
4. Motor Bearings: Permanently lubricated ball bearings up through 5 HP
5. Motor Bearings Grease lubricated ball bearings over 5 HP
6. Unusual Service Conditions:

    a. Ambient Temperature: **40 deg C 104 F.**
    b. Altitude: 100 above sea level.
    c. High humidity.

7. Efficiency: Premium efficient.
8. NEMA Design: B or C .
9. Service Factor: 1.15.

G. Control Panel:

1. Factory wired between pumps and float switches, for single or double external electrical connection.
2. Provide fused, control-power transformer if voltage exceeds 230 V ac.
3. NEMA 12, control panel, enclosure with hinged door and grounding lug, mounted on pump.
4. Motor controller for each pump. HOA selector switch

5. Electrical pump alternator to operate pumps in lead-lag sequence and allow both pumps to operate on receiver high level.
6. Momentary-contact "TEST" push button on cover for each pump.
7. Numbered terminal strip.
8. Disconnect switch.
9. Pilot light for running pump
10. Mounted and wired for single point power connection

H. Capacities and Characteristics: REFER TO PLANS AND SCHEDULES

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine equipment foundations and anchor-bolt locations for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for piping systems to verify actual locations of piping connections before pump installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install pumps to provide access for periodic maintenance including removing motors, impellers, couplings, and accessories.

B. Support pumps and piping separately so piping is not supported by pumps.

C. Install thermometers and pressure gages.

D. Equipment Mounting:

1. Install pumps on cast-in-place concrete equipment base(s).

3.3 CONNECTIONS

A. Comply with requirements for piping specified in Section 232213 "Steam and Condensate Heating Piping" and Section 232216 "Steam and Condensate Heating Piping Specialties."

B. Where installing piping adjacent to machine, allow space for service and maintenance.

C. Install a globe and check valve and pressure gage before inlet of each pump and a gate and check valve at pump outlet.

D. Pipe drain to nearest floor drain for overflow and drain piping connections.

E. Install full-size vent piping to outdoors, terminating in 180-degree elbow at point above highest steam system connection or as indicated.

F. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

G. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.4 STARTUP SERVICE

A. Perform start up services as per the following. For motors 20 hp and over engage a factory-authorized service representative to perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.
2. Clean strainers.
3. Set steam condensate pump controls.
4. Set pump controls for automatic start, stop, and alarm operation.
5. Perform the following preventive maintenance operations and checks before starting:

    a. Set float switches to operate at proper levels.
    b. Set throttling valves on pump discharge for specified flow.
    c. Check motors for proper rotation.
    d. Test pump controls and demonstrate compliance with requirements.
    e. Replace damaged or malfunctioning pump controls and equipment.
    f. Verify that pump controls are correct for required application.

6. Start steam condensate pumps according to manufacturer's written startup instructions.

3.5 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain steam condensate pumps.

END OF SECTION 232223

SECTION 233113 - METAL DUCTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Single-wall rectangular ducts and fittings.
2. Single-wall round and flat-oval ducts and fittings.
3. Sheet metal materials.
4. Duct liner.
5. Sealants and gaskets.
6. Hangers and supports.
7. Seismic-restraint devices.

B. Related Sections:

1. Section 230593 "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing requirements for metal ducts.

1.3 PERFORMANCE REQUIREMENTS

A. Delegated Duct Design: Duct construction, including sheet metal thicknesses, seam and joint construction, reinforcements, and hangers and supports, shall comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and performance requirements and design criteria indicated in "Duct Schedule" Article.

B. Structural Performance: Duct hangers and supports and seismic restraints shall withstand the effects of gravity and seismic loads and stresses within limits and under conditions described in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and ASCE/SEI 7. SMACNA's "Seismic Restraint Manual: Guidelines for Mechanical Systems."

1. Seismic Hazard Level A: Seismic force to weight ratio, 0.48.
2. Seismic Hazard Level B: Seismic force to weight ratio, 0.30.
3. Seismic Hazard Level C: Seismic force to weight ratio, 0.15.

C. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of the following products:

1. Liners and adhesives.
2. Sealants and gaskets.
3. Seismic-restraint devices.

B. Shop Drawings:

1. Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work.
2. Factory- and shop-fabricated ducts and fittings.
3. Duct layout indicating sizes, configuration, liner material, and static-pressure classes.
4. Elevation of top of ducts.
5. Dimensions of main duct runs from building grid lines.
6. Fittings.
7. Reinforcement and spacing.
8. Seam and joint construction.
9. Penetrations through fire-rated and other partitions.
10. Equipment installation based on equipment being used on Project.
11. Locations for duct accessories, including dampers, turning vanes, and access doors and panels.
12. Hangers and supports, including methods for duct and building attachment.
13. Seismic restraints, where applicable
14. Vibration isolation.

C. Delegated-Design Submittal:

1. Sheet metal thicknesses.
2. Joint and seam construction and sealing.
3. Reinforcement details and spacing.
4. Materials, fabrication, assembly, and spacing of hangers and supports.
5. Design Calculations: Calculations, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation for selecting hangers and supports and seismic restraints. For seismic bracing only

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Duct installation in congested spaces, indicating coordination with general construction, building components, and other building services. Indicate proposed changes to duct layout.
2. Suspended ceiling components.
3. Structural members to which duct will be attached.
4. Size and location of initial access modules for acoustical tile.
5. Penetrations of smoke barriers and fire-rated construction.
6. Items penetrating finished ceiling including the following:

a. Luminaires.
b. Air outlets and inlets.
c. Speakers.
d. Sprinklers.
e. Access panels.
f. Perimeter moldings.

B. Welding certificates.

C. Field quality-control reports.

1.6 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel," for hangers and supports. AWS D9.1M/D9.1, "Sheet Metal Welding Code," for duct joint and seam welding.

B. Welding Qualifications: Qualify procedures and personnel according to the following:

1. AWS D1.1/D1.1M, "Structural Welding Code - Steel," for hangers and supports.
2. AWS D9.1M/D9.1, "Sheet Metal Welding Code," for duct joint and seam welding.

C. ASHRAE/IES Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6.4.4 - "HVAC System Construction and Insulation."

D. Construct ductwork to NFPA 90A and NFPA 90B standards. All work, materials and equipment shall comply with the latest requirements of NFPA 90A, standards and the local authorities having jurisdiction.

E. All ductwork and fan and apparatus plenums constructed and having supported in accordance with the latest standards of the ASHRAE Guide and the Sheet Metal and Air Conditioning Contractors National Association (SMACNA).

F. Bracing, gauges, and supports indicated in SMACNA manuals are the minimum acceptable. Additional bracing or supports shall be installed to eliminate any distortion or vibration when the systems are operating or under tests.

PART 2 - PRODUCTS

2.1 General

A. General: Non-combustible or conforming to requirements for Class 1 air duct materials, or UL 181.

B. Galvanized Steel Ducts: ASTM A525 and ASTM A527 galvanized steel sheet, lock-forming quality, having zinc coating of 1.25 oz per sq ft for each side in conformance with ASTM A90.

C. Dissimilar Metals: Separate connections between dissimilar metals with Dielectric Insulation. Joints between dissimilar metal duct sections to be made with Companion flanges separated by a Neoprene gasket.

D. Fasteners: Rivets, bolts, screens, and other hardware used in the sheet metal construction to be constructed of materials identical or similar to the duct material to prevent galvanic corrosion.

E. Sealant: Non-hardening, water resistant, fire resistive, compatible with mating materials; liquid used alone or with tape, or heavy mastic as manufactured by 3M Company EC-800.

F. Hanger Rod: Steel, galvanized; threaded both ends, threaded one end, or continuously threaded.

2.2 SINGLE-WALL RECTANGULAR DUCTS AND FITTINGS

A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class unless otherwise indicated.

B. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-1, "Rectangular Duct/Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

C. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Duct/Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

D. Elbows, Transitions, Offsets, Branch Connections, and Other Duct Construction: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 4, "Fittings and Other Construction," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.3 SHEET METAL MATERIALS

A. General Material Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

B. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.

1. Galvanized Coating Designation: G90.
2. Finishes for Surfaces Exposed to View: Mill phosphatized.

C. PVC-Coated, Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.

1. Galvanized Coating Designation: G90.
2. Minimum Thickness for Factory-Applied PVC Coating: 4 mils thick on sheet metal surface of ducts and fittings exposed to corrosive conditions, and minimum 1 mil thick on opposite surface.
3. Coating Materials: Acceptable to authorities having jurisdiction for use on ducts listed and labeled by an NRTL for compliance with UL 181, Class 1.

D. Carbon-Steel Sheets: Comply with ASTM A 1008/A 1008M, with oiled, matte finish for exposed ducts.

E. Stainless-Steel Sheets: Comply with ASTM A 480/A 480M, Type 316, as indicated in the "Duct Schedule" Article; cold rolled, annealed, sheet. Exposed surface finish shall be No. 2B, No. 2D, No. 3, or No. 4 as indicated in the "Duct Schedule" Article.

F. Aluminum Sheets: Comply with ASTM B 209 Alloy 3003, H14 temper; with mill finish for concealed ducts, and standard, one-side bright finish for duct surfaces exposed to view.

G. Factory- or Shop-Applied Antimicrobial Coating:

1. Apply to the surface of sheet metal that will form the interior surface of the duct. An untreated clear coating shall be applied to the exterior surface.
2. Antimicrobial compound shall be tested for efficacy by an NRTL and registered by the EPA for use in HVAC systems.
3. Coating containing the antimicrobial compound shall have a hardness of 2H, minimum, when tested according to ASTM D 3363.
4. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.
5. Shop-Applied Coating Color: Black OR White.
6. Antimicrobial coating on sheet metal is not required for duct containing liner treated with antimicrobial coating.

H. Reinforcement Shapes and Plates: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.

1. Where black- and galvanized-steel shapes and plates are used to reinforce aluminum ducts, isolate the different metals with butyl rubber, neoprene, or EPDM gasket materials.

I. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

2.4 SEALANT AND GASKETS

A. General Sealant and Gasket Requirements: Surface-burning characteristics for sealants and gaskets shall be a maximum flame-spread index of 25 and a maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.

B. Two-Part Tape Sealing System:

1. Tape: Woven cotton fiber impregnated with mineral gypsum and modified acrylic/silicone activator to react exothermically with tape to form hard, durable, airtight seal.
2. Tape Width: 4 inches.
3. Sealant: Modified styrene acrylic.
4. Water resistant.
5. Mold and mildew resistant.
6. Maximum Static-Pressure Class: 10-inch wg, positive and negative.
7. Service: Indoor and outdoor.
8. Service Temperature: Minus 40 to plus 200 deg F.
9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum.

C. Water-Based Joint and Seam Sealant:

1. Application Method: Brush on.
2. Solids Content: Minimum 65 percent.
3. Shore A Hardness: Minimum 20.
4. Water resistant.
5. Mold and mildew resistant.
6. VOC: Maximum 75 g/L (less water).
7. Maximum Static-Pressure Class: 10-inch wg, positive and negative.
8. Service: Indoor or outdoor.
9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.

D. Solvent-Based Joint and Seam Sealant:

1. Application Method: Brush on.
2. Base: Synthetic rubber resin.
3. Solvent: Toluene and heptane.
4. Solids Content: Minimum 60 percent.
5. Shore A Hardness: Minimum 60.
6. Water resistant.
7. Mold and mildew resistant.
8. Maximum Static-Pressure Class: 10-inch wg, positive or negative.
9. Service: Indoor or outdoor.
10. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.

E. Flanged Joint Sealant: Comply with ASTM C 920.

1. General: Single-component, acid-curing, silicone, elastomeric.
2. Type: S.
3. Grade: NS.
4. Class: 25.
5. Use: O.

F. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.

G. Round Duct Joint O-Ring Seals:

1. Seal shall provide maximum leakage class of 3 cfm/100 sq. ft. at 1-inch wg and shall be rated for10-inch wg static-pressure class, positive or negative.
2. EPDM O-ring to seal in concave bead in coupling or fitting spigot.
3. Double-lipped, EPDM O-ring seal, mechanically fastened to factory-fabricated couplings and fitting spigots.

2.5 HANGERS AND SUPPORTS

A. Hanger Rods for Noncorrosive Environments: Cadmium-plated steel rods and nuts.

B. Hanger Rods for Corrosive Environments: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.

C. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct."

D. Steel Cables for Galvanized-Steel Ducts: Galvanized steel complying with ASTM A 603.

E. Steel Cables for Stainless-Steel Ducts: Stainless steel complying with ASTM A 492.

F. Steel Cable End Connections: Cadmium-plated steel assemblies with brackets, swivel, and bolts designed for duct hanger service; with an automatic-locking and clamping device.

G. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

H. Trapeze and Riser Supports:

1. Supports for Galvanized-Steel Ducts: Galvanized-steel shapes and plates.
2. Supports for Stainless-Steel Ducts: Stainless-steel shapes and plates.
3. Supports for Aluminum Ducts: Aluminum or galvanized steel coated with zinc chromate.

PART 3 - EXECUTION

3.1 DUCT INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of duct system. Indicated duct locations, configurations, and arrangements were used to size ducts and calculate friction loss for air-handling equipment sizing and for other design considerations. Install duct systems as indicated unless deviations to layout are approved on Shop Drawings and Coordination Drawings.

B. Install ducts according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" unless otherwise indicated.

C. Install ducts in maximum practical lengths and with fewest possible joints

D. Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections. Increase duct sizes gradually, not exceeding 15 degrees divergence wherever possible; maximum 0 degrees divergence upstream of equipment and 45 degrees convergence downstream.

E. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.

F. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.

G. Install ducts with a clearance of 2 inch, plus allowance for insulation thickness and with sufficient space around equipment to allow normal operating and maintenance activities. Provide easements where ductwork conflicts with piping and structure. Where easements exceed 10 percent duct area, split into two ducts maintaining original duct area.

H. Provide standard 45-degree lateral wye takeoffs unless otherwise indicated where 90 degree conical tee connections may be used.

I. Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.

J. Where ducts pass through non-fire-rated interior partitions and exterior walls and are exposed to view, cover the opening between the partition and duct or duct insulation with sheet metal flanges of same metal thickness as the duct. Overlap openings on four sides by at least 1-1/2 inches.

K. Protect duct interiors from moisture, construction debris and dust, and other foreign materials. Comply with SMACNA's "IAQ Guidelines for Occupied Buildings Under Construction," Appendix G, "Duct Cleanliness for New Construction Guidelines."

L. Provide openings in ductwork where required to accommodate thermometers and controllers. Provide pilot tube openings where required for testing of systems, complete with metal can with spring device or screw to ensure against air leakage. Where openings are provided in insulated ductwork, install insulation material inside a metal ring.

M. Where hanger rods must pierce ducts, provide closure plates around rods and fasten to duct using screws, rivets or welding. Seal with sealing compound.

N. Construct T's, bends, and elbows with radius of not less than 1-1/2 times width of duct on centerline. Where not possible and where rectangular elbows are used, provide airfoil turning vanes. Where acoustical lining is indicated, provide turning vanes of perforated metal with glass fiber insulation.

O. Where ductwork penetrates roofs or outside walls, seal the space around ductwork air tight with fire rated expanding spray foam sealer similar to 3-M Fire Block Foam. This also applies to duct roof penetrations into roof curbs.

P. All ductwork shall be inspected and pressure tested prior to enclosing in general construction or concealment above hung ceilings

3.2 INSTALLATION OF EXPOSED DUCTWORK

A. Protect ducts exposed in finished spaces from being dented, scratched, or damaged.

B. Trim duct sealants flush with metal. Create a smooth and uniform exposed bead. Do not use two-part tape sealing system.

C. Grind welds to provide smooth surface free of burrs, sharp edges, and weld splatter. When welding stainless steel with a No. 3 or 4 finish, grind the welds flush, polish the exposed welds, and treat the welds to remove discoloration caused by welding.

D. Maintain consistency, symmetry, and uniformity in the arrangement and fabrication of fittings, hangers and supports, duct accessories, and air outlets.

E. Repair or replace damaged sections and finished work that does not comply with these requirements.

F. Prime ductwork and paint with one coat enamel base paint. Color as per architectural plans. All ductwork surface finish shall be treated prior to priming by “pickling” in accordance with industry standards and paint manufactures requirements.

G. All ductwork in any building that is exposed to view, (except mechanical equipment rooms), shall double wall round ductwork or oval as indicated on plan. Where ductwork is to be painted, it shall be primed. Refer to the architectural plans for where ductwork shall be painted. Submit paint color chart for review and approval. Primer shall be specifically formulated for galvanized steel.

H. Duct sealants used on exposed ductwork of any type shall be clear.

3.3 DUCT SEALING

A. Seal ducts at a minimum to the following seal classes according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" Refer to the Duct Leakage and seal Classification Table below.

Leakage and Seal Classification Table			
Duct Class	1/2"-1",2" wg	3" wg	4", 6",10"wg
Sealing Applicable	Transverse Joints Only	Transverse Joints and Seams	Joints, Seams & all Wall penetrations
Leakage Class (C_l) - CFM leakage per 100 SF @ 1" H_2O			
Rectangular Metal	24	12	6
Round Metal	12	6	3

3.4 HANGER AND SUPPORT INSTALLATION

A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 5, "Hangers and Supports."

B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.

1. Where practical, install concrete inserts before placing concrete.
2. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
3. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches thick.
4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches thick.
5. Do not use powder-actuated concrete fasteners for seismic restraints.

C. Hanger Spacing: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct," for maximum hanger spacing; install hangers and supports within 24 inches of each elbow and within 48 inches of each branch intersection.

D. Hangers Exposed to View: Threaded rod and angle or channel supports.

E. Support vertical ducts with steel angles or channel secured to the sides of the duct with welds, bolts, sheet metal screws, or blind rivets; support at each floor and at a maximum interval of 16 feet.

F. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

G. Where hanger rods must pierce ducts, provide closure plates around rods and fasten to duct using screws, rivets or welding. Seal with sealing compound.

H. Where ceiling or sheetrock has to be opened for the installation of hangers, the contractor shall patch to match existing.

I. Where fire proofing is removed from structural members for the installation of hangers and supports the contractor shall re-fireproof the member to match the existing material and fireproof rating.
1.

3.5 CONNECTIONS

A. Make connections to equipment with flexible connectors complying with Section 233300 "Air Duct Accessories."

B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

C. Smoke purge supply and exhaust systems and stair pressure systems. Flexible connection shall be permitted at diffusers, a maximum of 3' long, and flexible connections are permitted at air handling equipment for vibration isolation only.

D. INSULATED FLEXIBLE DUCTS
1. UL 181, Class 0, interlocking spiral of aluminum foil; fiberglass insulation; polyethylene vapor barrier film.
2. Pressure Rating: 8 inches WG positive or negative.
3. Maximum Velocity: 5000 fpm
4. Temperature Range: -20 degrees F to 250 degrees F.

3.6 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Leakage Tests:

1. Comply with SMACNA's "HVAC Air Duct Leakage Test Manual." Submit a test report for each test.
2. Test the following systems:
    a. All Ducts with a Pressure Class equal to or Higher Than 2-Inch wg: Test representative duct sections totaling no less than 25 percent of total installed duct area for each system of the designated pressure class.
    b. All smoke purge system Ducts, including supply exhaust and return air. All stair pressurization ductwork. Test representative duct sections totaling no less than 50 percent of total installed duct area of each system.
3. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.
4. Test for leaks before applying external insulation.
5. Conduct tests at static pressures equal to maximum design pressure of system or section being tested. If static-pressure classes are not indicated, test system at maximum system design pressure. Do not pressurize systems above maximum design operating pressure.
6. Give seven days' advance notice for testing.

C. Duct System Cleanliness Tests:

1. Visually inspect duct system to ensure that no visible contaminants are present.

2. Test sections of metal duct system, chosen randomly by Owner, for cleanliness according to "Vacuum Test" in NADCA ACR, "Assessment, Cleaning and Restoration of HVAC Systems."

    a. Acceptable Cleanliness Level: Net weight of debris collected on the filter media shall not exceed 0.75 mg/100 sq. cm.

D. Duct system will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

3.7 DUCT CLEANING

A. Clean new duct system(s) before testing, adjusting, and balancing.

B. Use service openings for entry and inspection.

1. Create new openings and install access panels appropriate for duct static-pressure class if required for cleaning access. Provide insulated panels for insulated or lined duct. Patch insulation and liner as recommended by duct liner manufacturer. Comply with Section 233300 "Air Duct Accessories" for access panels and doors.
2. Disconnect and reconnect flexible ducts as needed for cleaning and inspection.
3. Remove and reinstall ceiling to gain access during the cleaning process.

C. Particulate Collection and Odor Control:

1. When venting vacuuming system inside the building, use HEPA filtration with 99.97 percent collection efficiency for 0.3-micron-size (or larger) particles.
2. When venting vacuuming system to outdoors, use filter to collect debris removed from HVAC system, and locate exhaust downwind and away from air intakes and other points of entry into building.

D. Clean the following components by removing surface contaminants and deposits:

1. Air outlets and inlets (registers, grilles, and diffusers).
2. Supply, return, and exhaust fans including fan housings, plenums (except ceiling supply and return plenums), scrolls, blades or vanes, shafts, baffles, dampers, and drive assemblies.
3. Air-handling unit internal surfaces and components including mixing box, coil section, air wash systems, spray eliminators, condensate drain pans, humidifiers and dehumidifiers, filters and filter sections, and condensate collectors and drains.
4. Coils and related components.
5. Return-air ducts, dampers, actuators, and turning vanes except in ceiling plenums and mechanical equipment rooms.
6. Supply-air ducts, dampers, actuators, and turning vanes.
7. Dedicated exhaust and ventilation components and makeup air systems.

E. Mechanical Cleaning Methodology:

1. Clean metal duct systems using mechanical cleaning methods that extract contaminants from within duct systems and remove contaminants from building.
2. Use vacuum-collection devices that are operated continuously during cleaning. Connect vacuum device to downstream end of duct sections so areas being cleaned are under negative pressure.
3. Use mechanical agitation to dislodge debris adhered to interior duct surfaces without damaging integrity of metal ducts, duct liner, or duct accessories.
4. Clean fibrous-glass duct liner with HEPA vacuuming equipment; do not permit duct liner to get wet. Replace fibrous-glass duct liner that is damaged, deteriorated, or delaminated or that has friable material, mold, or fungus growth.
5. Clean coils and coil drain pans according to NADCA 1992. Keep drain pan operational. Rinse coils with clean water to remove latent residues and cleaning materials; comb and straighten fins.
6. Provide drainage and cleanup for wash-down procedures.
7. Antimicrobial Agents and Coatings: Apply EPA-registered antimicrobial agents if fungus is present. Apply antimicrobial agents according to manufacturer's written instructions after removal of surface deposits and debris.

3.8 DUCTWORK PROTECTION

A. Duct work under construction or alteration shall not be left open ended during dust producing construction. All new and existing ductwork systems in the area of alteration or under construction shall be protected during construction. Open ends ducts shall be sealed with sheet metal or as approved.

B. For unenclosed buildings ductwork shall be kept dry and watertight. Seal open ends watertight during construction to prevent water infiltration. Keep all acoustical lining dry during construction. Lining that has become we shall be replaced. all incomplete ductwork being used to condition spaces in phase I or phase II that will be completed under a later phase must be protect from being internally contaminated by construction dust. All returns opening must have filters placed over then to prevent dust from being returned to the unit.

3.9 DUCT SCHEDULE

A. Fabricate ducts using the following material;

1. Outside air intake plenum and ductwork - Aluminum

2. Above ground in MER, conditioned space or unconditioned spaces – galvanized steel

B. Duct Pressure class;

1. All duct systems shall be constructed to have a pressure classification based on the maximum static pressure (positive or negative) developed by the air handling apparatus connected to the ductwork system. Unless otherwise noted below, refer to the equipment schedules and equipment notes for the design operating pressure of each system. Systems with operating pressures between pressure classes shall be constructed to the next higher pressure class.

Pressure Classification Table						
System operating pressure (OP) in wc	OP≤1"	1"≥OP<2"	2"≥OP<3"	3"≥OP<4"	4"≥OP<6"	6"≥OP<10"
SMACNA Construction classification	1"	2"	3"	4"	6"	10"

2. All ductwork shall be constructed in accordance with the leakage and seal classification. Note that the leakage and seal classification required by current code is more stringent than SMACNA requirements.

Leakage and Seal Classification Table			
System operating pressure in wc	<2" low	2"≥med<3"	High≥3"
Seal Class	C	B	A
Sealing	Transverse joints	Transverse joints and seams	Transverse joints and seams and all wall penetrations
Leakage class CL factor - Rectangular me	24	12	4
Leakage class CL factor - round metal	12	6	3

C. Intermediate Reinforcement:

1. Galvanized-Steel Ducts: Galvanized steel.
2. PVC-Coated Ducts:

   a. Exposed to Airstream: Match duct material.
   b. Not Exposed to Airstream: Match duct material.

3. Stainless-Steel Ducts:

   a. Exposed to Airstream: Match duct material.
   b. Not Exposed to Airstream: Match duct material.

4. Aluminum Ducts: Aluminum or galvanized sheet steel coated with zinc chromate

5. Sustainable design requiring compliance with ASHRAE/IES 90.1 must have duct insulation with an R-value that complies with tables titled "Minimum Duct Insulation R-Value, Cooling and Heating Only Supply Ducts and Return Ducts" and "Minimum Duct Insulation R-Value, Combined Heating and Cooling Supply Ducts and Return Ducts." If using interstitial insulation alone to satisfy thermal requirements, verify that material selected is available in thickness needed to provide thermal performance without jeopardizing other requirements.

D. Double-Wall Duct Interstitial Insulation:

1. Supply, Return, Exhaust Air Ducts: 1” inches thick. (When ducts are exposed in the conditions space)
2. Supply, Return, Exhaust Air Ducts: 1 1/2” inches thick. (When ducts are concealed in plenums or are located in unconditioned spaces)

E. Elbow Configuration:

1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."

    a. Velocity 1000 fpm or Lower:

        1) Radius Type RE 1 with minimum 0.5 radius-to-diameter ratio.
        2) Mitered Type RE 4 without vanes.

    b. Velocity 1000 to 1500 fpm:

        1) Radius Type RE 1 with minimum 1.0 radius-to-diameter ratio.
        2) Radius Type RE 3 with minimum 0.5 radius-to-diameter ratio and two vanes.
        3) Mitered Type RE 2 with turning vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."

    c. Velocity 1500 fpm or Higher:

        1) Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
        2) Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.
        3) Mitered Type RE 2 with turning vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."

2. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."

    a. Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
    b. Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.
    c. Mitered Type RE 2 with turning vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."

3. Round Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-4, "Round Duct Elbows."

    a. Minimum Radius-to-Diameter Ratio and Elbow Segments: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 3-1, "Mitered Elbows." Elbows with less than 90-degree change of direction have proportionately fewer segments.

1) Velocity 1000 fpm or Lower: 0.5 radius-to-diameter ratio and three segments for 90-degree elbow.
2) Velocity 1000 to 1500 fpm: 1.0 radius-to-diameter ratio and four segments for 90-degree elbow.
3) Velocity 1500 fpm or Higher: 1.5 radius-to-diameter ratio and five segments for 90-degree elbow.
4) Radius-to Diameter Ratio: 1.5.

b. Round Elbows, 12 Inches and Smaller in Diameter:
c. Round Elbows, 14 Inches and Larger in Diameter:

F. Branch Configuration:

1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-6, "Branch Connection."

a. Rectangular Main to Rectangular Branch: 45-degree entry.
b. Rectangular Main to Round Branch: Spin in.

2. Round and Flat Oval: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees." Saddle taps are permitted in existing duct.

a. Velocity 1000 fpm or Lower: 90-degree tap.
b. Velocity 1000 to 1500 fpm: Conical tap.
c. Velocity 1500 fpm or Higher: 45-degree lateral.

3.10 DUCTWORK PRESSURE TESTING

A. All high-pressure ductwork design or operated at 3wc or greater shall pressure tested in accordance with specification section 23 05 93 Testing Adjusting and Balancing.

B. The contractor review test report results and repair or replace any sections of ductwork with and air leakage rate over 4.0

END OF SECTION 233113

SECTION 235100 - BREECHINGS, CHIMNEYS, AND STACKS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following:
   1. Listed special gas vents.
   2. Outside air intake ducts.
   3. Listed building-heating-appliance chimneys, and boiler breeching
   4. Draft control damper and remote terminal panel

B. Product Data: Submit product data for all of the following:
   1. Listed special gas vents.
   2. Outside air intake ducts.
   3. Listed building-heating-appliance chimneys, and boiler breeching
   4. Draft control damper and remote terminal panel

C. Shop Drawings and Delegated-Design Submittals: For vents, breechings, chimneys, and stacks. Include plans, elevations, sections, details, and attachments to other work.
   1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, methods of field assembly, components, hangers, and location and size of each field connection.
   2. Retain subparagraph below if products are required to withstand specific design loads and design responsibilities have been delegated to Contractor or if structural data are required as another way to verify products' compliance with performance requirements. Professional engineer qualifications are specified in Section 014000 "Quality Requirements."
   3. All products shall comply with design loads, include calculations required for selecting restraints and structural analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
   4. The inner diameter of the flue system shall be verified by the manufacturer’s venting computations. The computations used shall be technically sound, follow ASHRAE calculation methods and shall incorporate the specific flow characteristics of the inner pipe. The contractor shall furnish the exact operating characteristics of all equipment to the factory representative. Flue gas velocity shall not exceed the manufactures maximum requirement or 1000 ft/min. The required draft shall be .1” min at the farthest appliance connected.
   5. The manufacturer shall provide “to scale” drawings depicting the actual layout. The prefabricated flue system shall be installed as designed by the manufacturer and in accordance with the terms of the manufacturer’s warranty and in conjunction with sound engineering practices
   6. Submit full draft calculations for review and approval this shall include velocity in each section.

7. Submit field verified plan view layout for coordination review and approval.
8. Submit riser diagram for review and coordination.
9. Submittals will not be approved, released or accepted until draft calculations and field verified dimensional drawings are submitted, reviewed and accepted by the Engineer.

1.3 INFORMATIONAL SUBMITTALS

A. Welding certificates.

1.4 QUALITY ASSURANCE

A. Source Limitations: Obtain listed system components through one source from a single manufacturer.

B. Delete first paragraph below if no welding. Retain "Welding certificates" Paragraph in "Informational Submittals" Article if retaining below. AWS states that welding qualifications remain in effect indefinitely unless welding personnel have not welded for more than six months or there is a specific reason to question their ability.

C. Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code--Steel," for hangers and supports and AWS D9.1/D9.1M, "Sheet Metal Welding Code," for shop and field welding of joints and seams in vents, breechings, and stacks.

D. Certified Sizing Calculations: Manufacturer shall certify venting system sizing calculations.

1.5 COORDINATION

A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.

B. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Section 077200 "Roof Accessories."

1.6 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of venting system that fail in materials or workmanship within specified warranty period. Failures include, but are not limited to, structural failures caused by expansion and contraction.

1. Warranty Period: All products shall have a minimum 15-year extended warranty from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 LISTED SPECIAL GAS VENTS, (Domestic water and heating HW Condensing Boilers)

A. Basis-of-Design Product: The basis of design shall be Security Chimney model SSID. Subject to review and approval by the engineer and compliance with the contract documents, provide the product indicated or a comparable product by one of the following alternate manufactures:
1. ENERVEX.
2. Heat Fab
3. Metal-Fab, Inc.
4. Selkirk Inc.; Selkirk Metalbestos

B. Description: Double-wall metal vents tested according to UL 1738 and rated for 480 deg F continuously, with positive or negative flue pressure complying with NFPA 211. And ULC – S636

C. Construction: Inner shell and outer jacket separated by at least a 1" inch high-temperature, ceramic-fiber insulation.

D. Inner Shell: ASTM A 959, Type 29-4C stainless steel.

E. Outer Jacket: Aluminized steel or type 441 stainless

F. Assembly shall be made by joining stacked sections with factory supplied high temperature sealant and overlapping "V" bands on interior section. With Vitron O ring gaskets. Exterior sections shall be made by joining stacked sections with high temperature joint cement and continuous welded joint grinded to a smooth finish.

G. Breeching lengths thru exterior wall, or roof in same construction as for flue and in diameter as shown on the drawings with a minimum penetration of 6 inches into the space. Connections to equipment and balance of breeching shall be done with provisions for expansion/contraction at the engine, boilers, etc. and along entire length of run.

H. Where exposed outside the building, the outer jacket shall be factory painted with heat resistant paint such as Rust-Down Series 4200 or 4300. Color as selected by Architect.

I. Accessories: Tees, elbows, increasers, draft-hood connectors, terminations, adjustable roof flashings, storm collars, support assemblies, thimbles, firestop spacers, and fasteners; fabricated from similar materials and designs as vent-pipe straight sections; all listed for same assembly.
   1. Termination: Stack cap designed to exclude minimum 90 percent of rainfall.
   2. Termination: Round chimney top designed to exclude minimum 98 percent of rainfall.
   3. Termination: Exit cone with drain section incorporated into riser.
   4. Smoke tight cleanout sections.
   5. Gasket material for cleanout door and caps, high temperature ceramic fiber rope; joint cement, acid resistant cement; sealant - Type VII as/07900.
   6. Footing connectors and bracing, design and number as per manufacturers' requirements and as required by construction conditions
   7. Provide base supports, wall supports and guides.
   8. Provide expansion segments as required.
   9. Riser drain with valve
   10. Wall thimble

J. Provide a prefabricated metal chimney, flue, breeching extensions and accessories arranged and sized as indicated on the drawings. Provide connections for boilers, domestic hot water heater and generator exhaust as indicated.

K. Applications;
   1. The domestic hot water heaters shall use double wall with 1" air space. Model SSD

2.2 OUTSIDE AIR INTAKE DUCTWORK

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Spot – Spiral pipe.

2. United McGill
3. R.L. Craig Company
4. US Duct.

B. Outside air intake ductwork and fittings for all gas- fired direct venting condensing & non-condensing appliance shall be single-wall spiral round galvanized steel. All ductwork and accessories shall be 4-ply spiral lock seam meeting ASTM A-653. All duct connections shall be made with a double legged EPDM gasket creating an airtight connection meeting ASTM a-653. Single-wall duct gauge shall be selected for positive, or negative pressure SMACNA leak class 3, and up to 10" WC with a minimum gauge of 24. The product is rated for zero clearance to combustibles. Provide straight sections, elbows, offsets, connection adapters, wall sleeves, and screened terminations.

2.3 LISTED BUILDING-HEATING-APPLIANCE: (GAS FIRED STEAM BOILER BREECHING AND CHIMNEY).

A. Basis-of-Design Product: The basis of design shall be ENERVEX Power Stack. Subject to review and approval by the engineer and compliance with the contract documents, provide the product indicated or a comparable product by one of the following alternate manufactures:

B. 1. Security Chimney – Secure Stack Pro
1. Heat-Fab, Inc. – Saf – T-vent Plus
2. United McGill Uni-Stack, 1402
3. Metal-Fab, Inc. IPC-2
4. Selkirk Inc.; Metalbestos Metal Bestos IPS C-2.

C. Boiler Breeching shall be double wall with 2" insulation – EPS-2

D. Chimney riser shall be single wall – EPS

E. For 1400 deg F (760 deg C) chimneys suitable for dual-fuel boilers, oven vents, water heaters, or exhaust for engines.

F. Description: Double-wall metal vents tested according to UL 103 and UL 959 and rated for 1400 deg F continuously, or 1800 deg F for 10 minutes; with positive or negative flue pressure complying with NFPA 211.

G. Construction: Inner shell and outer jacket separated by at least a 2-inch annular space filled with high-temperature, ceramic-fiber insulation. For lining applications inside existing masonry chimneys the annular space insulation may be omitted.

H. Inner wall: Fully welded ASTM A 666, type 316 -PCM stainless steel, or AL 29 4C stainless steel. Minimum .048" thick

I. Retain first three paragraphs below for Type HT chimneys suitable for fireplaces and other solid-fuel-burning appliances.

J. Outer Jacket: Type 304 polished stainless steel.

K. Flue sections shall be circular with internal and external diameters as indicated on the drawings.

L. The system sections and fittings shall be joined by clamping a U Band over the mating male-female flanges of adjacent components. The male flange connection shall have an integrated graphite seal. Silicone gaskets and silicone sealant at section joints are not acceptable. All joints shall have male-female connections; chimney systems without male-female connections are not acceptable. All tees shall be lateral (45°) tees; boot tees and 90° tees are not acceptable.

M. Breeching lengths thru exterior wall, or roof in same construction as for flue and in diameter as shown on the drawings with a minimum penetration of 6 inches into the space. Connections to equipment and balance of breeching shall be done with provisions for expansion/contraction at the engine, boilers, etc. and along entire length of run.

N. Where exposed outside the building, the outer jacket shall be factory painted with heat resistant paint such as Rust-Down Series 4200 or 4300. Color as selected by Architect.

O. Accessories: Tees, elbows, increasers, draft-hood connectors, terminations, adjustable roof flashings, storm collars, support assemblies, thimbles, firestop spacers, and fasteners; fabricated from similar materials and designs as vent-pipe straight sections; all listed for same assembly. Including.

1. Smoke tight cleanout sections.
2. Gasket material for cleanout door and caps, high temperature ceramic fiber rope; joint cement, acid resistant cement; sealant - Type VII as/07900.
3. Footing connectors and bracing, design and number as per manufacturers' requirements and as required by construction conditions.
4. Spark arrester. (Generator exhaust)
5. Provide air pollution control test ports, gas sampling platforms, and the like as required to complete the installation.
6. Provided an explosion relief valve in accordance with NFPA 37 requirements for engine exhaust. (Generator exhaust)
7. Provide extra heavy, base supports, wall supports and guides by the manufacturer.
8. Provide expansion segments as required.
9. Termination stack cap designed to exclude minimum 90 percent of rainfall
10. Provide riser drains with valve
11. Barometric damper at each appliance.

P. Provide and support prefabricated metal chimney, flue, breeching extensions and accessories arranged and sized as indicated on the drawings. Provide connections for boilers, domestic hot water heater. Provide supplemental steel as required for supports.

2.4 FIELD-FABRICATED METAL CHIMNEYS

A. Fabricate freestanding chimneys according to SMACNA's "Guide for Free Standing Steel Stack Construction." Design for minimum 75 high and size as shown on plan.

B. Fabricate chimneys from ASTM A 1011/A 1011M hot-rolled stainless steel with continuously welded joints, complying with NFPA 211 for minimum metal thickness.

1. Cross sectional area less than 1.069 Sq. Ft. or 14 Inches in Diameter: 0.053 inch.
2. Up to 1.396 Sq. Ft. or 16 Inches in Diameter: 0.067 inch.
3. Up to 1.764 Sq. Ft. or 18 Inches in Diameter: 0.093 inch.
4. Larger Than: 0.123 inch.

C. Fabricate cleanout doors from compatible material, same thickness as breeching, bolted and gasketed.

2.5 GUYING AND BRACING MATERIALS

A. This Article contains materials recommended by one manufacturer that also advises that a professional engineer design components and connections to adjacent structures.

B. Cable: Three galvanized, stranded wires of the following thickness:
1. Minimum Size: 1/4 inch in diameter.
2. For ID Sizes 4 to 15 Inches: 5/16 inch.
3. For ID Sizes 18 to 24 Inches: 3/8 inch.
4. For ID Sizes 27 to 30 Inches: 7/16 inch.
5. For ID Sizes 33 to 36 Inches: 1/2 inch.
6. For ID Sizes 39 to 48 Inches: 9/16 inch.
7. For ID Sizes 51 to 60 Inches: 5/8 inch.

C. Pipe: Three galvanized steel, NPS 1-1/4.

D. Angle Iron: Three galvanized steel, 2 by 2 by 0.25 inch.

2.6 BAROMETRIC DAMPERS

A. Damper Construction: High-temperature-enamel-painted steel damper and housing with galvanized-steel breeching connection. Adjustable counterweight with lock. Include knife-edge bearings that do not require lubrication.

2.7 VENT EXHAUST FANS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. ENERVEX Inc.
2. Field Controls L.L.C.
3. Tjernlund Products, Inc.

B. General: Centrifugal fan with variable-speed control mounted at end of vertical vent.

C. Test Standard: UL 378.

D. Fan Construction:

1. Cast-aluminum or Stainless-steel housing painted manufacturer's standard color of baked enamel.
2. Stainless-steel vent.
3. Cast-aluminum or Stainless-steel wheel.
4. Backward-inclined centrifugal or axial fan wheel statically and dynamically balanced.
5. Access panel at the discharge area.
6. Concentric makeup air-inlet duct surrounding the vent to allow zero clearance to combustibles.

E. Motor: Fully enclosed, variable-speed duty, permanent-split capacitor, out of the airstream, with prelubricated and sealed ball bearings.

F. Variable-Speed Controls: Boiler interlock relay starts fan when burner control cycles on. Pressure controller, control transformer, and miscellaneous controls for automatic modulation of fan speed to maintain preset negative pressure between zero- and minus 1.0-inch wg . Include controller with indicator lights, pressure-differential transmitter, chimney pressure-sensor probe, and fan-proving switch adjustable between minus 0.07- and minus 0.15-inch wg Include tubing.

G. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of work.

1. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 APPLICATION

A. Listed Special Gas Vent: Condensing gas appliances.

B. Listed Building-Heating-Appliance Chimneys: Dual-fuel boilers, oven vents, and exhaust for engines. Fireplaces and other solid-fuel-burning appliances.

3.3 INSTALLATION GENERAL:

A. Installations shall be made in accordance with the Specifications of the Underwriters' Laboratories, Inc. and those of the manufacturer, by the manufacturer of an authorized and experienced installer approved by the manufacturer and the Architect.

B. Chimney shall be set plumb to within 1 inch in 60 feet. Where applicable, grout base plate with non-shrink grout.

C. Required welding shall be accomplished by certified welders.

D. Furnish clean out at the ends of headers and drain at the base of risers. Provide temperature plug at the outlet of each boiler.

E. Provide patching of existing brick chimney at breeching penetration with new brick and mortar to match existing construction. Seal breeching with high temperature cement at penetration.

F. All connection from appliances to main breeching shall be made with 45 deg laterals fittings.

G. The contractor shall coordinate the installation of the new chimney liners with the manufacture requirements for supports and guides. Provide supplemental support and guides at intervals as required by the manufacture.

H. The contractor shall be responsible for providing access into the existing masonry chimney to perform the installation of new boiler chimneys. Coordinate with the general contractor. Cut openings number and size to be determined in the field. Patch openings to match existing construction.

3.4 INSTALLATION OF LISTED VENTS BREECHING AND CHIMNEYS

A. Locate to comply with minimum clearances from combustibles and minimum termination heights according to product listing or NFPA 211, whichever is most stringent.

B. Seal between sections of positive-pressure vents and grease exhaust ducts according to manufacturer's written installation instructions, using sealants recommended by manufacturer.

C. Support vents at intervals recommended by manufacturer to support weight of vents and all accessories, without exceeding appliance loading. Install guide and support wire as per the manufacturer’s recommendations.

D. Slope breechings down in direction of appliance, with condensate drain connection at lowest point piped to nearest drain.

E. Lap joints in direction of flow.

F. Connect base section to foundation using anchor lugs of size and number recommended by manufacturer.

G. Join sections with acid-resistant joint cement to provide continuous joint and smooth interior finish.

H. Erect stacks plumb to finished tolerance of no more than 1 inch out of plumb from top to bottom.

I. Provide a 1” drain line at the bottom of each stack as recommended by the manufacturer with a valve. Pipe to floor drain.

J. Stack shall extend to the bottom of the existing chimney. Support with a stand above the floor of the chimney and at intervals up the chimney.

3.5 CLEANING

A. After completing system installation, including outlet fittings and devices, inspect exposed finish. Remove burrs, dirt, and construction debris and repair damaged finishes.

B. Clean breechings internally, during and after installation, to remove dust and debris. Clean external surfaces to remove welding slag and mill film. Grind welds smooth and apply touchup finish to match factory or shop finish.

C. Provide temporary closures at ends of breechings, chimneys, and stacks that are not completed or connected to equipment.

D. The existing masonry chimney shall be brushed and vacuumed clean including all debris at the base prior of the chimney prior to installation of new chimney stack. Inspect the inside of the existing chimney and provide a written report of condition including any defects, cracks or structural problems with the masonry structure to the engineer, owner.

END OF SECTION 235100

SECTION 235216 - CONDENSING BOILERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes gas-fired, fire-tube condensing boilers, trim, and accessories for generating hot water.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for boilers.
2. Include rated capacities, operating characteristics, and furnished specialties and accessories.

B. Shop Drawings: For boilers, boiler trim, and accessories.

1. Include plans, elevations, sections, and mounting and attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

C. Delegated-Design Submittal: For each boiler.

1. Design calculations and vibration isolation base details, signed and sealed by a qualified professional engineer.

    a. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
    b. Vibration Isolation Base Details: Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.

D. Registration;

1. The contractor shall be responsible to register the boiler plant with the Westchester County Department of Health. (WCDH) This shall include but is not limited to the following:
   a. Completing all forms including application to construct and application to operate said boiler plant.
   b. Drawings, floor plans, chimney riser diagram and site plans of AS-Built conditionals required.
   c. The contractor shall complete all applications, pay fees and deliver to the WCDH.
   d. The contractor shall obtain approved application to construct obtain approved application to operate prior to close out.

1.4 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Data: Certificates, for boiler, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

B. Source quality-control reports.

C. Field quality-control reports.

D. Sample Warranty: For special warranty.

E. Product Certificates:

1. ASME Stamp Certification and Report: Submit "A," "S," or "PP" stamp certificate of authorization, as required by authorities having jurisdiction, and document hydrostatic testing of piping external to boiler.
2. CSA B51 pressure vessel Canadian Registration Number (CRN).

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For boilers to include in emergency, operation, and maintenance manuals.

1.6 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to repair or replace components of boilers that fail in materials or workmanship within specified warranty period.

1. Warranty Period for Fire-Tube Condensing Boilers:

    a. Leakage and Materials: 10 years from date of Substantial Completion.
    b. Heat Exchanger Damaged by Thermal Stress and Corrosion: Non prorated for ten years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. ASME Compliance: Fabricate and label boilers to comply with 2010 ASME Boiler and Pressure Vessel Code.

C. ASHRAE/IES 90.1 Compliance: Boilers shall have minimum efficiency according to "Gas and Oil Fired Boilers - Minimum Efficiency Requirements."

D. DOE Compliance: Minimum efficiency shall comply with 10 CFR 430, Subpart B, Appendix N.

E. UL Compliance: Test boilers for compliance with UL 795. Boilers shall be listed and labeled by a testing agency acceptable to authorities having jurisdiction.

F. CSA Compliance: Test boilers for compliance with CSA B51.

G. Mounting Base: For securing boiler to concrete base.

2.2 WATER JACKETED FORCED-DRAFT, FIRE-TUBE CONDENSING BOILERS

A. Basis-of-Design Product: The basis of design manufacture shall be Fulton EDR. Subject to review and approval by the engineer and compliance with the contract documents, provide the product indicated on plan or a comparable product by one of the following alternate manufactures:

1. AERCO
2. Bosch Corp.
3. Camus.
4. Lochinvar.

B. Description: Factory-fabricated, -assembled, and -tested, fire-tube condensing boiler with heat exchanger sealed pressure tight, built on a steel base, including insulated jacket; flue-gas vent; combustion-air intake connections; water supply, return, and condensate drain connections; and controls. Water-heating service only.

C. Heat Exchanger: Duplex stainless steel heat exchanger.

D. Pressure Vessel: Carbon steel with welded heads and tube connections where not in contact with combustion or flue gases.

E. Burner: Natural gas, forced draft; swing-open front and burner observation port. Fully modulating 15:1 turn down

F. Blower: Centrifugal fan to operate during each burner firing sequence and to pre-purge and post-purge the combustion chamber.

1. Motors: Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

a. Motor Sizes: Minimum size as indicated; if not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.

G. Gas Train: Combination gas valve with manual shutoff and pressure regulator. Include 100 percent safety shutoff with electronic flame supervision.

H. Ignition: Direct Spark ignition with 100 percent main-valve shutoff with electronic flame supervision.

I. Casing:

1. Jacket: Sheet metal, with snap-in or interlocking closures.
2. Control Compartment Enclosures: NEMA 250, Type 1A.
3. Finish: Baked-enamel or Powder-coated protective finish.
4. Insulation: Minimum 4-inch-thick, mineral-fiber insulation surrounding the heat exchanger.
5. Combustion-Air Connections: Inlet and vent duct collars.

J. Capacities and Characteristics:

1. Refer to plans and schedules for capacities
2. HeaRetain "Minimum Efficiency AFUE," "Minimum Thermal Efficiency," or "Minimum Combustion Efficiency" Subparagraph below. Specify standing or intermittent pilot with minimum AFUE. Sustainable design systems require compliance with ASHRAE/IES 90.1 and may require efficiency in excess of minimum efficiency required by ASHRAE/IES 90.1.
3. 160 PSIG max working pressure
4. 210 deg max working temperature
5.

2.3 TRIM

A. Include devices sized to comply with ASME B31.9.

B. Aquastat Controllers: Operating, firing rate, and high limit.

C. Low water cut off probe

D. Hi and low gas pressure switches

E. Emergency stop (E-stop) contact

F. Variable sped high pressure combustion blower

G. MERV 8 combustion air intake filter

H. Ventless gas train

I. Safety (pressure) Relief Valve: ASME rated at 60 psi

J. Pressure and Temperature Gage: Minimum 3-1/2-inch-diameter, combination water-pressure and -temperature gage. Gages shall have operating-pressure and -temperature ranges, so normal operating range is about 50 percent of full range.

K. Boiler Air Vent: Automatic.

L. Drain Valve: Minimum NPS 3/4 hose-end drain valve.

M. Circulation Pump: Non-overloading, in-line pump with split-capacitor motor having thermal-overload protection and lubricated bearings; designed to operate at specified boiler pressures and temperatures.

N. Condensate neutralization and drain kit with marble chips.

O. BACNet MSTP communications card.

P. High and low gas pressure switches with manual reset.

Q. Low water cut off with manual reset and test.

R. 30 PSI pressure relief

S. Optional Items
   1. Lead lag Ip switch
   2. BACnet Protonode
   3. Individual boiler condensate drain trap
   4. PH neutralizer kit
   5. Pressure and temperature gages
   6. Variable speed
   7. Inlet / outlet water temp sensors
   8. Outdoor air temp sensor with boiler plant cut off

2.4 CONTROLS

A. Refer to Section 230923 "Direct Digital Control (DDC) System for HVAC" and Section 230993.11 "Sequence of Operations for HVAC DDC."

B. Boiler operating controls shall be direct digital and fully self-contained. The operating control panel shall be mounted on the boiler front panel and shall be fully installed and programmed factory packed controller by the boiler manufacture. The controller shall have an LCD screen for user or operator interface.

C. Boiler operating controls shall include the following devices and features:

   1. Control transformer.
   2. Set-Point Adjust: Set points shall be adjustable.

3. Operating Pressure Control: Factory wired and mounted to cycle burner.
4. Low-Water Cutoff and Pump Control: Cycle feedwater pump(s) for makeup water control.

5. Sequence of Operation: Electric, factory-fabricated and OR field-installed panel to control burner firing rate to reset supply-water temperature inversely with outside-air temperature. At 0 deg F outside-air temperature, set supply-water temperature at 180 deg F; at 50 deg F outside-air temperature, set supply-water temperature at 140 deg F.

    a. Include automatic, alternating-firing sequence for multiple boilers to ensure maximum system efficiency throughout the load range and to provide equal runtime for boilers.

D. Burner Operating Controls: To maintain safe operating conditions, burner safety controls limit burner operation.

1. High Cutoff: Manual reset stops burner if operating conditions rise above maximum boiler design temperature.
2. Low-Water Cutoff Switch: (1) Electronic AND (1) Float and electronic probe shall prevent burner operation on low water. Cutoff switch shall be (1) manual AND (1) automatic-reset type.
3. Blocked Inlet Safety Switch: Manual-reset pressure switch field mounted on boiler combustion-air inlet.
4. Audible Alarm: Factory mounted on control panel with silence switch; shall sound alarm for above conditions.

E. Building Automation System Interface: Factory install hardware and software to enable building automation system to monitor, control, and display boiler status and alarms.

1. Hardwired Points:

    a. Monitoring: On/off status, common trouble alarm low-water-level alarm.
    b. Control: On/off operation, hot-water-supply temperature set-point adjustment.

2. A communication interface with building automation system shall enable building automation system operator to remotely control and monitor the boiler from an operator workstation. Control features available, and monitoring points displayed, locally at boiler control panel shall be available through building automation system.

2.5 ELECTRICAL POWER

A. Controllers, Electrical Devices, and Wiring: Electrical devices and connections are specified in electrical Sections.

B. Single-Point Field Power Connection: Factory-installed and -wired switches, motor controllers, transformers, and other electrical devices necessary shall provide a single-point field power connection to boiler.

1. House in NEMA 250, Type 1 enclosure.
2. Wiring shall be numbered, and color coded to match wiring diagram.

3. Install factory wiring outside of an enclosure in a metal raceway.
4. Field power interface shall be to nonfused disconnect switch.
5. Provide branch power circuit to each motor and to controls with a disconnect switch. Provide each motor with overcurrent protection.

2.6 VENTING KITS

A. Provide full boiler venting and OAI ducting. Refer to Section 235100 "Breeching Chimney and Stacks." For full requirements. The following paragraphs are the minimum requirements.

B. ASTM A 959, Type 29-4C stainless steel, or approved equal pipe, vent terminal, thimble, indoor plate, vent adapter, condensate trap and dilution tank, and sealant.
1. Provide all specialty fittings, including offsets, elbows, roof thimble, wall thimble screens and caps from boiler flue to termination point outdoors. Refer to plans for duct arrangement. Boiler vent piping shall be double wall with 1” of insulation and aluminum or stainless steel jacket. Vertical vent piping located inside existing masonry chimneys shall be single wall.

C. Combustion-Air Intake: Complete system, stainless steel, pipe, vent terminal with screen, inlet air coupling, and sealant.
1. Provide all specialty fittings, including offsets, elbows, screens for CA intake from boiler to OAI louver or termination point outdoors. Refer to plans for duct arrangement.

2.7 SOURCE QUALITY CONTROL

A. Burner and Hydrostatic Test: Factory adjust burner to eliminate excess oxygen, carbon dioxide, oxides of nitrogen emissions, and carbon monoxide in flue gas and to achieve combustion efficiency; perform hydrostatic test.

B. Test and inspect factory-assembled boilers, before shipping, according to 2010 ASME Boiler and Pressure Vessel Code.

C. Allow Owner access to source quality-control testing of boilers. Notify engineer 14 days in advance of testing.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in for concrete equipment bases, anchor-bolt sizes and locations, and piping and electrical connections to verify actual locations, sizes, and other conditions affecting performance of the Work.

1. Final boiler locations indicated on Drawings are approximate. Determine exact locations before roughing-in for piping and electrical connections.

B. Examine mechanical spaces for suitable conditions where boilers will be installed.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 BOILER INSTALLATION

A. Equipment Mounting:

1. Install boilers on cast-in-place concrete housekeeping pads. Concrete housekeeping pads shall be 5 ½" high and extend 6" longer on all sides then the mountings and shall have 45° chamfered edges.
   a. Pumps located above the lowest level (or when the lowest level is above grade), of the building shall be mounted on spring isolation inertia bases.
   b. Grout between boiler base and house keep pad.
   c. Provide neoprene vibration isolation pads between boiler and housekeeping pad.

B. Install gas-fired boilers according to NFPA 54.

C. Assemble and install boiler trim.

D. Install electrical devices furnished with boiler but not specified to be factory mounted.

E. Install control wiring to field-mounted electrical devices.

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties. Install all piping in accordance with manufactures recommendations.

B. Install piping adjacent to boiler to allow service and maintenance.

C. Install piping from acid neutralizing device / equipment drain connection to discharge indirectly to nearest floor drain. Piping shall be at least full size of connection. Provide an isolation valve if required by manufacturer. Drain piping shall be PVC.

D. Connect piping to boilers, except safety relief valve connections, with flexible connectors of materials suitable for service. Flexible connectors and their installation are specified in Section 232116 "Hydronic Piping Specialties."

E. Safety relief valves shall be hard piped, full size of relief valve outlet. Pipe down to within 18" of floor or to nearest floor drain. Discharge at floor drain shall be indirect connection.

F. Connect gas piping to boiler gas-train inlet with union and shut off valve. Piping shall be at least full size of gas-train connection. Provide a reducer if required. Provide plug valve for shut off and 6" drip leg.

G. Connect hot-water piping to supply- and return-boiler tappings with shutoff valve and union or flange at each connection.

H. Install piping from safety valves to drip-pan elbow and to nearest floor drain.

I. Boiler Venting:

1. Install flue venting kit and combustion-air intake.
2. Connect full size to boiler connections. Comply with requirements in Section 235100 "Breeching Chimney and Stacks"

J. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

K. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.4 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

C. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Perform installation and startup checks according to manufacturer's written instructions.
2. Leak Test: Hydrostatic test. Repair leaks and retest until no leaks exist.
3. Operational Test: Start units to confirm proper motor rotation and unit operation. Adjust air-fuel ratio and combustion.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

    a. Check and adjust initial operating set points and high- and low-limit safety set points of fuel supply, water level, and water temperature.
    b. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

D. Boiler will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

F. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

G. Performance Tests:

1. Engage a factory-authorized service representative to inspect component assemblies and equipment installations, including connections, and to conduct performance testing.
2. Boilers shall comply with performance requirements indicated, as determined by field performance tests. Adjust, modify, or replace equipment to comply.
3. Perform field performance tests to determine capacity and efficiency of boilers.

    a. Test for full capacity.

b. Test for boiler efficiency at low fire 20, 40, 60, 80, 100, 80, 60, 40, and 20 percent of full capacity. Determine efficiency at each test point.

4. Repeat tests until results comply with requirements indicated.
5. Provide analysis equipment required to determine performance.
6. Provide temporary equipment and system modifications necessary to dissipate the heat produced during tests if building systems are inadequate.
7. Notify engineer 48 hours minimum in advance of test dates.
8. Document test results in a report and submit to Architect.

3.5 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain boilers.

END OF SECTION 235216

SECTION 235223 - CAST-IRON BOILERS AND BURNERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes cast-iron boilers, trim, and accessories for generating steam.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for boilers.
2. Include rated capacities, operating characteristics, and furnished specialties and accessories.

B. Shop Drawings: For boilers, boiler trim, and accessories.

1. Include plans, elevations, sections, and mounting attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

C. Delegated-Design Submittal: For each boiler.

1. Design calculations and vibration isolation base details, signed and sealed by a qualified professional engineer.

    a. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
    b. Vibration Isolation Base Details: Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.

D. Registration;

1. The contractor shall be responsible to register the boiler plant with the Westchester County Department of Health. (WCDH) This shall include but is not limited to the following:
    a. Completing all forms including application to construct and application to operate said boiler plant.

b. Drawings, floor plans, chimney riser diagram and site plans of AS-Built conditionals required.
c. The contractor shall complete all applications, pay fees and deliver to the WCDH.
d. The contractor shall obtain approved application to construct obtain approved application to operate prior to close out.

1.4 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Data: Certificates, for boiler, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

B. Source quality-control reports.

C. Field quality-control reports.

D. Sample Warranty: For special warranty.

E. Product Test Reports:

1. CSA B51 pressure vessel Canadian Registration Number (CRN).
2. Startup service reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For boilers, components, and accessories to include in emergency, operation, and maintenance manuals.

1.6 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to repair or replace controls and heat exchangers of boilers that fail in materials or workmanship within specified warranty period.

1. Warranty Period for Controls: five years from date of Substantial Completion.
2. Warranty Period for Heat Exchangers: 20 years from date of Substantial Completion.

1.7 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. ASME Compliance: Fabricate and label boilers to comply with 2010 ASME Boiler and Pressure Vessel Code.

C. ASHRAE/IES 90.1 Compliance: Boilers shall have minimum efficiency according to "Gas and Oil Fired Boilers - Minimum Efficiency Requirements."

D. DOE Compliance: Minimum efficiency shall comply with 10 CFR 430, Subpart B, Appendix N.

E. I=B=R Compliance: Boilers shall be tested and rated according to AHRI's "Rating Procedure for Heating Boilers" and "Testing Standard for Commercial Boilers," with I=B=R emblem on a nameplate affixed to boiler.

F. UL Compliance: Test boilers for compliance with UL 726 and UL 795. Boilers shall be listed and labeled by a testing agency acceptable to authorities having jurisdiction.

G. CSA Compliance: Test boilers for compliance with CSA B51.

H. Mounting Frame: Steel rails used to mount assembled boiler package on concrete base.

1. Seismic Fabrication Requirements: Fabricate mounting base and attachment to boiler, accessories, and components with reinforcement strong enough to withstand seismic forces defined in Section 230548 "Vibration and Seismic Controls for HVAC" when mounting base is anchored to building structure.

1.8 REGULATORY REQUIREMENTS

A. Conform to applicable code for internal wiring of factory wired equipment.

B. Conform to ANSI/ASME SEC 4 and SEC 8D and ANSI/AGA Z21.13 for boiler construction.

C. Units: UL labeled.

D. ASME CSD-1.

E. All work shall be performed in accordance with Code Rule Part 4 of title 12, (12 NYCRR 14) Low Pressure Boilers and the State Education Department Manual of Planning Standards.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Deliver products to site under provisions of the contract.

B. Store and protect products under provisions of the contract and division 1.

C. Protect units before, during, and after installation from damage to casing by leaving factory shipping packaging in place until immediately prior to final acceptance.

D. Boilers shall be shipped knocked down in sections, and shall be assembled in the field by the Contractor. Provide all necessary labor, rigging, and field wiring to fully assemble complete boiler and burner systems. All sections of this unit must be able to fit through the existing boiler room doors.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Basis-of-Design Product: The basis of design manufacture shall be Weil McLean. Subject to review and approval by the engineer and compliance with the contract documents, provide the product indicated on plan or a comparable product by one of the following alternate manufactures:

B. Burnham Hydronics.
1. Smith Cast Iron Boilers.

2. Viessmann Manufacturing Co. (US) Inc.
3. Weil-McLain.
4. Buderus
5. Power Flame.

2.2 MANUFACTURED UNITS

A. Description: Factory fabricated, or field assembled.

1. Cast-iron sections shall be sealed pressure tight and held together with tie rods. Where indicated set on an insulated steel base, including insulated jacket and flue-gas vent connection.
2. Ship cast-iron sections disassembled with all materials and equipment, including seals, tie rods, and insulated jacket and flue-gas vent connection for field assembly.
3. Provide a new high efficiency hot water boilers suitable for forced draft with insulated jacket, sectional cast iron heat exchanger, oil burning system, gas burning system, refractory, controls, boiler trim, circulator pumps, and all accessories.
4. Provide packaged gas/oil burner complete with all required combustion and safety controls located in an integral panel mounted on the burner.
5. For forced draft firing, provide water wall design consisting of water backed combustion area with water circulating around firebox. Refractory chamber or separate base not required.
6. Boiler shall be capable of developing full I=B=R gross capacity at one hundred percent firing rate.
7. Boiler and burner assembly shall be certified for ASME CSD-1 and U.L. requirements.
8. Thermal efficiency shall meet or exceed 85.7% oil and 83.2 gas. Combustion efficiency shall meet or exceed 86.0 oil and 83.4 gas.
9. Assemble from cast iron sections in accordance with 80 psig ANSI/ASME Boilers and Pressure Vessels Code Rating.

B. Cast-Iron Section Design:

1. Configuration: Wet back.
2. Number of Passes: Multiple.
3. Sectional Joints: High-temperature sealant to seal flue-gas passages not in contact with heating medium, tapered cast-iron push nipples, O-ring gaskets, fiber roping, and held together with tie rods.
4. Drain and blowdown tappings.
5. Return injection tube to equalize water flow to all sections.
6. Crown inspection tappings with brass plugs.
7. Built in Return temperature stabilizer water distribution header.

C. Combustion Chamber: Equipped with refractory and flame observation ports, front and back.

D. Casing:

1. Jacket: Galvanized sheet metal, with snap-in or interlocking closures and baked-enamel or powder-coated protective finish.
2. Insulation: Minimum 2-inch-thick, mineral-fiber insulation surrounding the heat exchanger.
3. Combustion Chamber Access: Refractory lined, hinged, front.

4. Access: For cleaning between cast-iron sections.
5. Draft Hood: (for atmospheric boilers) Flue canopy and top or rear flue connection shall be constructed of aluminized or stainless steel containing adjustable outlet damper assembly.
6. Insulated base constructed of aluminized steel to permit boiler to be installed on combustible floor.

E. Draft Diverter: Steel assembly integral with boiler casing.

F. Provide burner mounting plate with refractory and flue collar with built-in breeching damper.

G. The packaged boiler-burner package shall be factory fire-tested before shipment. Each individual section and the complete assembly shall be hydrostatically pressure tested before shipment. Provide angle floor rails.

H. Contractor to verify building access for installation and provide all labor for field assembly as required.

I. Provide a lockable type disconnect switch for burner shutdown. Switch shall be located in an accessible location at the boiler or adjacent to it.

J. Provide a brass plug on the open end of the fitting used for inspector's test gauge. Location of test connection shall allow simultaneous viewing of test gauge and boiler pressure gauge. Provide a 1/4" NPT female test gauge connection with a shut-off valve for connection of an inspection test gauge.

K. 30 psi ASME relief valves

2.3 FORCED-DRAFT GAS AND BURNER

A. General; The combination gas, light-oil burner(s) shall be U.L. labeled and arranged for 100% full modulation operation with pre-purge, low fire start high fire run and low fire shutdown. The burner shall be furnished with a prewired control panel which incorporates an electronic combustion safeguard burner primary control with pre-purge timing, an ultraviolet sensitive electronic flame detector, and motor starter relay. The control panel shall be equipped with status indicating lights and a manual fuel transfer switch which will permit manual fuel changeover without burner adjustment modifications. The burner shall be furnished with a direct spark ignition and an air flow switch for proof of air flow prior to start of cycle.

B. Each burner shall be complete with an integral burner mounted control panel which shall house all required operating electrical components. All wiring within the combustion system shall be factory prewired to a terminal strip mounted within the control panel.
1. The control panel shall include a control circuit transformer fused on both the primary and secondary windings-flame safeguard control as specified above - on-off switch, motor starters, relays, terminal blocks and other electrical devices as required
2. The control panel shall be the Director System lamp package furnished with an eight (8) color Burner Graphic Management System with integral enunciator status lights. The system shall allow the operator a view of the operational status of the burner on a lighted graphic display. The graphic shall be mounted on the control panel door with a quick disconnect device to enable the operator to disconnect the system or remove the access door while maintaining the enunciator in full operation. The following points shall be annunciated on the Graphic Display:
   a. Power On - Green
   b. Limit Circuit Closed - Green

c. Modulation Mode - Green
d. Main Oil - Amber
e. Flame Failure - Red
f. Low Water Cutoff – Red

C. Burner: Welded construction with multivane, stainless-steel, flame-retention diffuser for fuel oil and natural gas.

D. Blower: Forward-curved centrifugal fan integral to burner, directly driven by motor, with adjustable, dual-blade damper assembly and locking quadrant to set air-fuel ratio.

1. Motors: Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

a. Motor Sizes: Minimum size as indicated; if not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.

E. Gas Train: Control devices and modulating control sequence shall comply with requirements in ASME CSD-1. Provide Seamans ventless gas regulator for each burner.

F. Gas Pilot: electric-spark pilot ignition with 100 percent main-valve and pilot-safety shutoff with electronic supervision of burner flame.

G. All controls shall be factory mounted and prewired. Gas train and fuel oil piping assemblies shall conform to UL-795 (gas) and UL-296 (oil) standards.

H. Gas pressure regulator shall be vented with piping terminating outdoors with an approved bug screen/vent cap, as per CSD-1. Unless ventless gas regulators are specified

I. Provide a manually operated leak test valve (NPS 1/8" or larger) installed in a vertical tube facing downwards. Test valve shall be located downstream of the gas safety shut-off valves to allow test for valve leakage with a cup of water. Provide a cup at end of vertical tube. Refer to ASME CSD-1, CF 150

2.4 TRIM FOR STEAM BOILERS

A. Include devices sized to comply with ASME B31.9.

B. Pressure Controllers: Operating, firing rate, and high limit.

C. Safety Relief Valve:

1. Size and Capacity: As required for equipment according to 2010 ASME Boiler and Pressure Vessel Code.
2. Description: Fully enclosed steel spring with adjustable pressure range and positive shutoff; factory set and sealed.

a. Drip-Pan Elbow: Cast iron and having threaded inlet and outlet with threads complying with ASME B1.20.1.

D. Pressure Gage: Minimum 3-1/2-inch diameter. Gage shall have normal operating pressure about 50 percent of full range.

E. Water Column: Minimum 12-inch glass gage with shutoff cocks.

F. Drain Valves: Minimum NPS 3/4 or nozzle size with hose-end connection.

G. Blowdown Valves: Factory-installed bottom and surface, slow-acting blowdown valves same size as boiler nozzle.

H. Stop Valves: Boiler inlets and outlets, except safety relief valves or preheater inlet and outlet, shall be equipped with stop valve in an accessible location as near as practical to boiler nozzle and same size as or larger than nozzle. Valves larger than NPS 2 shall have rising stem.

I. Stop-Check Valves: Factory-installed, stop-check valve and stop valve at boiler outlet with free-blow drain valve factory installed between the two valves and visible when operating stop-check valve.

J. Furnish and install a stack thermometer with 200•F to 1000•F range installed in the breeching of each boiler

2.5 CONTROLS

A. Refer to Section 230923 "Direct Digital Control" and Section 230993.11 "Sequence of Operations."

B. Furnish and install a microprocessor-based control system as manufactured by BMS system manufacturer. designed exclusively for the operation of modular hot water heating systems. The system must be compatible with the central DDC control system. See Section 230993 for additional information. The system shall incorporate the following integrated functions:
1. Outdoor temperature cutoff
2. Day/Night heat level programming
3. Optimum start/stop Hot water reset
4. Sequencing
5. Lead/Lag (Automatic)
6. Manual Override Functions

C. Burner operating controls shall include the following devices and features:

1. Control transformer.
2. Set-Point Adjust: Set points shall be adjustable.
3. Operating Pressure Control: Factory wired and mounted to cycle burner.
4. Low-Water Cutoff and Pump Control: Cycle feedwater pump(s) for makeup water control.
5. Fuel air ratio controller shall be Honeywell or Siemens Controls links linkageless modulating parallel positioning system including of the R7999 master controller with configuration display, Q7999A wiring subbase and the ML7999A actuators.
6. Sequence of Operation: Electric, factory-fabricated and field-installed panel to control burner firing rate to maintain space temperature in response to thermostat with heat anticipator located in heated space.
    a. Include automatic, alternating-firing sequence for multiple boilers to provide equal runtime for boilers.
7. Sequence of Operation: Electric, factory-fabricated and field-installed panel to control burner firing rate to maintain a constant steam pressure. Maintain pressure set point plus or minus 10 percent. (Set point range shall be 4psi to 7 psi)
    a. Include automatic, alternating-firing sequence for multiple boilers to provide equal runtime for boilers.

D. Safety Controls: To maintain safe operating conditions, burner safety controls limit burner operation.

1. High Limit Cutoff: manual reset stops burner if operating conditions rise above maximum boiler design pressure.
2. Low-Water Cutoff Switch: provide two low water cut offs. Float and electronic probe shall prevent burner operation on low water. One shall be manual and one shall be automatic-reset type.
3. Blocked Vent Safety Switch: Manual-reset switch factory mounted on draft diverter.
4. Rollout Safety Switch: Factory mounted on boiler combustion chamber.
5. Audible Alarm: Factory mounted on control panel with silence switch; shall sound alarm for above conditions.

E. In addition, the fuel burning systems controls shall provide the following functions:

1. Air flow supervision to the combustion chamber.
2. Pre-ignition purging of the combustion chamber.
3. Proven start and supervision of induced draft and forced draft fan operation.
4. Proven low fire start.
5. Shut down on low oil pressure and temperature.
6. Non recycling safety shut down or upper limit gas pressure or low limit gas pressure
7. 100% Full modulation with 100% open purge

F. Building Management System Interface: Factory install hardware and software to enable building management system to monitor, control, and display boiler status and alarms. All control features available and monitoring points displayed, locally at boiler control panel shall be available through building management system.

1. Hardwired Points:

a. Monitoring: On/off status, common trouble alarm low-water-level alarm.
b. Control: On/off operation, steam pressure adjustment.

G. INTERLOCKS
1. An integral end switch shall be electrically interlocked with the control burner circuit to ensure the fuel/air linkage is in the low fire start position before burner ignition sequence can begin.
2. Combustion air dampers and or fans shall have end switches electrical interlock to the burner operating circuit. The burner(s) shall be prevented from starting until all the respective end switches have proven the dampers open.

2.6 FLAME SAFEGUARD CONTROL

A. The flame safeguard control system shall include Ultraviolet sensor for flame detection and provide fully automatic sequencing of pre-purge, blower motor, ignition system, and fuel/air flow components. The flame safeguard control shall be the Honeywell Model RM7800L with digital display or equal as manufactured by Fireye or Siemens. The controls shall automatically de-energize the electric circuit to the main fuel valves within 4 seconds upon flame failure. The de-energized valve shall automatically close within the next 5 seconds.

B. The trial for ignition for of the burner(s) shall not exceed 15 seconds.

C. Flame supervisory and programming controls shall include a self-checking circuit. Self-checking must be performed once on each ignition cycle.

2.7 ELECTRICAL POWER

A. Controllers, Electrical Devices, and Wiring: Electrical devices and connections are specified in electrical Sections.

B. Single-Point Field Power Connection: Factory-installed and -wired switches, motor controllers, transformers, and other electrical devices necessary shall provide a single-point field power connection to boiler.

1. House in NEMA 250, Type 1 Insert type enclosure.
2. Wiring shall be numbered, and color coded to match wiring diagram.
3. Install factory wiring outside of an enclosure in a metal raceway.
4. Field power interface shall be to nonfused disconnect switch.
5. Provide branch power circuit to each motor and to controls with disconnect switch or circuit breaker.
6. Provide each motor with overcurrent protection.

2.8 CAPACITIES AND CHARACTERISTICS

A. Refer to plan notes and schedules for specific capacities:

B. Minimum performance shall be in accordance with the NY State [City] Energy Conservation Code.
1. Minimum Efficiency AFUE: <Insert number> percent.
2. Minimum Thermal Efficiency: 85.7% oil and 83.2% gas
3. Minimum Combustion Efficiency: 86.0 oil and 83.4 gas

2.9 VENTLESS GAS TRAIN PRESSURE REGULATOR

A. DESCRIPTION
1. SKP25pressure regulating electro-hydraulic actuators are used in combination with VG series gas valve bodies to provide safety shut-off and gas pressure regulation for industrial and commercial burners. The SKP25 can also be applied as a 1:1 air/gas ratio regulator or zero governor.
2. The compact SKP25 actuator SHALL open slowly and closes immediately when power is interrupted. The modular design allows the SKP25 to be used in combination with all VG series gas valve bodies from 1/2-inch to 6-inch in size. The actuator shall be mounted on the square flange of any VG valve with four pre-mounted screws. A visible position indicator on the front of the actuator displays the entire stroke of the valve. A light indicates when the actuator is powered.

2.10 FEATURES
1. UL listed, FM approved, CSA certified for USA and Canada, IRI approvable, ISO 9001 certified.
2. Certified as a ventless pressure regulator.
3. Safety shut-off function and pressure regulating function in one compact unit.
4. Proof of Closure with Over Travel (POC) versions are available.
5. Optional NEMA 4 protection.
6. Visual position indication.
7. "Power on" indication light

8. Quick connect wiring terminals
9. Optional adjustable auxiliary switch available.
10. Applicable as 1:1 air/gas ratio regulator or zero governor.
11. Accurate pressure control characteristics, and zero offset (droop).
12. Modular design with 360o actuator rotation for easy field wiring and installation.
13. Low, 13.5 VA power consumption

B. ACCESSORIES
1. Yellow setpoint spring for 6” to 48” WC (1.5 to 10 psi for SKP25.411U1)

C. SPECIFICATIONS
1. Physical characteristics
   a. Enclosure NEMA 1, 2, 5 and 12 for indoor use, NEMA 3, 3R, and 4 with optional AGA66 gasket
2. Connections
   a. Conduit connection Two 1/2-inch NPSM threaded knock-outs
   b. Electrical connection Spring loaded terminals for 14 AWG wires
   c. Gas connection 1/4” NPT
   d. Air connection 1/4” NPT
   e. Gas pressure test connection Hose barb with close-off screw
3. Operating characteristics
   a. Output force 100 lb
   b. Maximum stroke 1 inch
   c. Opening time for maximum stroke Varies with valve size, 14 seconds for max. stroke Closing time < 0.8 seconds
4. Operation/installation
   a. Outlet pressure spring range
      1) 0" to 8.5" WC (factory-installed, unpainted spring, AGA29)
      2) 6" to 48" WC (yellow spring, AGA22)
      3) 40" to 100" WC (red spring, AGA23)
   b. Maximum sensing line pressure 20 psi
   c. Maximum sensing line vacuum 3 psi for SKP25.0 models
   d. Minimum sensing line diameter 1/4" inside diameter
5. Auxiliary features
   a. Proof of closure switch Non-adjustable Setting
   b. range of auxiliary switch 40% to 100% of stroke
   c. Switch rating 6A/250 Vac resistive; 3A/120 Vac pilot duty

2.11 SOURCE QUALITY CONTROL

A. Test and inspect factory-assembled boilers, before shipping, according to 2010 ASME Boiler and Pressure Vessel Code.

B. Burner and Hydrostatic Test: Factory adjust burner to eliminate excess oxygen, carbon dioxide, oxides of nitrogen emissions, and carbon monoxide in flue gas and to achieve combustion efficiency; perform hydrostatic test.

C. Allow Owner access to source quality-control testing of boilers. Notify Architect 14 days in advance of testing.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in for concrete equipment bases, anchor-bolt sizes and locations, and piping and electrical connections to verify actual locations, sizes, and other conditions affecting performance of the Work.

1. Final boiler locations indicated on Drawings are approximate. Determine exact locations before roughing-in for piping and electrical connections.

B. Examine mechanical spaces for suitable conditions where boilers will be installed.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 BOILER INSTALLATION

A. Equipment Mounting:

1. Install boilers on cast-in-place concrete equipment base(s).
2. All boiler installed in New York City shall be mounted on approved vibration isolators

B. Install gas-fired boilers according to NFPA 54.

C. Install oil-fired boilers according to NFPA 31.

D. Assemble boiler sections in sequence and seal between each section.

E. Assemble and install boiler trim.

F. Install electrical devices furnished with boiler but not specified to be factory mounted.

G. Install control wiring to field-mounted electrical devices.

H. Mount boiler on 6” high concrete pad, 6” wider and longer than boiler.

I. Field erected boiler shall be constructed in accordance with the manufacture’s instructions.

3.3 CONNECTIONS

A. Piping installation requirements are specified in Section 232213 "Steam and Condensate Heating Piping." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to boiler to allow service and maintenance.

C. Connect gas piping to boiler gas-train inlet with union. Piping shall be at least full size of gas-train connection. Provide a reducer if required.

D. Connect oil piping full size to burner inlet with shutoff valve and union.

E. Connect hot-water piping to supply- and return-boiler tappings with shutoff valve and union or flange at each connection.

F. Connect steam and condensate piping to supply-, return-, and blowdown-boiler tappings with shutoff valve and union or flange at each connection.

G. Install piping from safety relief valves to nearest floor drain.

H. Install piping from safety valves to drip-pan elbow and to nearest floor drain.

I. Install piping from equipment drain connection to nearest floor drain. Piping shall be at least full size of connection. Provide an isolation valve if required.

J. Install flue-gas recirculation duct from vent to burner. Comply with requirements in Section 23 51 00 “Breeching Chimney and Stacks“ for recirculation duct materials.

3.4 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

C. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Perform installation and startup checks according to manufacturer's written instructions.
2. Leak Test: Hydrostatic test. Repair leaks and retest until no leaks exist.
3. Operational Test: Start units to confirm proper motor rotation and unit operation. Adjust air-fuel ratio and combustion.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

    a. Burner Test: Adjust burner to eliminate excess oxygen, carbon dioxide, oxides of nitrogen emissions, and carbon monoxide in flue gas and to achieve combustion efficiency.
    b. Check and adjust initial operating set points and high- and low-limit safety set points of fuel supply, water level, and [water temperature] [steam pressure].
    c. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

D. Remove and replace malfunctioning units and retest as specified above.

E. Adjust the new burners in accordance with the manufacturers' instructions and accepted industry standards. Perform a complete boiler combustion efficiency test and submit certified report for review. Combustion efficiency shall be a minimum of 85% with smoke density not to exceed a No. 1 reading.

F. Test and demonstrate all facets of boiler-burner operation, including safety trips and limit controls in the presence of personnel designated by the Owner. The Contractor shall provide all labor and materials for conducting such test and/or for assistance in the performance of such tests.

G. Hydrostatically pressure tests the boilers in field prior to jacket and/or covering installation. Tests shall be performed in accordance with manufacturer’s instructions and code requirements. Tests shall be witnessed by the Engineer. All test equipment shall be supplied by the contractors.

H. A Combustion Efficiency Test Report shall be completed and provided to the Engineer. These forms shall be completed prior to scheduling the final inspection. Set up and adjustment of burner shall be performed only by the manufacturers authorized representative.

I. Performance Tests:

1. Engage a factory-authorized service representative to inspect component assemblies and equipment installations, including connections, and to conduct performance testing.
2. Boilers shall comply with performance requirements indicated, as determined by field performance tests. Adjust, modify, or replace equipment to comply.
3. Perform field performance tests to determine capacity and efficiency of boilers.

    a. For dual-fuel boilers, perform tests for each fuel.
    b. Test for full capacity.
    c. Test for boiler efficiency at low fire 20, 40, 60, 80, 100, 80, 60, 40, and 20 percent of full capacity. Determine efficiency at each test point.
    d. smoke density

4. Repeat tests until results comply with requirements indicated.
5. Provide analysis equipment required to determine performance.
6. Provide temporary equipment and system modifications necessary to dissipate the heat produced during tests if building systems are inadequate.
7. Notify Architect in advance of test dates.
8. Document test results in a report and submit to Architect.

J. Boiler will be considered defective if it does not pass tests and inspections.

K. Prepare test and inspection reports.

3.5 ADJUSTING

A. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

B. Boiler shall be thoroughly cleaned in accordance with manufacturer’s instructions prior to being placed into service. Cleaning procedure and chemicals must be compatible with chemical treatment solutions. Contractor to provide written documentation that cleaning was performed and solutions used.

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain boilers.

END OF SECTION 235223

SECTION 235700 - HEAT EXCHANGERS FOR HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes shell-and-tube heat exchangers.

1.3 DEFINITIONS

A. TEMA: Tubular Exchanger Manufacturers Association.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include rated capacities, operating characteristics, and furnished specialties and accessories.

B. Shop Drawings: Signed and sealed by a qualified professional engineer. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1. Design Calculations: Calculate requirements for selecting seismic restraints and for designing bases.
2. Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment.

C. Delegated-Design Submittal: Details and design calculations for seismic restraints for heat exchangers.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Equipment room, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Tube-removal space.
2. Structural members to which heat exchangers will be attached.

B. Seismic Qualification Data: Certificates, for heat exchanger, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Heat Exchanger: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of heat exchanger anchorage devices on which certification is based and their installation requirements.

C. Product Certificates: For each type of shell-and-tube heat exchanger. Documentation that shell-and-tube heat exchangers comply with "TEMA Standards."

D. Source quality-control reports.

E. Field quality-control reports.

F. Sample Warranty: For manufacturer's warranty.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For heat exchangers to include in emergency, operation, and maintenance manuals.

1.7 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of domestic-water heat exchangers that fail in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:

a. Structural failures including heat exchanger, storage tank, and supports.
b. Faulty operation of controls.
c. Deterioration of metals, metal finishes, and other materials beyond normal use.

2. Warranty Periods: From date of Substantial Completion.

a. Shell-and-Tube, Domestic-Water Heat Exchangers:

1) Tube Coil: One year(s).
2) Other Components: One year(s).

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design seismic restraints for heat exchangers.

2.2 SHELL-AND-TUBE HEAT EXCHANGERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Armstrong Pumps, Inc.
2. ITT Corporation.
3. Spirax Sarco, Inc.
4. TACO Comfort Solutions, Inc.
5. Thrush Co. Inc.

B. Description: Packaged assembly of tank, heat-exchanger coils, and specialties.

C. Construction:

1. Fabricate and label heat exchangers to comply with ASME Boiler and Pressure Vessel Code, Section VIII, "Pressure Vessels," Division 1.
2. Fabricate and label shell-and-tube heat exchangers to comply with "TEMA Standards."

D. Configuration: U-tube with removable bundle.

E. Shell Materials: Steel.

F. Head:

1. Materials: Cast iron
2. Flanged and bolted to shell.

G. Tube:

1. Seamless copper Steel, Stainless-steel, Cupronickel tubes.
2. Tube diameter is determined by manufacturer based on service.

H. Tubesheet Materials: Steel, Stainless steel.

I. Baffles: Steel, or Stainless steel.

J. Piping Connections: Factory fabricated of materials compatible with heat-exchanger shell. Attach tappings to shell before testing and labeling.

1. NPS 2 and Smaller: Threaded ends according to ASME B1.20.1.
2. NPS 2-1/2 and Larger: Flanged ends according to ASME B16.5 for steel and stainless-steel flanges and according to ASME B16.24 for copper and copper-alloy flanges.

K. Support Saddles:

1. Fabricated of material similar to shell.
2. Fabricate foot mount with provision for anchoring to support.
3. Fabricate attachment of saddle supports to pressure vessel with reinforcement strong enough to resist heat-exchanger movement during seismic event when heat-exchanger saddles are anchored to building structure.

L. Capacities and Characteristics:
1. For capacities and sizes refer to Plans and equipment notes.

2.3 ACCESSORIES

A. Hangers and Supports:

1. Custom, steel support cradles for mounting on floor, wall, structural steel as depicted on plan.

a. Minimum Number of Cradles: 3. Or as specified by the unit manufacture

2. Factory-fabricated steel cradles to ensure both horizontal and vertical support of heat exchanger. Comply with requirements in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

B. Shroud: Aluminum sheet.

C. Miscellaneous Components for High-Temperature Hot-Water Unit: Control valve, valves, and piping. Include components fitted for control valves

D. Miscellaneous Components for Steam Unit: Strainers, steam-control valve, steam trap, valves, pressure gage, thermometer, and piping. Include components fitted for control valves.

E. Pressure Relief Valves: Bronze or Brass, ASME rated and stamped.

1. Pressure relief valve setting: 15 psig.

2.4 SOURCE QUALITY CONTROL

A. Factory Tests: Test and inspect heat exchangers according to ASME Boiler and Pressure Vessel Code, Section VIII, "Pressure Vessels," Division 1. Affix ASME label.

B. Hydrostatically test heat exchangers to minimum of one and one-half times pressure rating before shipment.

C. Heat exchangers will be considered defective if they do not pass tests and inspections.

D. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas for compliance with requirements for installation tolerances and for structural rigidity, strength, anchors, and other conditions affecting performance of heat exchangers.

B. Examine roughing-in for heat-exchanger piping to verify actual locations of piping connections before equipment installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 SHELL-AND-TUBE HEAT-EXCHANGER INSTALLATION

A. Equipment Mounting:

1. Install heat exchangers on cast-in-place concrete equipment bases.

B. Install heat exchangers on saddle supports.

C. Heat-Exchanger Supports: Use factory-fabricated steel cradles and supports specifically designed for each heat exchanger.

D. Install heat exchangers on saddle supports. Furnish and install field our factory angle iron stands. Stand shall be fabricated out of 2”x2”x1/4” angle iron. Stand shall be high enough to allow condensate drainage by gravity. All joints shall be welded. Provide cross bracing on long ends. Paint stand with grey enamel.

3.3 CONNECTIONS

A. Comply with requirements for piping specified in other Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Comply with requirements for steam and condensate piping specified in Section 232213 "Steam and Condensate Heating Piping" and Section 232216 "Steam and Condensate Heating Piping Specialties."

C. Maintain manufacturer's recommended clearances for tube removal, service, and maintenance.

D. Install piping adjacent to heat exchangers to allow space for service and maintenance of heat exchangers. Arrange piping for easy removal of heat exchangers.

E. Install shutoff valves at heat-exchanger inlet and outlet connections.

F. Install relief valves on heat-exchanger heated-fluid connection and install pipe relief valves, full size of valve connection, to floor drain.

G. Install vacuum breaker at heat-exchanger steam inlet connection.

H. Install hose end valve to drain shell.

I. Install thermometer on heat-exchanger and inlet and outlet piping, and install thermometer on heating-fluid inlet and outlet piping. Comply with requirements for thermometers specified in Section 230519 "Meters and Gages for HVAC Piping."

J. Install pressure gages on heat-exchanger and heating-fluid piping. Comply with requirements for pressure gages specified in Section 230519 "Meters and Gages for HVAC Piping."

3.4 FIELD QUALITY CONTROL

A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

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

B. Heat exchanger will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

3.5 CLEANING

A. After completing system installation, including outlet fitting and devices, inspect exposed finish. Remove burrs, dirt, and construction debris and repair damaged finishes.

3.6 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain heat exchangers.

END OF SECTION 235700

SECTION 238239.16 - PROPELLER UNIT HEATERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes propeller unit heaters with hot-water coils.

1.3 DEFINITIONS

A. CWP: Cold working pressure.

B. PTFE: Polytetrafluoroethylene plastic.

C. TFE: Tetrafluoroethylene plastic.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include rated capacities, operating characteristics, furnished specialties, and accessories.

B. Shop Drawings:

1. Include plans, elevations, sections, and details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include location and size of each field connection.
4. Include details of anchorages and attachments to structure and to supported equipment.
5. Include equipment schedules to indicate rated capacities, operating characteristics, furnished specialties, and accessories.
6. Indicate location and arrangement of piping valves and specialties.
7. Indicate location and arrangement of integral controls.
8. Wiring Diagrams: Power, signal, and control wiring.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans, reflected ceiling plans, and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Suspended ceiling components.
2. Structural members to which propeller unit heaters will be attached.
3. Method of attaching hangers to building structure.
4. Size and location of initial access modules for acoustical tile.
5. Items penetrating finished ceiling, including the following:

a. Lighting fixtures.
b. Air outlets and inlets.
c. Speakers.
d. Sprinklers.
e. Access panels.
f. Other equipment

B. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For propeller unit heaters to include in emergency, operation, and maintenance manuals.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Products shall be one of the following;
1. Rattling
2. Sterling
3. Modine
4. Vulcan

2.2 DESCRIPTION

A. Assembly including casing, coil, fan, and motor in vertical and/or horizontal discharge configuration as scheduled with adjustable discharge louvers.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Electric propeller unit heaters shall comply with UL 2021

D. Explosion-proof electric propeller unit heaters shall comply with UL 823.

2.3 PERFORMANCE REQUIREMENTS

A. ASHRAE/IESNA 90.1 Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

2.4 HOUSINGS

A. Finish: Manufacturer's standard baked enamel applied to factory-assembled and -tested propeller unit heaters before shipping.

B. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

C. Discharge Louver: Adjustable fin diffuser for horizontal units and conical diffuser for vertical units.

2.5 COILS

A. General Coil Requirements: Test and rate hot-water and steam propeller unit-heater coils according to ASHRAE 33.

B. Hot-Water Coil: Copper tube, minimum 0.025-inch wall thickness, with mechanically bonded aluminum fins spaced no closer than 0.1 inch and rated for a minimum working pressure of 200 psig and a maximum entering-water temperature of 325 deg F, with manual air vent. Test for leaks to 350 psig underwater.

C. Steam Coil: Copper tube, minimum 0.025-inch wall thickness, with mechanically bonded aluminum fins spaced no closer than 0.1 inch and rated for a minimum working pressure of 75 psig.

D. Electric-Resistance Heating Coil: Nickel-chromium heating wire, free from expansion noise and 60-Hz hum, embedded in magnesium oxide refractory and sealed in steel or corrosion-resistant metallic sheath with fins no closer than 0.16 inch. Element ends shall be enclosed in terminal box. Fin surface temperature shall not exceed 550 deg F at any point during normal operation.

1. Circuit Protection: One-time fuses in terminal box for overcurrent protection and limit controls for high-temperature protection of heaters.
2. Wiring Terminations: Stainless-steel or corrosion-resistant material.

2.6 FAN AND MOTOR

A. Fan: Propeller type with aluminum wheel directly mounted on motor shaft in the fan venturi.

B. Motor: Permanently lubricated, multispeed. Comply with requirements in Section 230513 "Common Motor Requirements for HVAC Equipment."

2.7 CONTROLS

A. Control Devices:

1. Wall-mounted, fan-speed switch, and thermostat compatible with building temperature control system.

2. Provide strap on “aquastat” on the HW supply line to prevent fan start up if hot water is not available.

2.8 CAPACITIES AND CHARACTERISTICS

A. Heating Capacity are as scheduled or noted on plans.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas to receive propeller unit heaters for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for piping and electrical connections to verify actual locations before unit-heater installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install propeller unit heaters to comply with NFPA 90A.

B. Install propeller unit heaters level and plumb.

C. Suspend propeller unit heaters from structure with all-thread hanger rods and elastomeric hangers. Hanger rods and attachments to structure are specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

D. Install wall-mounted thermostats and switch controls in electrical outlet boxes at heights to match lighting controls. Verify location of thermostats and other exposed control sensors with Drawings and room details before installation.

3.3 CONNECTIONS

A. Drawings indicate general arrangement of piping, fittings, and specialties. Piping installation requirements are specified in the following Sections:
1. Section 232113 "Hydronic Piping."
2. Section 232116 "Hydronic Piping Specialties."
3. Section 232213 "Steam and Condensate Heating Piping."

4. Section 232216 "Steam and Condensate Heating Piping Specialties."

B. Install piping adjacent to machine to allow service and maintenance.

C. Connect piping to propeller unit heater's factory, hot-water piping package. Install the piping package if shipped loose.

D. For units' hot water or steam coils comply with safety requirements in UL 1995.

E. For hot water unit, unless otherwise indicated, install union and gate or ball valve and strainer on supply-water connection and union and calibrated balancing valve on return-water connection of propeller unit heater. Hydronic specialties are specified in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties."

F. For steam units unless otherwise indicated, install union, drip leg and gate or ball valve on steam-supply connection and union, strainer, steam trap, and gate or ball valve on condensate-return connection of propeller unit heater. Steam specialties are specified in Section 232216 "Steam and Condensate Piping Specialties."

G. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

H. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.4 FIELD QUALITY CONTROL

A. Perform the following tests and:

1. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
2. Operate electric heating elements through each stage to verify proper operation and electrical connections.
3. Test and adjust controls and safety devices. Replace damaged and malfunctioning controls and equipment.

B. Units will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

3.5 ADJUSTING

A. Adjust initial temperature set points.

B. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.6 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain propeller unit heaters.

END OF SECTION 238239.16