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Briar Place Condominium MEP
Relocation
Houston, Texas

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02/23/2018

DIVISION 22, 23

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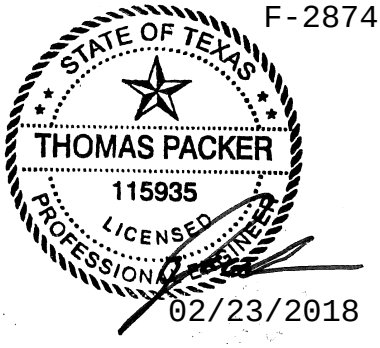

02/23/2018

DIVISION 22,28

SECTION 23 05 00 - COMMON WORK RESULTS FOR HVAC

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Common work results for requirements specifically applicable to Division 23.

B. Requirements of Division 01 Specifications, General Provisions of the Contract and General and Supplementary Conditions apply to this Division.

1.2 REGULATORY REQUIREMENTS

A. Perform Work specified in Division 23 in accordance with standards listed below of the latest applicable edition adopted by the authority having jurisdiction. Where these Specifications are more stringent, they shall take precedence. In case of conflict, obtain a decision from the Architect.
   1. NFPA 30: Flammable and Combustible Liquids Code
   2. NFPA 54: National Fuel Gas Code
   3. NFPA 70: National Electrical Code
   4. NFPA 72: National Fire Alarm and Signaling Code
   5. NFPA 90A: Standard for the Installation of Air Conditioning and Ventilating Systems
   6. NFPA 90B: Standard for the Installation of Warm Air Heating and Air Conditioning Systems
   7. NFPA 92A: Standard for Smoke-Control Systems Utilizing Barriers and Pressure Differences
   8. NFPA 96: Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations
   9. NFPA 101: Life Safety Code
   10. NFPA 101A: Guide on Alternative Approaches to Life Safety
   11. NFPA 101B: Standard on Means of Egress for Buildings and Structures
   12. NFPA 105: Standard for the Installation of Smoke Control Door Assemblies and Other Opening Protectives
   13. NFPA 241: Standard for Safeguarding Building Construction, Alterations, and Demolition Operations
   14. NFPA 5000: Building Construction and Safety Code
   15. ANSI A17.1: Elevators, Dumbwaiters, Escalators and Moving Walks
   16. ANSI Handicapped Code-A117.1
   17. ASTM E814-08B: Standard Test Method for Fire Tests Penetration Firestop Systems.
   18. U.L. Fire Resistance Index.
   19. All applicable Occupational Safety and Health Administration (OSHA) Publications, Rules and Regulations.
   20. Americans with Disabilities Act (ADA)
   21. Special regulations, supplement, and amendments of the State and/or local authorities having jurisdiction.

1.3 REFERENCE STANDARDS

A. AGA: American Gas Association.

B. ANSI: American National Standards Institute.

C. ARI: American Refrigeration Institute.

D. ASHRAE: American Society of Heating Refrigeration and Air Conditioning Engineers.

E. ASME: American Society for Mechanical Engineers.

F. ASTM: American Society for Testing and Materials.

G. AWWA: American Water Works Association.

H. FM: Factory Mutual

I. IRI: Industrial Risk Insurers

J. MSS: Manufacturer's Standardization Society of the Valve and Fitting Industry.

K. NEMA: National Electrical Manufacturers' Association.

L. NFPA: National Fire Protection Association.

M. SMACNA: Sheet Metal and Air Conditioning Contractors' National Association.

N. UL: Underwriters' Laboratories, Inc.

O. U.L. Fire Resistance Index

1.4 SUBMITTALS

A. Incomplete submittals containing unmarked cutsheets or not providing specific detail of what is being proposed will be rejected and will not be reviewed.

B. Include Products as specified in the individual sections of Division 23.

C. Submit shop drawing and product data grouped to include complete submittals of related systems, products, and accessories in a single submittal.

D. Prepare shop drawings completely independent of the Engineer of Record's CADD files or Revit model. Should the Contractor or Vendor wish to use the Engineer of Record's CADD files or Revit model as the basis for developing their shop drawings, a release form, obtainable from the Engineer or Architect, must be signed. A nominal charge of $50.00 per sheet must be made payable to the engineering firm to cover the cost of preparing the drawings for use by others.

E. Submit copies of shop drawings, including:
   1. Building Automation System including direct digital control drawings.
   2. Concrete pads and foundations including anchor bolt and sleeve locations.
   3. Prepare and submit coordination drawings as specified herein. Facilitate the coordination effort with all other trades, specifically Divisions 21, 22, 26 and 28 and shall include:
      a. Boiler Room
      b. Electric Switchgear Rooms
      c. Mechanical Rooms
      d. Coordinated room layouts shall include:
         1) Room dimensions.
         2) Support column locations.
         3) Locations and dimensions of equipment foundations and pads required.

4) Locations and dimension of equipment and apparatus, including electrical control panels and starters, and service and coil pull areas.
5) Dimensioned floor drain locations.
6) Locations of wall mounted equipment.
7) Trench locations and sizes.
8) Sleeve locations in mechanical rooms and equipment rooms.
9) AHU (fan) and duct layouts in AHU equipment rooms.
10) Piping 3" and larger.
11) Conduit 3" and larger.

F. Brochures: Submit manufacturer's product data and brochures including:
1. Complete descriptions.
2. Illustrations.
3. Rating data, accessories, dimensional data, and applicable options and features marked for the specific items scheduled on drawings and specified herein.
4. Capacities stated in the terms specified.
5. Performance curves for all air handling units, fans, and pumps.

1.5 FIELD CONDITIONS

A. Layouts indicated on drawings are diagrammatic and intended to show relative positions and arrangement of equipment, ductwork and piping. Coordinate mechanical work with other trades and measurements obtained at the job site, as applicable, prior to installation. Generally, install work in locations shown on Drawings, using as necessary rises, drops, offsets, transitions, and alternate routings to fit in the available space unless prevented by Project conditions.

B. If prevented by project conditions, prepare drawings showing proposed rearrangement of Work, including changes to Work specified in other sections. Obtain permission of Architect before proceeding.

C. Place anchors, sleeves, and supports prior to pouring concrete or installation of masonry work.

D. Cause as little interference or interruption of existing utilities and services as possible. Schedule work which will cause interference or interruption in advance with Owner, authorities having jurisdiction, and all affected trades.

E. Determine sizes and verify locations of existing utilities on or near site.

F. Keep roads clear of materials and debris.

G. Visit site and be informed of conditions under which Work must be performed.

H. Locate equipment requiring periodic servicing so that it is readily accessible. Provide means of service access, following appropriate manufacturer's recommended service clearance space or, as applicable, means of access using duct, wall, or ceiling access doors.

I. Install ductwork and piping to leave sufficient space for AHJ inspection of wall construction.

1.6 FEES AND PERMITS

A. Obtain and pay for all necessary permits and inspection fees required to perform Division 23 work.

1.7 COORDINATION DRAWINGS

A. Prior to commencement of installation, prepare coordination drawings for work under this division, as specified in Division 01, in full cooperation with persons performing work under other Divisions, including but not limited to mechanical, electrical, plumbing, fire protection, telecommunications, audio/visual and miscellaneous steel.

B. Drawings shall not be formally submitted but shall be kept on site for reference. Notify Architect and Construction Manager of conflicts that cannot be resolved.

C. Coordination Drawings shall be prepared to include the following:
1. Drawn to a scale of 1/4" = 1'-0".
2. Room dimensions.
3. Sheet size matching contract documents.
4. Duct sizes with bottom elevation from finished floor.
5. Show equipment, columns, and beams.
6. Duct fitting details.
7. Construction details of plenums and casings.
8. Concrete pad and foundation layouts including anchor bolt and sleeve locations.
9. Dimensioned floor drain locations.
10. Wall mounted equipment.
11. Piping 3" and larger, with elevations from finished floor to bottom of pipe.
12. Space allocation for conduits and cable trays.
13. Ceiling height.
14. Ductwork, air terminal units, and piping 3" and larger shall be shown in proper graphic scale.
15. Clearance requirements for control panels, inspections, and maintenance.
16. Coordination drawings are to indicate air terminal units, fan coil units, air handling units, control panels, and all other devices and materials to proper scale.

1.8 COMPLETENESS OF WORK

A. The Contract Documents depict HVAC systems which are intended to be complete and functioning systems. All products, materials, and labor necessary to render a fully functional system to fulfill the design intent shown on the documents shall be provided by the Contractor.

B. Catalog numbers referenced throughout the Division 23 Drawings and Specifications are intended to convey a general understanding of the type and quality of the product required. Where written descriptions differ from information conveyed by a catalog number, the written description shall govern. No extra shall be allowed because a catalog number is found to be incomplete or obsolete.

1.9 PRODUCT SUBSTITUTIONS

A. Comply with provisions of Division 01.

1.10 RECORD DRAWINGS

A. Provide record drawings that illustrate the work of Division 23 as finally constructed. Deliver record drawings to the Architect in a form suitable for reproduction.

B. Provide record drawings that illustrate the work of Division 23 as finally constructed. Deliver record drawings to the Architect electronic format and also three (3) copies marked in red ink to reflect work as constructed.

C. Record drawings shall reflect all changes made to the Contract Documents, whether generated by addenda, change orders, or field conditions. Maintain a daily record of these changes and keep current set of drawings showing these changes.

D. Deliver record drawings to Architect within 30 days of Substantial Completion.

E. Record drawings are to indicate air terminal units, fan coil units, air handling units, fans, control panels, and all other devices and materials to proper scale.

1.11 OWNING AND OPERATING MANUALS

A. Manuals shall include clear and comprehensive instructions with appropriate graphics and project specific marked data to enable owner to operate and maintain all systems specified in this Division.

B. Copies of final reviewed submittals indicating all model numbers, serial numbers, cut sheets, and all performance criteria on furnished equipment shall be included.

PART 2 - PRODUCTS

2.1 EQUIPMENT SUPPORTS

A. Structural Steel for Supports: ASTM A36.
   1. Use galvanized members installed in fan plenums or areas of high humidity or condensation, and outside. All fasteners shall be stainless steel. Any damage caused by cutting, drilling, or welding or any other means to galvanized surface must be repaired by apply two coats of cold-galvanizing.
   2. Use hot dipped galvanized members installed in fan plenums or areas of high humidity or condensation, in tunnels and outside. All fasteners shall be stainless steel. Any damage caused by cutting, drilling, or welding or any other means to galvanized surface must be repaired by applying two coats of cold-galvanizing.
   3. Furnish other members with shop coat of primer.
   4. Retouch primer after field welding.

2.2 FLASHINGS AND COUNTERFLASHINGS

A. Furnish materials and coordinate installation for flashing and counterflashing roof penetrations for ductwork and piping.

B. Materials:
   1. Sheetmetal: 24 gauge minimum ASTM A525, Class G90.
   2. Sheet lead: 3 pounds per square foot.
   3. Stainless steel: Minimum 20 gauge.
   4. Sheet copper: 24 OZ/SF.

2.3 WALL AND CEILING ACCESS PANELS

A. Style and type as required for material in which installed.

B. Size: 24"x24" minimum, as indicated, or as required to allow inspection, service and removal of items served.

C. 14 gauge minimum sheet metal for doors, 16 gauge frames of cadmium-plated or galvanized construction. Doors shall have expanded plaster rings where located in plaster walls or flanged finish where located in drywall or block construction.

D. Panels shall have spring hinges with screwdriver locks in non-public areas. Key lock, keyed alike, for panels in public areas.

E. Prime painted or rust inhibitive paint finish.

F. UL labeled when in fire-rated construction, 1-1/2 hour rating.

G. Provide in walls, floors, and ceilings to permit access to all equipment and piping requiring service or adjustment. Examples of such equipment needing access are fire and/or smoke dampers, mechanical system valves, and equipment needing periodic or replacement maintenance.

H. Furnish and locate access panels under this Division. Coordinate with trades who are responsible for building system in which panels are to be installed.

I. Acceptable manufactures: Milcor, Nystrom, Karp, J.L. Industries, or Williams Brothers.
   1. For masonry and drywall construction: Milcor Style M.
   2. For plastered masonry walls and ceiling: Milcor Style K.
   3. For ceramic tile or glazed structural tile: Use stainless steel panels.

2.4 PIPE ENCLOSURES

A. For exposed vertical piping in kitchen: 18 gauge stainless steel (Type 302) with No. 4 finish.
   1. Extend from 2" above ceiling to equipment or island partition.
   2. Size covers to contain number of pipes served.

B. Minimize number of covers by enclosing maximum number of pipes in each drop.

C. Anchor to equipment or partition.

D. Fasten seams and joints with stainless steel pop rivets.

E. Provide 1-1/2" ceiling flange as closure.

2.5 SLEEVES

A. Materials:
   1. Concrete floors, concrete and masonry walls: 18 gauge galvanized steel sheetmetal or Schedule 10 galvanized steel pipe.
   2. Drywall partitions: 18 gauge galvanized steel sheetmetal or Schedule 10 galvanized steel pipe.

B. Sleeves shall be sized such that the annular space between outside surface of pipe or pipe insulation and the inside surface of the sleeve is not less than 1/2". Provide larger annular space if required by firestopping product installation instructions or water proofing seal in exterior wall penetration.

C. Sleeves supporting riser piping 4" and larger shall have three 6" long reinforcing rods welded radially at 120 degree spacing to the sleeve and shall be installed with the rods embedded in the concrete slab.

D. Exterior wall and floor penetrations shall be sleeved and sealed with a Link Seal Modular Seal by GPT Industries or Flexicraft Industries.
   1. Exterior wall and floor penetrations: Install Link Seal Modular Seal by GPT or Flexicraft Industries. Seal shall be suitable for use in direct ground contact, water or atmospheric condiditons with EPDM seal element. Provide Nitrile rubber seal element where subject to oils and fuel. All bolts, nuts and fasteners shall be Steel with 2-part Dichromate corrosion inhibiting coating or Type 316 Stainless steel.

2.6 ESCUTCHEON PLATES

A. Provide B & C No. 10 or equal chrome plated escutcheon plates where pipes penetrate partitions or ceilings in finished areas.

PART 3 - EXECUTION

3.1 EXCAVATING AND BACKFILLING

A. Contractor shall review Division 31 and 33 and shall perform excavation and backfilling in accordance with the most stringent requirements. Contractor shall request clarification before proceeding if there are conflicting instructions.

B. Contract Documents show the approximate location of underground utilities known to exist in the area of construction. Contractor shall determine the exact location of utilities.
   1. Locate and uncover existing utilities which require new connections before trenching in the vicinity of indicated utility connection.
   2. Clear all vegetation and other objectionable material from the area required for the excavation and backfill operations. Disposal of material removed by the clearing operation shall be approved by the Owner's Representative.

C. Provide trenching, excavating, and backfilling necessary for performance of work indicated in Contract Documents.

D. Excavate to depths indicated on the drawings or as necessary to permit the installation of pipe, bedding, backfill, structures or appurtenances. Provide a firm, undisturbed, uniform surface in the bottom of trenches. Where excavation exceeds the required depth, bring the excavation to proper grade through the use of an approved incompressible backfill material. Store excavated material and dispose of surplus excavated material.
   1. Excavate trench to sufficient depth to permit a minimum of 36" of cover over the top of the pipe unless otherwise required by pipe elevations indicated on the Drawings. The trench width shall be 18" plus the diameter of the pipe and/or the largest bell.

E. Trenching and excavation shall be unclassified. No extra will be paid in the event that rock is encountered.

1. Should rock excavation be required, use only experienced personnel for blasting.
2. Exercise extreme care when blasting with signals of danger given before firing any charge.
3. Conform to and obey all public authority regulations for the protection of life and property.

F. Provide sheathing, shoring, dewatering, and cleaning necessary to keep trenches an their grades in proper condition and to meet applicable codes.

G. Provide a minimum of 6" of No. 67 crushed stone or clean sand bedding, or equal, in the bottom of the trench to maintain the required grade and continuous support of the bottom quadrant of the pipe. On bell and spigot piping, dig bell holes so bottom of bells do not support pipe.

H. Upon completion of excavation, and prior to the laying of the pipe, the trench bottom shall be brought up to the required elevation with min. 6" pipe bedding. Pipe bedding shall be select material deposited in the trench, and shall be compacted, leveled off, and shaped to obtain a smooth compacted bed along the laying length of the pipe. Material for pipe bedding shall comply with local codes. In absence of local code requirements the bedding shall be bank sand or select back fill material approved by the Architect. Any material used shall pass a 1/4 inch screen.

I. Clean and inspect pipe for defects before lowering into trench for assembly. Install pipe in accordance with provisions of Contract Documents and with the recommendations of the pipe manufacturer.
   1. Ensure pipe is of proper strength and classification for specified service. Discard damaged or defective pipe discovered during pipe laying operations.
   2. Maintain alignment and grade during layout operation. Use acceptable method for maintaining grade and alignment to produce desired results.

J. Where crushed stone backfill is required, use No. 67 stone, clean sand or equal.

K. After bedding has been shaped and the pipe assembled, place crushed stone carefully around the pipe and to a point 12" above the pipe. Backfill above this point shall be as described below:
   1. Backfill areas of vehicular traffic shall consist entirely of crushed stone and compacted crusher run material.
   2. Backfill for shoulders of roadways, sidewalk, and slab on grade structures shall consist entirely of crushed stone.
   3. Backfill areas not subject to vehicular traffic may consist of suitable excavated material as described above.

L. Where crushed stone is not required, suitable excavated material may be utilized. This includes fine, dry earth or a mixture of earth and shot rock. Rocks larger than 6" in any dimension may not be included in any portion of the backfill material.

M. Trenches shall be backfilled only after piping has been inspected, tested, and approved by the Architect. All backfill material shall be placed in the trench either by hand or by approved mechanical methods. The compaction of backfill material shall be accompanied by tamping, with hand tools or approved pneumatic tampers, by using vibratory compactors, by puddling, or by any combination of the three. The method of compaction shall be approved and all compaction shall be done to the satisfaction of the Architect. Backfill completely around pipe, including 18" above the pipe, with suitable bank sand, tamped in 4" layers under, around, and over pipe. Water down backfill as required. The remainder of the backfill shall be select backfill material tamped at intervals of no more than 12" depths. All materials to be used as selected material backfill shall be approved by the Architect. If, in the opinion of the Architect, the excavated material does not meet the requirements of selected material, the Contractor shall be

required to screen the material prior to its use as selected material backfill. Material used in the upper portion of the backfill or subgrade shall not contain stone, rock, or other material larger than six inches in its longest dimension. No wood, vegetable matter, or other material which, in the opinion of the Architect, is unsuitable shall be included in the backfill. The upper 24" of backfill may be water jetted, if desired. Backfill shall be brought up to finish grade identified on the Architectural Drawings, including additional backfill required to offset settlement during consolidation.

3.2 CUTTING AND PATCHING

A. Repair or replace damage caused by cutting or installation of work specified in Division 23.

B. Perform repairs with materials which match existing and install in accordance with the appropriate section of these specifications.

3.3 FLASHING AND COUNTERFLASHING

A. Counterflash ducts and pipes where penetration of roofs and outside walls occur.

3.4 CONNECTION TO EQUIPMENT FURNISHED BY OWNER

A. Connect and/or install equipment shown on mechanical drawings that requires mechanical connections.

B. Provide piping, isolation valves, unions, and other piping appurtenances required for a complete installation.

C. Provide steam strainers, steam traps, and pressure reducing valves in steam lines.

3.5 DELIVERY, STORAGE, AND PROTECTION

A. Insofar as possible, deliver items in manufacturer's original unopened packaging. Where deliver in original packaging is not practical, provide cover and shielding for all items with protective materials to keep them from being damaged. Use care in loading, transporting, unloading, and storing to keep items from being damaged.

B. Store items in a clean, dry place, and protect from damage. Mechanical equipment may not be staged or stored outdoors unless intended for outdoor use.

C. Protect nameplates on motors, pumps, and similar equipment. Do not paint or insulate over nameplate data.

D. Protect valves and piping from damage. Cover equipment during work of finishing trades.

E. Keep dirt and debris out of pipes and ducts.

F. Repair, restore, and replace damaged items.

G. Cover factory finished equipment during work of finished trades, such as fan coils, fin tubes, etc.

H. Protect cooling and/or heating coils with temporary filter media during construction.

3.6 SLEEVES

A. Floors: Sleeve all pipe penetrations. Extend sleeve 1-1/2" above finished floor, except piping within pipe chases. Sleeve shall be flush with underside of floor.

B. Masonry or concrete walls: Sleeve all pipe penetrations. Sleeves shall be flush on both sides of wall.

C. Drywall partitions: Sleeve all penetrations of piping in systems over 160 degree F.

D. Seal voids between outside surface of sleeve and wall, partition or floor. Seals shall be airtight.

E. Install piping, insulation and sleeves in strict accordance with applicable U.L. floor or partition assembly instructions. Coordinate with Division 07 Firestop manufacturer's installation instructions.

F. Clearance between sleeve and pipe: Minimum of 1/2 inch for hot piping and 1 inch for cold piping or as otherwise dictated by U.L. Fire Resistance Directory.

G. Penetrations not Sleeved or Firestopped:
   1. Seal voids between pipe and partition. Seals shall be airtight.

3.7 ESCUTCHEON PLATES

A. Provide chromium plated escutcheon plates for exposed uninsulated pipes projecting through floors or walls in "finished" spaces. Mechanical rooms, store rooms, electric closets, and janitor closets are not considered "finished" spaces.

3.8 EQUIPMENT GUARDS

A. Use suitable structural frames with minimum 12 gauge, 3/4" galvanized mesh, or expanded metal mesh. Attach to equipment by removable clips and bolts with wing nuts, or other approved connectors.

B. At belts, provide opening for measuring RPM.

C. Provide at all belts, couplings, moving machinery and equipment.

D. Design for easy access to belts and other items requiring replacement.

E. Comply with OSHA Regulations.

3.9 CLEANING HVAC SYSTEMS

A. General Cleanup:
   1. Upon completion of contract and progressively as work proceeds, clean up dirt, debris, old materials, etc., and remove from site, keeping premises in neat and clean condition to satisfaction of the Architect. See Division 01 of specifications for further requirements.
   2. Seepage, discoloration or other damage to parts of the building, its finish, or furnishings due to Contractor's failure to properly clean piping systems or duct systems shall be repaired without cost to the Owner.

B. Factory Finishes:
   1. Clean items with factory finishes. Touch up bare places, scratches and other minor damage to finishes. Use only factory supplied paint of matching color and formula. If finishes are badly damaged or if there are many damaged, scratched or bare places, refinish the entire item.

C. Ducts and Apparatus:
   1. Thoroughly clean ducts and apparatus casings before fans and filters are operated.

D. HVAC Closed and Open Water Systems:
   1. Initial flushing:
      a. Remove loose dirt, mill scale, metal chips, weld beads, rust, and like deleterious substances without damage to any system components.
      b. Bypass factory equipment unless acceptable means of protection are provided, or by subsequent inspection of water boxes and other "hide-out" areas takes place.
      c. Isolate or protect "clean" system components including pumps and pressure vessels and any component that may be damaged.
      d. Open all valves, drains, vents, strainers, and the like at all system levels. Close all valves isolating piping from the existing central piping systems.
      e. Remove plugs, caps, spool pieces, and components to facilitate early discharge from the system.
      f. Sectionalized system to obtain debris carrying velocity of six feet per second.
      g. Connect dead end supply and return headers and the like as necessary, or provide drains in dead end eccentric caps.
      h. Install temporary strainers where necessary to protect downstream equipment.
      i. Supply and drain-off "flushing" water by fire hoses, garden hoses, temporary or permanent piping, Contractor's booster pumps, and the like.
      j. Flush for not less than four hours. Drain all dirt legs. If water drained is not visibly clean, repeat the above procedure until dirt legs are visibly clean.
      k. Before starting the cleaning and flushing process, confirm a thermometer has been installed on the system. During flushing and cleaning process, monitor the water temperature to ensure the water temperature does not become too hot.
   2. Cleaning (Closed Systems Only):
      a. Utilize defoamers to preclude damage to existing work, and specifically adjacent electrical equipment.
      b. Utilize heat to maximize effectiveness of compounds or use live steam injection where practical and safe. Do not raise cleaning water temperature in excess of 150 degrees F. Install a thermometer in the piping system and constantly monitor the water during cleaning to prevent over-heating.
      c. Install temporary strainers, reinforced against blowout, sized to not impair equipment performance, to preclude passing of particles larger than 60% of smallest radial and at a minimum to retain all particles larger than 1000 microns.
      d. Permanent facility pumps shall not be used for circulating cleaning water. Contractor shall supply temporary pumps for this process.
         1) If the system construction, flow rates, and pressures are such that it is impractical for the Contractor to provide temporary pumps, the permanent facility pumps may be used with the specific express permission of the Owner, provided the guarantee on the entire pump assembly is unconditionally extended for two years after date of Substantial Completion. Leakage from pump seals or other damage resulting from circulating the uncleaned water shall require immediate rectification at no additional cost to the Owner.

e. Add 20 pounds of Garratt Callahan Formula 248, or equal, alkaline cleaner for each 1000 gallons of system water for chemical cleaning (approximate .2% solution). Formula 248 is a dry blend of buffered phosphates, a corrosion inhibitor, a surfactant, and an iron oxide sequestrant.
f. Circulate for a period of at least 72 hours.
g. Every eight hours, blow-down the condensers and system low points for three minutes.
h. Drain and flush the system. Rapid flushing from the lowest point in the system is needed to remove debris.
i. Inspect the system and repeat first four steps.
j. Begin the corrosion control program immediately at double the normal inhibitor dosage for one week. After one week, drop to the normal dosage.
k. Chemical treatment compound: Use Garratt Callahan Company Formula 12-L closed system inhibitor strictly following manufacturer's directions.

3.10 OPERATION OF HVAC SYSTEMS DURING CONSTRUCTION

A. Install all specified filters prior to system operation. In addition to specified filters, install a roughing filter upstream of mixed air filter. Roughing filter shall consist of two layers of roll filter media clipped and sealed to entering side of filter frame. Change roughing filter as necessary to minimize dust collection on specified filters.

B. Cover return and exhaust air grilles with temporary filter media. Attach media to avoid damage to grille or ceiling. Change temporary media as required to protect against dust buildup on ductwork. Remove temporary media from grilles after flooring is installed, walls are sanded and painted and other dust generating construction has been completed.

C. During periods of excessive dust generation such as drywall sanding, seal off return and exhaust openings and grilles to prevent dust from accumulating in ductwork.

D. If outside air source contains less dust than building air, adjust A/C unit dampers to operate with as much outside air as possible without causing a freezing condition for coil or exceeding capacity of coil to adequately condition supply air.

E. Furnish and install a new set of specified filter media prior to start of system test and balance. Furnish a new, clean set of the specified media and turn over to Owner's Representative.

3.11 TESTING MECHANICAL SYSTEMS

A. Test all systems and equipment installed to demonstrate proper operation.

B. Advise Architect of scheduled systems testing and completed system demonstration/operation schedules so that he may witness, if desired.

C. Correct and retest work found defective when tested.

D. Make repairs to piping systems with new materials. Peening, doping, or caulking of joints or holes will not be acceptable.

E. HVAC Circulating Water Piping: Hydrostatically test piping at 150 psig pressure or at 1-1/2 times design pressure as indicated on drawings, whichever is greater, for a period of six hours without evidence of leaking.

F. Steam and Steam Condensate Piping: Hydrostatically test piping at 150 psig pressure or 1-1/2 times design working pressure for a period of six hours without evidence of leaking.

G. Fuel Oil Piping: Test piping with nitrogen at 100 psi pressure for two hours without evidence of leaking.

H. Ductwork Pressure Testing: Refer to Section 23 31 13 for required pressure testing for ductwork.

I. Chemical Water Treatment Systems: Have equipment manufacturer field check installations of boiler water treatment systems, and cooling tower water treatment systems, including field calibration of pumps, controllers and other operable parts. Chemical water treatment for HVAC including cleaning, testing, and treatment shall be performed in accordance with Section 23 25 00.

J. System Balance and Testing: Prepare to assist test and balance firm by assuring systems are complete and operational.

K. Test all smoke and combination fire/smoke, dampers by observing damper operation during fire alarm system commissioning.

L. Records of Testing: Maintain records of system testing and results thereof. Deliver results as part of project closing file and on an intermediate basis as requested by Architect.

END OF SECTION

SECTION 23 05 13 - COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Single phase electric motors.

B. Three phase electric motors.

1.2 RELATED REQUIREMENTS

A. Section 26 27 17 - Equipment Wiring

B. Section 26 29 13 - Enclosed Controllers

C. Section 26 29 23 - Variable Frequency Motor Controllers

1.3 REFERENCE STANDARDS

A. Each motor, controller and all components shall be designed, manufactured and tested in accordance with the folling applicable standards:
   1. ABMA STD 9 - Load Ratings and Fatigue Life for Ball Bearings; 2015.
   2. IEEE 112 - IEEE Standard Test Procedure for Polyphase Induction Motors and Generators; 2004.
   3. IEEE Standard 112, Test Method "B"; 1996.
   4. IEEE Standard 444 (ANSI C34.3); 1992.
   5. IEEE Standard 519; 1992.
   6. NEMA MG 1 - Motors and Generators; 2014.
   7. NEMA MG1, Part 31 - Definite Purpose, Inverter Fed Motors; 2012.
   8. NEMA - ICS-3-303
   9. NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
   10. Energy Policy Act of 1992

B. All equipment and material to be furnished and installed on this Project shall be UL or ETL listed, in accordance with the requirements of the authorities having jurisdiction, and suitable for it's intended use on this Project.

1.4 SUBMITTALS

A. Submit motor information with submittals and shop drawings for Division 23 equipment.

B. Product Data: Provide wiring diagrams with electrical characteristics and connection requirements.

C. Test Reports: Indicate test results verifying nominal efficiency and power factor for three phase motors larger than 1/2 horsepower.

D. Manufacturer's Installation Instructions: Indicate setting, mechanical connections, lubrication, and wiring instructions.

E. Operation Data: Include instructions for safe operating procedures.

F. Maintenance Data: Include assembly drawings, bearing data including replacement sizes, and lubrication instructions.

1.5 QUALITY ASSURANCE

A. Conform to NFPA 70.

B. Products Requiring Electrical Connection: Listed and classified by Underwriters Laboratories Inc. as suitable for the purpose specified and indicated.

1.6 DELIVERY, STORAGE, AND HANDLING

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

1.7 WARRANTY

A. Provide two year manufacturer warranty from the date of substantial completion for motors smaller than 20 horserpower.

B. Provide five year manufacturer warranty from the date of substantial completion for motors 20 horsepower and larger.

PART 2 PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Baldor, General Electric, Gould, Lincoln, MagneTek/Century, Marathon, Reliance, Siemens, Toshiba, U.S. Motors, and Westinghouse.

B. Substitutions: Refer to Division 01.

2.2 GENERAL CONSTRUCTION AND REQUIREMENTS

A. Electrical Service:
1. Motors 1/2 HP and smaller: 115 volts, single phase, 60 Hz.
2. Motors larger than 1/2 Horsepower: 460 volts, three phase, 60 Hz.

B. Windings and Insulation:
1. All motors shall have copper windings.
2. Motors shall be equipped with Class B, 80 deg. C rise or Class F, 105 deg. C rise insulation suitable for use in a 40 deg. C ambient temperature.
3. Motors used for cooling tower applications shall be equipped with Class F, 105 deg. C insulation suitable for use in a 40 deg. C ambient temperature. Windings shall be treated with an epoxy varnish to inhibit the moisture absorption.

C. Bearings:
1. Single phase, fractional horsepower motors shall be equipped with quiet operating, all angle babbitt lined sleeve bearings.

2. Polyphase motors shall be equipped with deep groove type ball bearings, generously sized for the loads to which applied and for severe duty application. Provide the necessary seals on the shaft to keep the bearing system free of contamination and moisture. Lubricant shall be high temperature, nonbleeding grease.
    a. Provide inlet and outlet plugs on poly phase motors so that grease fittings can be easily inserted for bearing lubrication except as otherwise specified. The end shields shall be carefully machined to add extra grease capacity. Lower outlet plugs shall be equipped with combination breather/drains on TEFC and TEAO motors.

D. Motors on belt driven equipment shall have slide rails with adjusting screws for belt tension adjustment.

E. Motors specified with variable frequency motor controllers shall comply with NEMA MG1, Part 31 for Definite Purpose, Inverter Fed motors including insulation meeting the requirement for 1600 Vpk at 0.1 uS rise time. In addition to compliance with MG1, Part 31, motors also shall be designed for starting across the line and specifically designed to reduce inrush current.
    1. To protect motor bearings and shafts from damage due to induced electrical currents along the motor shaft, provide Aegis shaft grounding ring (SGR), conductive microfiber motor shaft grounding ring on the driven end of all inverter fed motors. For inverter fed motors 100 HP and larger, also provide either an insulated motor bearing or a ceramic bearing on non-driven end of motor. Comply with manufacturer's installation instructions and with NEMA MG1, Part 31 for inverter fed motor bearings.

F. Sound power levels shall not be greater than recommended in NEMA M61-12.49. Inverter duty rated motors shall not increase by more than 3 dB when operating on a variable frequency motor controller.

G. Provide motors with drive shafts long enough to extend completely through belt sheaves when sheaves are properly aligned and balanced.

H. Motors exposed to the weather shall be weather protected.

I. Install premium efficiency electric motors for motors 1 horsepower and above. Premium efficiency motors shall have efficiency and losses determined in accordance with the latest revisions of IEEE Standard 112. Polyphase squirrel cage motors rated 1 through 150 horsepower shall be tested by dynamometer method B. The efficiency shall be determined using segregated losses in which stray load loss is obtained from a linear regression analysis to reduce the effect of random errors in the test measurements. Guaranteed minimum load efficiency shall be as follows:
    1. HP:3/4 Eff:80.0%
    2. HP:1 Eff:84.0%
    3. HP:1 1/2 Eff:86.5%
    4. HP:2 Eff:86.5%
    5. HP:3 Eff:89.5%
    6. HP:5 Eff:89.5%
    7. HP:7 1/2 Eff:91.7%
    8. HP:10 Eff:91.7%
    9. HP:15 Eff:93.0%
    10. HP:20 Eff:93.6%

J. Explosion-Proof Motors: UL approved and labeled for hazard classification, with over temperature protection.

K. Motors shall be specifically designed for quiet operation and for severe duty. Standard open drip proof motors shall be equipped with aluminum or stainless steel stamped nameplates. Totally enclosed fan cooled and air over motors shall be equipped with stainless steel stamped nameplates with either zinc or cadmium plated hardware. Motor nameplates shall clearly indicate manufacturer's name and model number, frame size, horsepower, frequency, voltage, RPM, starting torque class, insulation class, full load amps, locked rotor amps, service factor, power factor, efficiency and winding material.

L. Motors shall be specifically designed for quiet operation and for severe duty. Standard open drip proof motors shall be equipped with aluminum or stainless steel stamped nameplates. Totally enclosed fan cooled and air over motors shall be equipped with stainless steel stamped nameplates with either zinc or cadmium plated hardware. Motor nameplates shall clearly indicate frame size, horsepower, frequency, voltage, speed, starting torque class, insulation class, service factor and winding material.

M. Wiring Terminations:
   1. Provide terminal lugs to match branch circuit conductor quantities, sizes, and materials indicated. Enclose terminal lugs in terminal box sized to NFPA 70, threaded for conduit.
   2. For fractional horsepower motors where connection is made directly, provide threaded conduit connection in end frame.

2.3 APPLICATIONS

A. Exception: Motors less than 250 watts, for intermittent service may be the equipment manufacturer's standard and need not conform to these specifications.

B. Single phase motors for shaft mounted fans, oil burners, and centrifugal pumps: Split phase type.

C. Single phase motors for shaft mounted fans or blowers: Permanent split capacitor type.

D. Single phase motors for fans, pumps, blowers, and air compressors: Capacitor start type.

E. Single phase motors for fans, blowers, and pumps: Capacitor start, capacitor run type.

F. Three phase motors for blowers, fans, pumps, and other HVAC equipment: Squirrel cage type.

G. Motors located in exterior locations, wet air streams downstream of sprayed coil dehumidifiers, draw through cooling towers, air cooled condensers, humidifiers, direct drive axial fans, roll filters, explosion proof environments, and dust collection systems: Totally enclosed type.

H. Motors located in outdoors, in wet air streams downstream of sprayed coil dehumidifiers, in draw through cooling towers, and in humidifiers: Totally enclosed weatherproof epoxy-treated type.

I. Motors located outdoors and in draw through cooling towers: Totally enclosed weatherproof epoxy-sealed type.

2.4 SINGLE PHASE POWER - SPLIT PHASE MOTORS

A. Starting Torque: Less than 150 percent of full load torque.

B. Starting Current: Up to seven times full load current.

C. Breakdown Torque: Approximately 200 percent of full load torque.

D. Drip-proof Enclosure: Class A (50 degrees C temperature rise) insulation, NEMA Service Factor, prelubricated sleeve or ball bearings.

E. Enclosed Motors: Class A (50 degrees C temperature rise) insulation, 1.0 Service Factor, prelubricated ball bearings, automatic reset overload protector.

2.5 SINGLE PHASE POWER - PERMANENT-SPLIT CAPACITOR MOTORS

A. Starting Torque: Exceeding one fourth of full load torque.

B. Starting Current: Up to six times full load current.

C. Multiple Speed: Through tapped windings.

D. Open Drip-proof or Enclosed Air Over Enclosure: Class A (50 degrees C temperature rise) insulation, minimum 1.0 Service Factor, prelubricated sleeve or ball bearings, automatic reset overload protector.

2.6 SINGLE PHASE POWER - CAPACITOR START MOTORS

A. Starting Torque: Three times full load torque.

B. Starting Current: Less than five times full load current.

C. Pull-up Torque: Up to 350 percent of full load torque.

D. Breakdown Torque: Approximately 250 percent of full load torque.

E. Motors: Capacitor in series with starting winding; provide capacitor-start/capacitor-run motors with two capacitors in parallel with run capacitor remaining in circuit at operating speeds.

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

G. Enclosed Motors: Class A (50 degrees C temperature rise) insulation, 1.0 Service Factor, prelubricated ball bearings, automatic reset overload protector.

2.7 THREE PHASE POWER - SQUIRREL CAGE MOTORS

A. Starting Torque: Between 1 and 1-1/2 times full load torque.

B. Starting Current: Six times full load current.

C. Power Output, Locked Rotor Torque, Breakdown or Pull Out Torque: NEMA Design B characteristics.

D. Design, Construction, Testing, and Performance: Conform to NEMA MG 1 for Design B motors.

E. Insulation System: NEMA Class B or better.

F. Testing Procedure: In accordance with IEEE 112. Load test motors to determine free from electrical or mechanical defects in compliance with performance data.

G. Motor Frames: NEMA Standard T-Frames of steel, aluminum, or cast iron with end brackets of cast iron or aluminum with steel inserts.

H. Thermistor System (Motor Frame Sizes 254T and Larger): Three PTC thermistors embedded in motor windings and epoxy encapsulated solid state control relay for wiring into motor starter; refer to Section 26 29 13.

I. Bearings: Grease lubricated anti-friction ball bearings with housings equipped with plugged provision for relubrication, rated for minimum ABMA STD 9, L-10 life of 20,000 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.

J. Sound Power Levels: To NEMA MG 1.

K. Part Winding Start Where Indicated: 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.

L. Weatherproof Epoxy Sealed Motors: Epoxy seal windings using vacuum and pressure with rotor and starter surfaces protected with epoxy enamel; bearings double shielded with waterproof non-washing grease.

M. Nominal Efficiency: As scheduled at full load and rated voltage when tested in accordance with IEEE 112.

N. Nominal Power Factor: As scheduled at full load and rated voltage when tested in accordance with IEEE 112.

PART 3 EXECUTION

3.1 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Install base mounted motors securely on firm foundation.

C. Align motors on direct drive equipment using dial type gauges.

D. Check line voltage and phase and ensure agreement with nameplate. Test motor for proper rotation under Division 26.

3.2 ADJUSTMENTS

A. Motors, together with driven equipment, shall be dynamically and statically balanced. Imbalance shall be reduced to minimum specified by equipment manufacturers.

END OF SECTION

SECTION 23 05 23 - GENERAL-DUTY VALVES FOR HVAC

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Valves for chilled water systems.

B. Valves for heating water systems.

1.2 RELATED REQUIREMENTS

A. Section 23 21 13 - HVAC Piping

B. Section 23 07 00 - HVAC Insulation

1.3 SUBMITTALS

A. Indicate valve service, construction material, sizes and locations to be used. Submit performance ratings, rough-in details, weights, support requirements, and piping connections.

B. Operation and Maintenance Data: Include manufacturer's descriptive literature, operating instructions, maintenance and repair data, and parts listings.

1.4 QUALITY ASSURANCE

A. Valve Bodies, Shells, and Seats: Factory tested.

B. Bronze Body Valves:
   1. Materials for pressure containing parts: ASTM B-62 (less than 200 psi), B-61 (200 psi and above)
   2. Design, workmanship, testing: MSS-SP-80

C. Iron Body Valves:
   1. Materials for pressure containing parts: ASTM A126, Grade B
   2. Face-to-face and end-to-end dimensions: ANSI B16.10
   3. Design, workmanship, testing: MSS-SP-70, 71 and 78.

D. Butterfly Valves:
   1. Face-to-face and end-to-end dimensions: MSS-SP-67

E. Valve Stems: ASTM B584-78, Class 13C (cast silicon brass), ASTM B-371-79, Alloy A (rolled silicon brass), or other material equally resistant to dezincification.

F. Pressure Castings: Free of impregnating materials.

G. Valve name or trademark and working pressure stamped or cast into body.

H. Standard for 200 PSI and 300 PSI valves with metallic seats: ASTM B61-76.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Iron body valves: Crane, Dezurik, Kennedy, Kitz, Milwaukee, Mueller, Nibco, or Stockham.

B. Bronze body valves: Dezurik, Kennedy, Kitz, Milwaukee, Nibco, or Stockham.

C. Butterfly valves: Crane, Dezurik, Milwaukee, Mueller, Nibco, or Stockham.

D. Ball valves: Apollo, Hammond, Jamesbury, Kitz, Milwaukee, Nibco, or Watts.

2.2 MATERIALS

A. Nibco Figure numbers are indicated below unless noted otherwise:

B. Valve Connections: Two inches and smaller - threaded; 2-1/2 inches and larger - flanged.

C. Provide chain operators for gate valves, butterfly valves, and plug cocks located in mechanical rooms as required by mechanical plans or where valves are mounted above 7'-0" A.F.F.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Furnish and install valves in each piping connection at each piece of HVAC equipment to allow equipment to be isolated from piping systems.

B. Furnish and install valves in all piping systems to isolate each floor or main section of the building. Install sufficient number of valves to minimize the portion of the system which must be shut down for service or maintenance purposes.

C. Install valves in water piping systems so ordinary maintenance work can be performed on the equipment that the valves isolate, without having to drain the system beyond the valve.

D. Locate valves so as to be easily accessible by maintenance personnel. Installation shall be made so that the valve can be fully opened and have a minimum clearance of 6" beyond valve stem end at the full open position and will include sufficient clearance for removal of stem for repair.

E. Identify valves as required by Section 23 05 53.

END OF SECTION

SECTION 23 05 29 - HANGERS FOR HVAC PIPING

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Hangers for HVAC piping

1.2 RELATED REQUIREMENTS

A. Section 23 05 23 - General Duty Valves for HVAC

B. Section 23 07 00 - HVAC Insulation

C. Section 23 21 13 - HVAC Piping

1.3 SUBMITTALS

A. Submit product data and information in accordance with the provisions of Division 01.

B. Indicate where each type of hanger will be used, what piping service and if pipe system will be insulated and with what thickness.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Anvil, B-Line, Carpenter and Patterson, Fee and Mason, Michigan, Reliable, and Viking. Anvil numbers are used for reference.

B. Substitutions: Refer to Division 01.

2.2 HANGERS

A. Anvil Figure #260 MSS Type 1, clevis hangers for:
   1. Non-insulated steel and galvanized piping 2" through 24" diameter
   2. Non-insulated PVC piping

B. Anvil Figure #260 clevis hangers with Figure 167, MSS Type 40 galvanized insulation protection shields (sized for supporting insulation having a compressive strength of 4 psi). Support piping on outside of insulation. Size hangers so that pipe insulation passes through them without interruption.
   1. Steam and condensate piping 3" diameter and less.
   2. Heating water piping above 160 degrees F. 4" diameter and less.
   3. Chilled water piping
   4. Insulated condenser water piping
   5. All other insulated piping

C. Anvil Figure CT-69, MSS Type 10 with adjustable wrought tubing ring hanger, copper plated for:
   1. Non-insulated copper tubing with no longitudinal movement

D. Anvil Figure #171, MSS Type 41 with pipe roller, Anvil Figure #16x protection saddle and Anvil Figure 167, MSS Type 40 galvanized insulation protection shields (sized for supporting insulation having a compressive strength of 4 psi, at 8 foot intervals). Support piping on outside of insulation. Size hangers so that pipe insulation passes through them without interruption. Use these for:
   1. Steam and condensate piping 4" diameter and larger.
   2. Heating water piping above 160 degrees F. 6" diameter and larger.

E. Anvil Figure #CT-121, MSS Type 8, riser clamps (at floor slab penetrations) to support:
   1. Copper pipe risers

F. Anvil Figure #261, MSS Type 8, galvanized riser clamps (at floor slab penetrations) to support:
   1. Steel pipe risers
   2. PVC pipe risers
   3. Polypropylene risers

G. Anvil Powerstrut Trapeze Hangers: Where three or more lines of pipe run parallel, support them with trapeze hangers.

H. Except for copper hangers, all other hangers and supports shall be hot-dipped galvanized.

2.3 INSERTS

A. Concrete Insert: Anvil Figure #281, MSS Type 18, universal concrete inserts, adequately sized and correctly positioned to support full load operating systems.

B. Concrete Insert, Wedge Type: Anvil Figure #281, 1/4" to 7/8"

C. Lightweight Concrete Insert: Anvil Figure #285

D. Continuous Concrete Insert: Anvil Powerstrut Figure #PS-349 pre-galvanized

2.4 EXPANSION ANCHORS

A. Hilti Kwik-bolt, zinc-plated, metal expansion anchor.

B. Anchor to meet U.L., ICBO-4627 and FM listings.

2.5 HANGER RODS

A. Provide mild steel all-thread rods with maximum loads as follows:
   1. 3/8" - 300 lbs
   2. 1/2" - 600 lbs
   3. 5/8" - 1,200 lbs
   4. 3/4" - 2,000 lbs
   5. 1" - 5,000 lbs

2.6 CLAMPS

A. C-Clamps: Anvil Figure #92, MSS Type 23.
   1. Use these for attaching hangers to steel beams. Do not weld hanger rods to structural steel members.

B. Malleable Beam Clamps: Anvil Figure #218, MSS Type 30: Use these for attaching hangers to bar joists. Attach clamps to top chord of bar joists only. Confirm with structural engineer for maximum loading and restrictions.

PART 3 - EXECUTION

3.1 PIPE HANGERS

A. Support pipes on specified hangers so that equipment, pumps, and fittings do not bear weight or stresses from vibration and swaying of pipe. Support pipe risers at regular intervals in pipe shafts at least once at each floor level or a maximum of 12'-0" apart. Do not use perforated metal, strap iron, or band iron. Do not make offsets in hangers.

B. Maximum allowable spacing of pipe hangers is listed below. Space hangers and brackets at closer intervals where necessary to maintain levels, slopes, and drainage, or to prevent sagging or swaying of pipe.

C. Steel and Galvanized Pipe - Water
1. 1/4" to 1-1/2" - 7' 0" O.C.
2. 2" to 2-1/2" - 10' 0" O.C.
3. 3" to 4" - 12' 0" O.C.
4. 5" and above - 14'0" O.C.

D. Steel and Galvanized Pipe - Vapor
1. 1/4" to 1-1/2" - 8' 0" O.C.
2. 2" to 2-1/2" - 13' 0" O.C.
3. 3" and above - 15' 0" O.C.

E. Copper Pipe - Water
1. 1/4" to 1-1/4" - 5'0" O.C.
2. 2" to 2-1/2" - 8'0" O.C.
3. 3" and above - 10'0" O.C.

F. Copper Pipe - Vapor
1. 1/4" to 1" - 5'0" O.C.
2. 1-1/4" to 2" - 8'0" O.C.
3. 2-1/2" to 4" - 10' 0" O.C.
4. 5" and above -15' 0" O.C.

G. Sway Bracing
1. Provide sway bracing and additional supports to meet the seismic bracing requirements.

END OF SECTION

SECTION 23 05 53 - IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Nameplates.

B. Tags.

C. Stencils.

D. Pipe Painting and Markers.

E. Printed Labels / Ceiling Markers / Tacks

F. Control Diagrams.

1.2 RELATED REQUIREMENTS

A. Section 09 90 00 - Painting and Coating: Identification painting.

1.3 REFERENCE STANDARDS

A. ASME A13.1 - Scheme for the Identification of Piping Systems; 2007.

B. ASTM D709 - Standard Specification for Laminated Thermosetting Materials; 2013.

1.4 SUBMITTALS

A. List: Submit list of wording, symbols, letter size, and color coding for mechanical systems identification.

B. Chart and Schedule: Submit valve chart and schedule, including valve tag number, location, function, and valve manufacturer's name and model number. Follow existing facility standards if applicable.

C. Product Data: Provide manufacturers catalog literature for each product required.

D. Samples: Submit samples of ceiling markers/tacks, duct labels, nameplates, pipe markers, and valve tags.

E. Manufacturer's Installation Instructions: Indicate special procedures, and installation.

F. Project Record Documents: Record actual locations of tagged valves.

PART 2 PRODUCTS

2.1 IDENTIFICATION APPLICATIONS

A. Access Doors: Stencil painting compliant with NFPA 90A where applicable.

B. Major HVAC equipment including, but not limited to AHU's, boilers, chillers, fans, pumps, and RTU's: Nameplates.

C. Air Terminal Units: Nameplates

D. Automatic Controls: Tags. Key to control schematic.

E. Control Panels and major control components: Nameplates.

F. Automatic Control Dampers: Ceiling markers/tacks, where located above lay-in ceiling.

G. Ductwork: Stencil painting.

H. Fire, Smoke, and Combination Dampers: Labels.

I. Heat Transfer Equipment: Nameplates.

J. Major Control Components: Nameplates.

K. Piping: Pipe markers.

L. Pumps: Stencil painting.

M. Unitary Equipment: Nameplates.

N. Tanks: Stencil painting.

O. Thermostats: Printed Labels.

P. Valves: Tags and ceiling tacks where located above lay-in ceiling.

Q. Water Treatment Devices: Nameplates.

2.2 ACCEPTABLE MANUFACTURERS

A. Brady Corporation, Kolbi Pipe Marker Company, Marking Services, Inc., MIFAB, Inc., or Seton Identification Products

B. Substitutions: Refer to Division 01.

2.3 NAMEPLATES

A. Rigid plastic with engraved lettering.

B. Fasteners: Commercial quality, rust resisting nuts and bolts with backwashers, self-tapping screws, or rivets. If equipment surface does not allow for direct attachment, use copper or brass rings to attach tags.

C. Use names, numbers, and abbreviations appearing in schedules on Contract Drawings or as otherwise directed by the Owner.

D. Letter Color: White.

E. Letter Height: 1/2 inch.

F. Background Color: Black.

G. Plastic: Conform to ASTM D709.

2.4 TAGS

A. Tags shall be provided showing the valve service and number or equipment number.
   1. At substantial completion, submit chart showing all valve and equipment numbers to Owner and Engineer.
   2. Alpha-numeric I.D. shall include floor level and buliding section as part of the identification.
   3. Securely fasten tags to valves with a brass "S" hook or chain.

B. Plastic Tags: Laminated three-layer plastic with engraved black letters on light contrasting background color. Tag size minimum 1-1/2 inch diameter.

C. Metal Tags: Brass with stamped letters; tag size minimum 1-1/2 inch diameter with smooth edges. Provide with permanently stamped black filled letters and numbers.

D. Valve Tag Chart: Typewritten letter size list in anodized aluminum frame.

2.5 ADHESIVE-BACKED DUCT MARKERS

A. Acceptable Manufacturers:
   1. Brimar Industries, Inc.: www.pipemarker.com.

B. Material: High gloss acrylic adhesive-backed vinyl film; printed with UV and chemical resistant inks.

C. Style: Individual Label.

D. Color: Yellow/Black.

2.6 STENCILS

A. Where stenciling is used to identify large pieces of equipment, such as boilers, chillers, and air handling units, stenciling shall be in a conspicuous place and visible from control panel area.

B. Use names, numbers, and abbreviations appearing in schedules on Contract Drawings or as otherwise directed by the Owner.

C. Piping stencils shall include flow direction arrow and identification of fluid being conveyed
   1. Steam piping shall indicate operating pressure in addition to contents and flow direction

D. Stencils: With clean cut symbols and letters of following size:
   1. 3/4 to 1-1/4 inch Outside Diameter of Insulation or Pipe: 8 inch long color field, 1/2 inch high letters.
   2. 1-1/2 to 2 inch Outside Diameter of Insulation or Pipe: 8 inch long color field, 3/4 inch high letters.
   3. 2-1/2 to 6 inch Outside Diameter of Insulation or Pipe: 12 inch long color field, 1-1/4 inch high letters.

4. 8 to 10 inch Outside Diameter of Insulation or Pipe: 24 inch long color field, 2-1/2 inch high letters.
5. Over 10 inch Outside Diameter of Insulation or Pipe: 32 inch long color field, 3-1/2 inch high letters.
6. Ductwork and Equipment: 2-1/2 inch high letters.

E. Stencil Paint: Semi-gloss enamel or latex. Color shall be black or white, whichever provides the highest contract to the adjacent surface. Comply with colors in ASME A13.1 where applicable.

2.7 PIPE PAINTING AND MARKERS

A. Painting of HVAC piping:
1. Paint all exposed piping (or exterior surface of insulation) in mechanical rooms, central energy plants, and rooms without ceilings in its entirety.
2. Colors:
a. Chilled Water Supply: Blue
b. Chilled Water Return: Light Blue
c. Condenser Water Supply: Light Green
d. Condenser Water Return: Green
e. Heating Water Supply: Purple
f. Heating Water Return: Light Purple
g. Steam: Orange
h. Steam Condensate: Light Orange
i. Boiler Feedwater and drain piping: Dark Orange
j. Fuel Oil Supply: Brown
k. Fuel Oil Return: Light Brown
l. Refrigerant Piping: Same as current ASHRAE Standard 34 container color based on refrigerant type.

B. Plastic Pipe Markers: Factory fabricated, flexible, semi- rigid plastic, preformed to fit around pipe or pipe covering. At a minimum, marker shall have flow direction arrows and identification of fluid being conveyed.

C. Steam piping shall indicate operating pressure in addition to contents and flow direction.

D. Underground Plastic Pipe Markers: Bright colored continuously printed plastic ribbon tape, minimum 6 inches wide by 4 mil thick, manufactured for direct burial service. At a minimum, marker shall have flow direction arrows and identification of fluid being conveyed.

E. Colors shall conform to ASME 13.1 where applicable.

2.8 PRINTED LABELS

A. Printed Labels
1. Printed labels / asset tags to be coordinated with Owner and applied by Contractor.
2. Prior to Substantial Completion date, Contractor to work with owner, as required, to locate devices above the ceiling requiring a printed label / asset tag.

B. Ceiling Marker / Tack description: Steel with 3/4 inch diameter color coded head.
1. Contractor to provide an install.
2. Color code as follows:

a. HVAC Equipment: Yellow.
b. Fire Dampers and Smoke Dampers: Red.
c. Valves: Blue.

2.9 CONTROL DIAGRAM FRAMES

A. Provide printed diagrams for all major HVAC equipment. Mount diagrams on walls in conspicuous, easily accessible places in each separate equipment room housing the equipment which the individual diagrams are applicable. Diagrams shall be laminated and represent as-built conditions. Lettering to be no smaller than 10 pt font.

B. The following diagrams are required:
1. Written sequences of operation.
2. Graphic control diagram indicating relative device locations and labels.

C. Provide and install mounting hardware to secure each diagram to the wall. If adequate wall space is not available adjacent to the associated equipment, coordinate an alternate mounting location with Owner.

PART 3 EXECUTION

3.1 PREPARATION

A. Degrease and clean surfaces to receive adhesive for identification materials.

B. Prepare surfaces in accordance with Division 09 for stencil painting.

3.2 INSTALLATION

A. Install nameplates with corrosive-resistant mechanical fasteners, or adhesive. Apply with sufficient adhesive to ensure permanent adhesion and seal with clear lacquer.

B. Install tags with corrosion resistant chain.

C. Apply stencil painting in accordance with Division 09.

D. Install plastic pipe markers in accordance with manufacturer's instructions at no less than 25 foot intervals, at valves, and at least once in each separate space through which the pipe passes. Label all vent piping and pressure relief piping.

E. Install underground plastic pipe markers 6 to 8 inches below finished grade, directly above buried pipe.

F. Use tags on piping 3/4 inch diameter and smaller.
1. Identify service, flow direction, and pressure.
2. Install in clear view and align with axis of piping.
3. Locate identification not to exceed 25 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.

G. Label ductwork at no less than 25 foot intervals, on both sides of barriers and rated wall penetrations, and at all ductwork penetrations into and exiting from enclosed chases.

H. Install ceiling tacks to locate valves or dampers above lay-in panel ceilings. Locate in corner of panel closest to equipment.

I. Confirm with Owner or Architect prior to placing ceiling tacks or labels on surfaces other than lay-in panel ceilings.

END OF SECTION

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

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Testing, adjustment, and balancing of air systems.

B. Testing, adjustment, and balancing of hydronic, plumbing, steam, and refrigeration systems.

C. Measurement of operating condition of existing HVAC and plumbing systems prior to construction.

D. Measurement of final operating condition of HVAC and plumbing systems.

E. HVAC ductwork pressure testing.

1.2 REFERENCE STANDARDS

A. AABC MN-1 - AABC National Standards for Total System Balance; 2002.

B. ASHRAE Std 111 - Measurement, Testing, Adjusting, and Balancing of Building HVAC Systems; 2008.

1.3 SUBMITTALS

A. Installer Qualifications: Submit name of adjusting and balancing agency and TAB supervisor for approval within 30 days after award of Contract.

B. TAB Plan: Submit a written plan indicating the testing, adjusting, and balancing standard to be followed and the specific approach for each system and component.
   1. Submit to Architect and Engineer.
   2. Include at least the following in the plan:
      a. List of all air flow, water flow, sound level, system capacity and efficiency measurements to be performed and a description of specific test procedures, parameters, formulas to be used.
      b. Copy of field checkout sheets and logs to be used, listing each piece of equipment to be tested, adjusted and balanced with the data cells to be gathered for each.
      c. Identification and types of measurement instruments to be used and their most recent calibration date.
      d. Discussion of what notations and markings will be made on the duct and piping drawings during the process.
      e. Final test report forms to be used.
      f. Any balancing or procedural concerns.
      g. Time schedule for TAB work to be done in phases (by floor, etc.).
      h. Time schedule for deferred or opposed seasonal TAB work.
      i. Specific list of rooms requiring specific pressure differentials and the target differential pressure for each room.
      j. Procedures for formal deficiency reports, including scope, frequency and distribution.

PART 2 PRODUCTS - NOT USED

PART 3 EXECUTION

3.1 GENERAL REQUIREMENTS

A. Perform total system balance in accordance with:
   1. If these specifications set forth more stringent requirements than the above referenced standard(s), these specifications shall become the minimum requirements.

B. During Construction, the TAB shall inspect the installation of major HVAC equipment, piping systems, sheetmetal work, and temperature controls as well as other parts of the HVAC and plumbing systems. The inspections shall be performed periodically as work progresses. A minimum of two inspections are required as follows:
   1. When 60% of the ductwork is installed.
   2. When 90% of the equipment is installed.
   3. The TAB shall submit a written report of each inspection to the Owner, Engineer, Contractor, and Architect.

C. Upon completion of the installation and start-up of the equipment by the mechanical contractor, the TAB shall test and balance the system components to obtain optimum conditions in each conditioned space in the building. If construction deficiencies ar encountered that preclude obtaining optimum conditions, and the deficiencies cannot be corrected by the Contractor within a reasonable period of time, the TAB shall proceed to other systems to test as available or cease testing and balancing services and advise the Owner and Engineer in writing of the deficiencies. TAB work shall be completed prior to Substantial Completion of the project.

D. Where HVAC systems and/or components interface with life safety systems, including fire and smoke detection, alarm, and control, coordinate scheduling and testing and inspection procedures with the authorities having jurisdiction.

E. TAB Agency Qualifications:
   1. Company specializing in the testing, adjusting, and balancing of systems specified in this section.
   2. Having minimum of three years documented experience and six projects of like size and scope.
   3. Certified by one of the following:

F. TAB Supervisor and Technician Qualifications: Certified by same organization as TAB agency.

G. The TAB firm shall be capable of performing the services specified at the location of the facility described within the time specified, of preparing and submitting the detailed report of the actual field work performed, and following up on the basic work as may be required.

3.2 PROCEDURES FOR TESTING, ADJUSTING AND BALANCING EXISTING SYSTEMS

A. Perform a pre-construction inspection of existing equipment that is to remain and be reused.
   1. Measure and record the operating speed, airflow, and static pressure of each fan.
   2. Measure the motor voltage and amperage. Compare the values to the motor nameplate information.
   3. Check the refrigerant charge.

4. Check the condition of the filters.
5. Check the condition of the coils.
6. Check the operation of the drain pan and condensate drain pan trap.
7. Check bearings and other lubricated parts for proper lubrication.
8. Report on the operating conditions of the equipment and the results of the measurements taken. Identify deficiencies and provide report of all information to the Owner and Engineer.

B. Before performing testing and balancing of existing systems, inspect existing equipment that is to remain and be reused to verify that equipment has been cleaned and refurbished. Report any deficiencies to the Owner and Engineer.
   1. New filters are installed.
   2. Coils are clean and combed.
   3. Drain pans are clean and draining.
   4. Fans are clean.
   5. Bearings and other parts are properly lubricated.
   6. Deficiencies noted in the pre-construction report are corrected.

C. Perform and record air flow measurements of each supply fan, return fan, air system and air device in the project area prior to demolition and/or renovation.
   1. Measure and record exhaust fan airflow, static pressure, voltage and amperage of each fan system including each air device inlet, fan inlet and outlet.
   2. Measure and record airflow of each supply and return air device in the project area.
   3. Measure and record airflow, inlet static pressures, outlet static pressures and static pressure drops across each component (coils, filters, dampers, etc.) of equipment serving the project area that is to remain in use.

D. Perform testing and balancing of existing systems to the extent that existing systems are affected by the renovation work.
   1. Compare the indicated airflow of the renovated work to the measured fan airflows and determine the new fan speed, filter and coil face velocity.
   2. Verify that the indicated airflows of the renovated work result in filter and coil face velocities and fan speeds that are within the acceptable limits defined by the equipment manufacturer.
   3. If calculations increase or decrease the airflow and water flow rates by more than 5 percent, make equipment adjustments to achieve the calculated and required airflow and water flow rates. If 5 percent or less, equipment adjustments are not required.
   4. Air balance each supply, return and exhaust air outlet and inlet.
   5. Refer to the existing A/C system balance schedule on the drawings.

3.3 EXAMINATION

A. Contractor shall verify that systems are complete and operable before commencing balancing work. Ensure the following conditions:
   1. Systems are started and operating in a safe and normal condition.
   2. Temperature control systems are installed complete and operable.
   3. Proper thermal overload protection is in place for electrical equipment.
   4. Air Distribution Systems:
      a. All specified filters are clean and in place. Replace used/dirty filter media prior to TAB work being performed. If required, install temporary media in addition to final filters.
      b. Duct systems are clean of debris.

c. Fans are rotating correctly, checked for proper belt tension, and are free from excessive noise and vibration at full load.
d. All supply, return, exhaust and transfer grilles, registers, diffusers, and terminal units with controls are installed. All air devices shall be clean externally and internally.
e. Rated dampers, motorized dampers, and manual volume dampers are in properly installed, clean, powered (where applicable), and open. Volume damper handles shall be exposed through insulation. Motorized dampers shall have unrestricted movement from full open to full closure. Control wiring to dampers shall be in place and operational. Should any device not be readily accessible, Contractor shall provide access as requested by the TAB firm.
f. Air coil fins are cleaned and not damaged. Damaged fins shall be combed or replaced prior to coil performance testing.
g. Blank off sections are installed at all filters and coils to eliminate excessive by-pass or leaking of air.
h. Access doors are closed and duct end caps are in place.
i. Air outlets are installed and connected.
j. Duct system leakage is minimized.
k. Supply, return, outside air, make-up air, and exhaust ductwork is terminated and pressure tested for leakage as required by specifications.

5. Water Circulating Systems:
   a. Hydronic systems are flushed, filled, and vented.
   b. Pumps are rotating correctly. Gauge cocks and/or PT test plugs are installed correctly.
   c. Strainers are clean and in place. Purge all air from water lines including coils, risers, heat exchangers, and other equipment.
   d. Service and balance valves are open. Set mixing valves to full flow through system components.
   e. Piping to cooling coils is complete and set for counter flow. Verify location of thermometer wells, gauge cocks, and balance cocks for coils.
   f. Operating temperatures of chillers, boilers, and heat exchangers are set as scheduled.
6. Automatic Controls:
   a. Verify that control components are installed in accordance with project requirements and are functional, including electrical interlocks, damper sequences, air and water resets, fire and freezestats, temperature and humidity sensors, and high and low limit switches.
   b. Verify that airflow and static pressure controllers/transmitters are installed and calibrated.
   c. Verify that controlling instruments are calibrated and set for design operating conditions.
   d. Verify variable frequency devices are adjusted in manual mode to allow drive to meet rated motor nameplate amps.

B. Notification of System Readiness
1. After completion of the work above, notify the TAB agent certifying that the work has been accomplished and that the building and the air conditioning systems are ready for testing, adjusting, and balancing.
2. Provide the TAB contractor all project drawings and specifications, addendum, approved revisions, RFI's, equipment submittal data, approved shop drawings, and equipment brochures as appropriate.
3. Report defects and deficiencies that will or could prevent proper system balance.

C. As part of bid, Contractor shall include costs necessary to make any changes in the sheaves, belts, dampers, and other devices required for correct balance as required by the TAB.

3.4 PREPARATION

A. Hold a pre-balancing meeting at least one week prior to starting TAB work.
   1. Require attendance by all installers whose work will be tested, adjusted, or balanced.

B. Coordinate the installation of any additional balancing devices with the Contractor as required.

C. Complete readiness of the building requires that construction status of the building shall permit the closing of doors and windows and ceilings shall be installed to obtain projected operating conditions. Exterior doors shall remain closed during the balancing process of adjacent spaces and during building pressurization testing.

D. Provide and coordinate services of qualified, responsible trades, suppliers and personnel as required to correct, repair, adjust or replace any and all deficient items or conditions found during the testing, adjusting and balancing period.

E. Contractor shall operate said systems at his expense for the length of time necessary to complete the TAB process.

F. Project completion schedules shall provide sufficient time to permit the completion of TAB services prior to Owner occupancy.

3.5 ADJUSTMENT TOLERANCES

A. Air Handling Systems: Adjust to within plus or minus 10 percent of design for supply systems and plus or minus 10 percent of design for return and exhaust systems.

B. Air Terminal Units: Adjust total to within plus or minus 10 percent of design.

C. Air Valves: Adjust total to within plus or minus 5 percent of design.

D. Air Outlets and Inlets: Adjust total airflow to each space to within plus 10 percent and minus 5 percent of design. Adjust individual outlets and inlets in space to within plus or minus 10 percent of design.

E. Hydronic Systems: Adjust to within plus or minus 10 percent of design.

3.6 RECORDING AND ADJUSTING

A. Field Logs: Maintain written logs including:
   1. Running log of events and issues.
   2. Discrepancies, deficient or uncompleted work by others.
   3. Contract interpretation requests.
   4. Lists of completed tests.

B. Ensure recorded data represents actual measured or observed conditions.

C. Permanently mark settings of valves, dampers, and other adjustment devices allowing settings to be restored. Set and lock memory stops.

D. Mark on the drawings the locations where traverse and other critical measurements were taken and cross reference the location in the final report.

E. During the TAB work, the temperature regulation shall be adjusted for proper relationship between controlling instruments. Advise Owner of any instruments out of calibration.

F. The TAB agent shall perform troubleshooting functions such as obtaining static pressure profiles, temperature and pressure readings, or additional traverses to assist in determining any system balancing problems. The TAB agent shall suggest solutions to any balancing problems to the Contractor and Engineer.

G. After adjustment, take measurements to verify balance has not been disrupted or that such disruption has been rectified.

H. Leave systems in proper working order, replacing belt guards, closing access doors, closing doors to electrical switch boxes, and restoring thermostats normal setpoints.

I. At final inspection, recheck random selections of data recorded in report. Recheck points or areas as selected and witnessed by the Owner or Owner's Representative.
   1. If random tests demonstrate a measured flow deviation of 10 percent or more from that recorded in the certified TAB report, the report shall automatically be rejected. In the event the report is rejected, all systems shall be readjusted and tested, new data recorded, a new certified TAB report submitted, and a new inspection test made, all at no additional cost to the Owner.

J. TAB firm shall provide for one callback request to retest any unresolved problems noted in the final report. The revised results shall be submitted after completion of the retesting.

K. Make one inspection within 90 days after occupancy of the building to insure that satisfactory conditions are being maintained throughout and to satisfy any unusual conditions. Prepare and submit a report stating the 90 day visit is completed and note any adjustments made.

3.7 OPPOSED SEASON TESTING

A. The balancing agency shall perform an inspection of the HVAC system during the opposite season from that in which the initial adjustments were made. The balancing agency shall make any necessary modifications to the initial adjustments to produce optimum system operation.

B. During the opposed season testing, any necessary modifications to the initial adjustment required to produce optimum operation of the system components shall be made to produce the proper seasonal conditions in each conditioned space. At the time of opposed season checkout, give Owner timely notification before any readings or adjustments are made.

C. This service allows for testing of equipment that, due to extreme weather conditions, cannot be accurately tested at the time of the initial balance. If a project is balanced during the summer, the opposed season test is performed during the winter months and vice-versa.

D. Submit updated final report with a summary of the system modifications made and updated setpoints.

3.8 AIR SYSTEM PROCEDURE

A. Exhaust Air:
   1. Fans checked for rotation, measure and record motor amperage, fan differential pressure, and RPM. Measure and record exhaust inlets prior to fan or damper adjustment.
   2. Insure backdraft damper is open and has free operation.
   3. Perform pitot tube traverse, adjust fan speed, and proportion main branch lines.
   4. Balance inlets within specified tolerance. Use branch ductwork dampers to proportion airflow in the system and to minimize the amount of volume regulation required at the manual damper nearest each air inlet.
   5. Measure and record final total exhaust air through a pitot tube traverse and record static pressure and flow at traverse point.
   6. Identify system leakage through traverse and inlet summation. If traverse quantities and inlet summations differ by more than 5 percent, then an explanation must be presented with appropriate recommendations.
   7. Note any objectionable noise created by dampers or diffusers.

3.9 WATER SYSTEM PROCEDURE

A. Condenser Water:
   1. With strainers clean and all valves wide open, set pump head and GPM.
   2. Proportion hot water basins in tower for even distribution.
   3. If flow measuring stations are installed, the measuring station shall take precedence over the pressure drops for flow determination.
   4. Reset pump head and GPM if necessary, and record final results including GPM, suction/discharge pump pressures, motor amps, motor nameplate and heater sizes.
   5. Record pressure drop and temperatures through condenser; calculate and record GPM.

B. Controls:
   1. Hot water boiler control:
      a. Verify operation of boiler control valves for calibration and outdoor air temperature reset schedule. Record final entering and leaving water temperatures.
   2. Thermostats and Controllers:
      a. Check for proper control of valves, air terminal units, supply fans, exhaust fans, ventilation fans, unit heaters, radiant heaters, and air curtains.
      b. Determine calibration setpoint of all thermostats.
      c. Set at design setpoint, unless noted or directed otherwise.

C. Capacity and Performance Test
   1. Cooling Towers: (Test performed simultaneously with chiller test):
      a. Record full load entering and leaving condenser water temperature with glass stem, mercury thermometers accurate to 1/4 degree F.
      b. Record condensing temperature of refrigerant at time of test.
      c. Record GPM at time of test.
      d. Record a minimum of four tower inlet wet bulb readings.
      e. Record a minimum of four tower leaving wet bulb readings.
      f. Perform log-test for a minimum of one hour taking readings at least every ten minutes.
      g. Average all readings and compute actual BTU/HR and tons rejected.

h. Convert actual approach at entering wet bulb conditions back to design temperatures to insure design capacity. (Those tests during winter months may not be possible due to extreme reduction in ambient wet bulb conditions and building load.)

2. Thermostat Calibration:
   a. Measure and record dry and wet bulb temperatures at each thermostat.
   b. Note any thermostat which is not controlling with +/- 1-1/2 degree F.
3. Control Temperature Readouts:
   a. Test actual temperature next to sensing bulb (if possible) and compare to read-out gauge. BAS readout.
   b. Report any gauge out of calibration.

D. Domestic Water Booster Pumps:
   1. Measure and record incoming water pressures, outlet water pressures.
   2. Measure pump and record GPM and compare to required secheduled conditions
   3. Measure pump controls and operation to meet required conditions.
   4. Measure pump and record RPM, BHP and amperage draw during use.
   5. Measure and record operation and setpoints of any pressure reducing valve in the system.

3.10 MINIMUM DATA TO BE REPORTED

A. Electric Motors (record along with information listed under associated equipment, as applicable):
   1. Manufacturer
   2. Model/Frame
   3. HP/BHP
   4. Phase, voltage, amperage; nameplate & operating
   5. RPM
   6. Service factor
   7. Starter size, rating, heater elements
   8. Sheave Make/Size/Bore

B. Pumps:
   1. Identification/number
   2. Manufacturer
   3. Size/model
   4. Impeller
   5. Service
   6. Design flow rate, pressure drop
   7. Actual flow rate, pressure drop
   8. Discharge pressure
   9. Suction pressure
   10. Total operating head pressure
   11. Shut off, discharge and suction pressures
   12. Shut off, total head pressure

C. Combustion Equipment:
   1. Boiler manufacturer
   2. Model number
   3. Serial number
   4. Firing rate
   5. Overfire draft
   6. Gas pressure at meter outlet

7. Gas flow rate
8. Heat input
9. Burner manifold gas pressure
10. Percent carbon monoxide (CO)
11. Percent carbon dioxide (CO2)
12. Percent oxygen (O2)
13. Percent excess air
14. Flue gas temperature at outlet
15. Ambient temperature
16. Net stack temperature
17. Percent stack loss
18. Percent combustion efficiency
19. Heat output

D. Cooling Tower:
1. Tower identification/number
2. Manufacturer
3. Model number
4. Serial number
5. Rated capacity
6. Entering air WB temperature, specified and actual
7. Leaving air WB temperature, specified and actual
8. Ambient air DB temperature
9. Condenser water entering temperature
10. Condenser water leaving temperature
11. Condenser water flow rate
12. Fan RPM

E. Heat Exchangers:
1. Identification/number
2. Location
3. Service
4. Manufacturer
5. Model number
6. Serial number
7. Steam pressure, design and actual
8. Primary water entering temperature, design and actual
9. Primary water leaving temperature, design and actual
10. Primary water flow, design and actual
11. Primary water pressure drop, design and actual
12. Secondary water leaving temperature, design and actual
13. Secondary water leaving temperature, design and actual
14. Secondary water flow, design and actual
15. Secondary water pressure drop, design and actual

F. Exhaust Fans:
1. Location
2. Manufacturer
3. Model number
4. Serial number
5. Air flow, specified and actual

6. Total static pressure (total external), specified and actual
7. Inlet pressure
8. Discharge pressure

G. Room Pressure Monitors
1. Identification/location
2. Manufacturer
3. Model Number
4. Design differential pressure/setpoint
5. Actual differential pressure
6. Supply air CFM
7. Return/exhaust air CFM

END OF SECTION

SECTION 23 07 00 - HVAC INSULATION

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Pipe insulation

B. HVAC equipment insulation

1.2 RELATED REQUIREMENTS

A. Section 23 05 53 - Identification for HVAC Piping and Equipment

B. Section 23 21 13 - Hydronic Piping

C. Section 23 21 14 - Hydronic Specialties

D. Section 23 23 00 - Refrigerant Piping

E. Section 23 31 13 - Sheetmetal Ductwork

1.3 DEFINITIONS

A. Exposed - Equipment, ducts and piping in areas which will be visible without removing ceilings or opening access panels.

B. Concealed - Installed above ceiling, in walls or chases.

C. Outdoors - Exposed to the weather or ambient conditions.

D. Underground - Buried.

1.4 REFERENCE STANDARDS

A. ASTM C553 - Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications; 2013.

B. ASTM C612 - Standard Specification for Mineral Fiber Block and Board Thermal Insulation; 2014.

C. ASTM C1071 - Standard Specification for Fibrous Glass Duct Lining Insulation (Thermal and Sound Absorbing Material); 2012.

D. ASTM C1290 - Standard Specification for Flexible Fibrous Glass Blanket Insulation Used to Externally Insulate HVAC Ducts; 2011.

E. ASTM C533 - Standard Specification for Calcium Silicate Block and Pipe Thermal Insulation; 2013.

F. ASTM C534/C534M - Standard Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form; 2013.

G. ASTM C547 - Standard Specification for Mineral Fiber Pipe Insulation; 2012.

H. ASTM C552 - Standard Specification for Cellular Glass Thermal Insulation; 2013.

I. ASTM C578 - Standard Specification for Rigid, Cellular Polystyrene Thermal Insulation; 2013.

J. SMACNA (DCS) - HVAC Duct Construction Standards; Sheet Metal and Air Conditioning Contractors' National Association; 2005.

1.5 SUBMITTALS

A. Submit manufacturer's product data and installation procedures for review. Product data shall identify specific thermal characteristics, list of materials and thickness for each service.

1.6 QUALITY ASSURANCE

A. Manufacturer Qualifications: ISO 9001-2000 certified.

B. Fire-Test Response Characteristics: Testing in accordance with ASTM E84. Insulation and related materials, adhesives, coatings, sealers, jackets and tapes, shall have a fire-test response characteristic of: Flame spread rating of 25 or less; Smoke development of 50 or less.

C. Materials shall meet the requirements of NFPA 90A.

PART 2 - PRODUCTS

2.1 PIPE AND EQUIPMENT INSULATION

A. Materials for Pipe and Equipment: Provide factory premolded insulation for pipe, pipe fittings, and valves.

B. Fitting insulation: Same thickness and material as adjoining pipe insulation.

C. Cellular Glass (Foamglass):
   1. Acceptable manufacturers: Pittsburgh Corning "Foamglas"; with a "K" value of 0.29 BTU-in/hr-ft2-degree F at 75 degrees F.
   2. Mastic: Water based, Foster 30-80 or equal
      a. Outside Applications: Foster Vapor Safe 30-80, Childers Chil Low CP-38 or Vimasco 749 Vapor-Blok. Coatings must meet MIL 19565C and be QPD listed. Water vapor permeance shall be in accordance with ASTM C755, section 7.2.2 and Table 2 for insulation type and service conditions when tested in accordance with ASTM E96.
      b. Inside applications: Foster Vapor Safe 30-80, Childers Chil Low CP-38 or Vimasco 749 Vapor-Blok. Water vapor permeance shall be in accordance with ASTM C755, section 7.2.2 and Table 2 for insulation type and service conditions when tested in accordance with ASTM E96.
   3. Use on the following services:
      a. Condenser water pipe above grade at cooling tower to 18" below grade, 1-1/2" thick.
      b. Chilled water piping located in central plants and outdoors , 2" and less pipe, 1-1/2" thick; 2-1/2" and greater, 2" thick.
      c. At hanger and support points as specified herein.

D. Flexible Tubular Elastomeric:
   1. Provide fire-retardant closed-cell slip-on flexible type; with a "K" value of 0.245 BTU-in/hr-ft2-degree F at 75 degrees F.
   2. Acceptable manufacturers: Aeroflex "Aerocel", Armacell "AP/Armaflex", or K-Flex "Insul-Tube".
   3. Use on the following services:
      a. Moisture condensate drains: 1/2" thick.
      b. Refrigerant lines for kitchen freezer and cooler suction: 1-1/2" thick (2 layers of 3/4" thick).
      c. Ice rink refrigerant suction piping, valves, and fittings: 1-1/2" thick.

E. Flexible Sheet Elastomeric:
   1. Provide closed-cell flexible sheet type; minimum "R" value of 4.20 per inch of thickness.
   2. Acceptable manufacturers: Aeroflex, Armacell "AP/Armaflex", or Rubatex.
   3. Use on the following services:
      a. Refrigeration machine cooler, suction piping, and pipe connections: 1-1/2" thick (2 layers of 3/4").
      b. Chilled water pump casings and flanges: 1" thick (2 layers of 1/2").
      c. Plate and Frame Heat Exchanger: 1" thick (2 layers of 1/2").

F. Fiberglass Pipe Insulation:
   1. Acceptable manufacturers: Johns-Manville "Micro-Lok 850, CertainTeed, Knauf, or Owens Corning.
   2. Jacket: ASJ fiberglass reinforced kraft paper with aluminum foil; minimum R value of 3.6.
   3. Use on the following services:
      a. Chilled water piping: 1-1/2" thick.
      b. Heating water piping:
         1) Pipe sizes 1 1/2" and less: 1-1/2" thick.
         2) Pipe sizes 2" and greater: 2" thick.
         3) Insulate all run outs to coil connections including valves, control valves, fittings and connections regardless of the piping size or length of the run out.
      c. Air separators: 1-1/2" thick
      d. Steam condensate piping:
         1) Pipe sizes 1-1/4" and less: 1-1/2" thick.
         2) Pipe sizes 1-1/2" and greater: 2" thick.
      e. Steam piping to 15 psi:
         1) Pipe sizes 3" and less: 2.5" thick.
         2) Pipe sizes 4" and greater: 3.0" thick.
      f. Steam piping 121 to 425 psi:
         1) Pipe sizes 3/4" and less: 4.5 thick.
         2) Pipe sizes 1" to 4": 5.0 thick
         3) Pipe sizes over 4 to 8": 5.0 thick.
      g. Steam converter: 3.0" thick.
      h. Kitchen dishwasher final rinse booster heater: 2" thick.
      i. Boiler trim including boiler feed water lines and blow down piping: 1-1/2" thick.
      j. Vent piping from relief valves: 1-1/2" thick.
      k. Condensate receiver tanks and vent piping: 1-1/2" thick.
      l. Steam absorption chiller generator and piping: 1-1/2" thick.
      m. Drain bodies, traps and horizontal drain lines receiving cold condensate: 1/2" thick.
      n. Run around coil piping: 1" thick.

o. Ice rink sub-floor heating piping: 1-1/2" thick.

G. Polyurethane pipe insulation:
1. Acceptable Manufacturers: Dow, Johns-Manville, or Owens Corning.
2. Use on the following services:
a. Ice rink brine piping: 2" thick.
b. Ice rink brine pumps: 2" thick.
c. Ice rink heat exchanger: 2" thick.
d. Ice rink chiller: 3" thick. Provide removable insulation caps to facilitate maintenance of chiller heads
e. Covering: 0.016" thick aluminum jacket equivalent to Childers and cover fittings with factory formed covers equivalent to Ell jacs or white PVC jacketing.

H. Calcium Silicate:
1. Noncombustible hydrous calcium silicate, 15 PCF density, minimum thermal conductivity of 0.55 at 800 degrees F
2. Acceptable manufacturers: Johns-Manville "Thermo-12 Gold".
3. Covering: ASJ fiberglass reinforced kraft paper with aluminum foil
4. Use on the following services:
a. Boiler breeching, boiler stacks within boiler room, steam supply headers at boilers and incinerator breaching: 2-1/2" thick.
b. Deaerator tank, unless factory preinsulated: 1-1/2" thick.
c. Blowdown separator, including vent and drain connections and piping (except piping in trench): 1-1/2" thick.

I. Semi-Rigid, High Temperature, Fiberglass Board Insulation:
1. Noncombustible semi-rigid, high temperature, fiberglass board insulation, 500 degrees F. or greater, snap on jacket, 3 pounds per cubic foot density; minimum "R" of 2.63.
2. Jacket: Aluminum or ASJ as described below.
3. Acceptable manufacturers: CertainTeed, Johns-Manville, Owens Corning, or Pittsburgh Corning.
4. Use for the following services:
a. Boiler breeching with boiler room: 2-1/2" thick with ASJ jacket.
b. Boiler stacks within boiler room: 2-1/2" thick with ASJ jacket.
c. Gas fired absorption generator stack: 2-1/2" thick with ASJ jacket.
d. Steam supply piping from boiler outlet to main steam header and main steam header at boiler: 4.5" thick with ASJ jacket.
e. Deaerator tank, if not factory insulated: 2" thick and covered with aluminum jacket.
f. Absorption chiller - generator and absorber sections: 2" thick with ASJ jacket.
g. Domestic hot water tanks, if not factory insulated: 2" thick covered with ASJ jacket.
h. Blowdown separator including vents and drain connections: 2" thick covered with ASJ jacket.

J. Flexible High Temperature Blanket:
1. Noncombustible highly vibration-resistant glass fiber mat type, 11 pounds per cubic foot density, 1200 degrees F, minimum "R" of 2.78 at 400 degrees F. mean temperature completely enclosed in
2. Acceptable manufacturers: CertainTeed, Johns-Manville "Glass-Mat 1200", Owens Corning, or Pittsburgh Corning.
3. Use on the following services:
a. Engine and generator engine exhaust piping

2.2 MATERIALS FOR FITTINGS, VALVES, AND SPECIAL COVERINGS

A. For all services, use full thickness premolded insulation for pipe fittings, elbows, tees, valves, and couplings 2-1/2 and larger. Finish shall be as specified under Products above or as specified below. PVC fitting covers may be used over the premolded insulation for chilled water and heating water systems.

B. PVC fitting covers with full thickness fiberglass inserts may be used on piping fittings elbows and valves 2" and less for chilled water and heating water systems.

C. For tanks, heat exchangers and large pipes in systems operating over 60 degrees F. When exposed-to-view inside building or in equipment rooms, cover insulation with a smoothing coat of Keane Powerhouse cement, one layer of white colored woven glass fabric embedded and finished with Foster GPM mastic.

D. For pipe fittings, valves, strainers, and other irregular surfaces, in chilled water or refrigerant systems operating below 60 degrees F, when inside building or in equipment rooms, cover insulation with white colored woven glass fabric embedded in white vapor barrier coating, Foster 30-35 or equal.

E. For any service when above grade exposed-to-the-weather outside building or in tunnels or manholes, cover straight pipe insulation with 0.016" thick smooth, aluminum jacket equivalent to Childers and cover fittings with factory formed covers equivalent to Ell jacs. Install jacket seams on bottom of pipe.

F. For any service, except for steam and steam condensate, when below grade direct buried, cover straight pipe and fitting insulation with equivalent of Pittsburgh Corning "Pittwrap" or "Pitticoat No. 300 with PC Fabric 79". Valves in systems operating above 60 degrees F and installed in valve boxes shall not be insulated, however the valves shall be painted with rust-resistant product equivalent to Rustoleum.

G. Elastomeric adhesives and finishing:
   1. Adhesive shall be the insulation manufacturer's reccommended contact adhesive, Armaflex 520, Armaflex 520BLV or equivalent.
   2. Insulation finish shall be the insulation manufacturer's recommended finish--WB Armaflex finish and shall be paintable.
   3. Accessories such as adhesives, mastics and cements shall have the same properties as listed above and not detract from any of the system reatings as specified.
   4. Where exposed to view inside buildings, the painted finish color shall be as selected by the Architect.

H. For externally insulated sheet metal ducts when above grade exposed-to-the-weather outside building, slope ductwork and insulation to allow drainage and prevent ponding of water on top of ductwork. Cover duct insulation with glass mesh embedded and adhered to insulation using air drying weatherproof plastic fabricated cutback asphalt adhesive and finish with two coats of gray color flexible fire retardant protective coating having proven ability to withstand a wide range of temperatures without cracking or crazing and be highly resistant to damage by bumping and abrasion. Product shall be Johns-Mansville, Insulkote, or equivalent.

I. Use prefabricated removable insulated, valve jackets on all valves in steam and steam condensate piping. Insulated jackets shall cover the entire valve including flanges and bonnet.
   1. Acceptable manufacturers: Auburn Manufacturing, Inc. (AMI) or ThermaXX.

2. Inner lining: AMI GL2025-XX-9383 heat treated fiberglass cloth (<450F).
3. Insulating material: AMI AM1000 needled fiberglass mat (<1000F).
4. Outer cover: AMI AGL2025 aluminum foil laminated fiberglass cloth.
5. Fastener: AMI GLR fiberglass draw string.

J. Provide steel insulation shields on steam piping as specified in Section 23 05 29 when roller hangers are utilized.

2.3 JACKETS

A. Canvas Jacket: UL listed 6oz/sq. yd. plain weave cotton fabric treated with dilute fire retardant lagging adhesive compatible with insulation.

B. Aluminum Jacket: ASTM B209 formed aluminum sheet of 0.016 inch, smooth finish with longitudinal slip joints and 2" laps, 0.016" thick die shaped fittings with factory attached protective liner. Adhere with 3/8" wide aluminum bands.

C. PVC Jacket: One piece molded type fitting covers and sheet material, off-white in color, 15 mil thickness, 0.002 perm inch maximum in accordance with ASTM E96. Adhere with pressure sensitive color matching vinyl tape.

PART 3 - EXECUTION

3.1 INSTALLATION - GENERAL

A. Deliver and store insulation materials in manufacturers containers and keep free from dirt, water, chemical and mechanical damage.

B. Complete piping and ductwork pressure testing prior to applying insulation.

C. Apply insulation in workmanlike manner by experienced, qualified, workmen.

D. Surfaces shall be clean and dry when covering is applied. Covering to be dry when installed and before and during application of any finish, unless such finish specifically requires a wetted surface for application.

E. Adhesives, cements and mastics shall be compatible with materials applied and shall not attack materials in either wet or dry state and not diminish or void the specified flame spread and smoke developed ratings.

F. Stop duct coverings, including jacket and insulation, at fire penetrations of fire or smoke rated partitions, floors above grade and roofs. "Fan-out" or extend jacketed insulation at least 2" beyond angle frames of fire dampers and secure to wall. Maintain vapor barrier.

3.2 INSTALLATION OF PIPE AND EQUIPMENT COVERING

A. Where glass fiber or flexible tubular elastomeric insulation is used on piping sized 2" and larger, insert a section of foamglass or calcium silicate insulation, at hanger or support points, between pipe and metal shield for full length of shield, to prevent crushing of insulation. Where insulation passes through pipe hangers and across trapeze supports, 12" long metal saddles shall be used. Insulation thickness to be same as adjoining glass fiber insulation. On cold pipe, vapor barrier should be carried through the hanger and sealed. Saddles shall be used where rigid foamglass inserts are not acceptable. Pipe saddles shall cover 180 degrees of the pipe.

B. Foamglass insulation shall be strictly applied as follows:
   1. Both the circumferential and longitudinal joints shall be buttered with fire-resistive pliable sealer. Voids and cracks shall be filled with sealer. Mastic shall be Foster 30-80 or equal. Secure insulation with 3/4" wide x 0.010" thick aluminum bands on 8" centers.
   2. The circumferential joints shall be staggered.
   3. Fittings, valves, flanges, traps, and air vents shall be insulated with the same thickness of insulation using factory fabricated fitting sections or pre-molded insulated fittings.
   4. Block type insulation shall be adhered by stick-clips or bands, in addition to the sealer, as required to provide support for the insulation.
   5. Finish above furred ceilings and in chases shall be the bare insulation.
   6. Finish in equipment rooms and elsewhere where exposed-to-view shall be white ASJ.
   7. Finish on underground insulation shall be Pittsburgh Corning Pittwrap as recommended by manufacturer.

C. Finish for all piping exposed-to-the-weather shall be Childers, or equal, .016 inch thick aluminum jacket on piping and Ell jacs, or equal, pre-formed aluminum covering on fittings.

D. Apply flexible tubular elastomeric insulation to pipe and fittings with all joints tightly fitted and sealed with adhesive.

E. Apply semi-rigid high temperature, fiberglass board insulation as recommended by the manufacturer.

F. Apply flexible high temperature blanket type in two steps. First, cover fitting with 1/2" thick matt only; then apply finished envelope containing 2" thick matt material. Secure envelope using stainless steel or monel bands, hooks washers, and lacing.

G. Heat Traced Piping: Insulate fittings, joints, and valves with insulation of like material, thickness, and finish as adjoining pipe. Size large enough to enclose pipe and heat tracer. Cover with aluminum jacket with seams located on bottom side of horizontal piping.

END OF SECTION

SECTION 23 09 13 - INSTRUMENTATION AND CONTROL DEVICES

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Provide input and output control devices to integrate with direct digital control and building automation system.

B. Furnish instrumentation control devices as an integral part of the Building Automation Section specified in Section 23 09 23.

1.2 RELATED REQUIREMENTS

A. Section 23 05 00 - Common Work Results for HVAC

B. Section 23 20 00 - HVAC Piping

C. Division 26: Electrical

1.3 SUBMITTALS

A. Submit product data and schedules for all input/output devices.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Provide products and components by manufacturers listed. Where manufacturers are not listed, provide component that complies with specifications.

B. Manufacturers listed must meet performance and material specifications of product or component. Listing of a manufacturer as an acceptable manufacturer does not grant permission to deviate from the specification requirements.

2.2 INPUT DEVICES

A. General Requirements
   1. Installation, testing, and calibration of all sensors, transmitters, and other input devices shall be provided to meet the system requirements.

B. Temperature Sensors
   1. Acceptable Manufacturers: Automated Logic, Johnson Controls, Setra, or Siemens.
      a. Substitutions: Not permitted.
   2. General Requirements:
      a. Sensors and transmitters shall be provided, as outlined in the input/output summary and sequence of operations.
      b. The temperature sensor shall be of the resistance type, and shall be either two-wire 1000 ohm nickel RTD, or two-wire 1000 ohm platinum RTD.
      c. Accuracy values indicated include errors associated with the sensor, lead wire, and analog to digital conversion.
   3. Room Temperature Sensors

a. Refer to temperature sensor legend, schedules, floor plans, and control sequences for specific room temperature sensor requirements in each zone.
b. Room sensors shall be constructed for either surface or wall box mounting.
c. Room sensors shall have the following options when specified:
    1) Local setpoint adjustment providing a +/- 3 degree (adjustable) range.
    2) Timed override request push button with LED status for activation of after-hours operation.
    3) Flush mounting (sensor only, no local adjustment)
    4) Integral LCD display and keypad with the following capabilities:
        (a) Display room and outside air temperatures.
        (b) Display room setpoint.
        (c) Password selectable adjustment of setpoint and override modes.

4. Stand Alone Thermostats
    a. Stand alone, heavy-duty electric thermostats shall be provided for unit heaters, cabinet unit heaters, and ventilation fans, when equipment is not indicated to be connected to the BAS. Thermostats shall be provided with concealed adjustment and function to cycle the equipment fan, electric coil, and/or control valves as applicable to maintain the space temperature setpoint. Finish of covers for all room-type instruments shall match and, unless otherwise indicated or specified, covers shall be manufacturer's standard finish.
5. Thermo Wells
    a. When thermo wells are required, the sensor and well shall be supplied as a complete assembly, including wellhead and Greenfield fitting.
    b. Thermo wells shall be pressure rated and constructed in accordance with the system working pressure.
    c. Thermo wells and sensors shall be mounted in a threadolet or 1/2" NFT saddle and allow easy access to the sensor for repair or replacement.
    d. Thermo wells shall be constructed of 316 stainless steel.
6. Outside Air Sensors
    a. Outside air sensors shall be designed to withstand the environmental conditions to which they will be exposed. They shall also be provided with a solar shield.
    b. Sensors exposed to wind velocity pressures shall be shielded by a perforated plate that surrounds the sensor element.
    c. Temperature transmitters shall be of NEMA 3R construction and rated for ambient temperatures.
7. Duct Mount Sensors
    a. Duct mount sensors shall mount in an electrical box through a hole in the duct, and be positioned so as to be easily accessible for repair or replacement.
    b. Duct sensors shall be insertion type and constructed as a complete assembly, including lock nut and mounting plate.
    c. For outdoor air duct applications, a weatherproof mounting box with weatherproof cover and gasket shall be used.
8. Averaging Sensors
    a. Provide at the following locations:
        1) Heating coils and cooling coils at air handling units and fan coil units.
        2) Ductwork greater in any dimension that 48 inches and/or where air temperature stratification exists.
    b. For plenum applications, such as mixed air temperature measurements, a string of sensors mounted across the plenum shall be used to account for stratification and/or air turbulence. The averaging string shall have a minimum of 4 sensing points per 12-foot long segment.

c. Capillary supports at the sides of the duct shall be provided to support the sensing string.

9. Low Limit Temperature Sensors
   a. Provide vapor charged sensing element that reacts to coldest 14" of sensor length.
   b. Sensor shall have field adjustable setpoint.

C. Humidity Sensors
1. Acceptable Manufacturers: Johnson Controls, Mamac, or Veris Industries.
   a. Substitutions: Not permitted.
2. The sensor shall be a solid-state type, relative humidity sensor of the Bulk Polymer Design. The sensor element shall resist service contamination.
3. The humidity transmitter shall be equipped with non-interactive span and zero adjustments, a 2-wire isolated loop powered, 4-20 mA, 0-100% linear proportional output.
4. The humidity transmitter shall meet the following overall accuracy, including lead loss and Analog to Digital conversion. 3% between 20% and 80% RH @ 77 Deg F unless specified elsewhere.
5. Outside air relative humidity sensors shall be installed with a rain proof, perforated cover. The transmitter shall be installed in a NEMA 3R enclosure with sealtite fittings and stainless steel bushings.
6. A single point humidity calibrator shall be provided, if required, for field calibration. Transmitters shall be shipped factory pre-calibrated.
7. Duct type sensing probes shall be constructed of 304 stainless steel, and shall be equipped with a neoprene grommet, bushings, and a mounting bracket.

D. Differential Pressure Transmitters
1. Acceptable Manufacturers: Automated Logic, Johnson Controls, Mamac, Setra, or Siemens.
   a. Substitutions: Not permitted.
2. General Air and Water Pressure Transmitter Requirements:
   a. Pressure transmitters shall be constructed to withstand 100% pressure over-range without damage, and to hold calibrated accuracy when subject to a momentary 40% over-range input.
   b. Pressure transmitters shall transmit a 0 to 5 VDC, 0 to 10 VDC, or 4 to 20 mA output signal.
   c. Differential pressure transmitters used for flow measurement shall be sized to the flow sensing device, and shall be supplied with tee fittings and shut-off valves in the high and low sensing pick-up lines to allow the balancing Contractor and Owner permanent, easy-to-use connection.
   d. A minimum of a NEMA 1 housing shall be provided for the transmitter. Transmitters shall be located in accessible local control panels wherever possible.
3. Differential Pressure Transmitters: (chilled water and hot water systems)
   a. Provide self-contained, variable capacitance type differential pressure transmitters at chillers, boilers and air handling units to measure system and equipment differential pressures.
   b. Installed by the contractor where indicated on the drawings including system DPs at AHU coils and across chillers. Wiring terminals and electronics shall be in separate compartments, so the electronics remain sealed during installation. Reverse polarity protection shall be included to keep wiring mishaps from damaging the transmitter. Wiring installed by the contractor between the control system and the transmitter(s) shall be Belden 9320, two wire, shielded twisted cable, and shall not be included in conduit containing AC circuit wiring.

c. Design range shall be as required by system. External zero and span adjustments, over-pressure to 2,000 PSI, and no humidity effects.
d. Minimum accuracy shall be 0.25% of calibrated span. Includes combined effects of linearity, hysteresis and repeatability. Stability shall be 0.25% of upper range limit for six months. No internal mechanical linkages shall be used in the transmitter(s).
e. Low Differential Water Pressure Applications (0" - 20" w.c.)
    1) The differential pressure transmitter shall be of industrial quality and transmit a linear, 4 to 20 mA output in response to variation of flow meter differential pressure or water pressure sensing points.
    2) The differential pressure transmitter shall have non-interactive zero and span adjustments that are adjustable from the outside cover and meet the following performance specifications:
        (a) .01-20" w.c. input differential pressure range.
        (b) 4-20 mA output.
        (c) Maintain accuracy up to 20 to 1 ratio turndown.
        (d) Reference Accuracy: +0.2% of full span.
f. Medium to High Differential Water Pressure Applications (Over 21" w.c.)
    1) The differential pressure transmitter shall meet the low pressure transmitter specifications with the following exceptions:
        (a) Differential pressure range 10" w.c. to 300 PSI.
        (b) Reference Accuracy: +1% of full span (includes non-linearity, hysteresis, and repeatability).
    2) Standalone pressure transmitters shall be mounted in a bypass valve assembly panel. The panel shall be constructed to NEMA 1 standards. The transmitter shall be installed in the panel with high and low connections piped and valved. Air bleed units, bypass valves, and compression fittings shall be provided.

4. Building Differential Air Pressure Applications (-1" to +1" w.c.)
    a. The differential pressure transmitter shall be of industrial quality and transmit a linear, 4 to 20 mA output in response to variation of differential pressure or air pressure sensing points.
    b. The differential pressure transmitter shall have non-interactive zero and span adjustments that are adjustable from the outside cover and meet the following performance specifications:
        1) -1.00 to +1.00 w.c. input differential pressure ranges. (Select range appropriate for system application)
        2) 4-20 mA output.
        3) Maintain accuracy up to 20 to 1 ratio turndown.
        4) Reference Accuracy: +0.2% of full span.
5. Building Low Range Differential Air Pressure Applications (0" to 5" w.c.)
    a. The differential pressure transmitter shall be of industrial quality and transmit a linear, 4 to 20 mA output in response to variation of differential pressure or air pressure sensing points.
    b. The differential pressure transmitter shall have non-interactive zero and span adjustments that are adjustable from the outside cover and meet the following performance specifications:
        1) (0.00 - 1.00" to 5.00") w.c. input differential pressure ranges. (Select range appropriate for system application.)
        2) 4-20 mA output.
        3) Maintain accuracy up to 20 to 1 ratio turndown.
        4) Reference Accuracy: +0.2% of full span.
6. Building Medium Range Differential Air Pressure Applications (5" to 21" w.c.)

a. The pressure transmitter shall be similar to the Low Air Pressure Transmitter, except that the performance specifications are not as severe. Differential pressure transmitters shall be provided that meet the following performance requirements:
   1) Zero & span: (c/o F.S./Deg. F): .04% including linearity, hysteresis and repeatability.
   2) Accuracy: 1% F.S. (best straight line) Static Pressure Effect: 0.5% F.S. (to 100 PSIG.
   3) Thermal Effects: <+.033 F.S./Deg. F. over 40 Deg. F. to 100 Deg. F. (calibrated at 70 Deg. F.).
b. Standalone pressure transmitters shall be mounted in a bypass valve assembly panel. The panel shall be constructed to NEMA 1 standards. The transmitter shall be installed in the panel with high and low connections piped and valved. Air bleed units, bypass valves, and compression fittings shall be provided.

E. Carbon Monoxide Sensors
1. Acceptable manufacturers: Toxalert or Vulcain Model VA201M.
   a. Substitutions: Refer to Division 01.
2. Provide a step down power transformer rated at 110V to 17-27 Vac or 24-38 Vdc for each CO sensor.
3. CO sensors shall be capable of remote sensing at distances up to 100 feet.
4. Sensors shall be capable of activating garage ventilation fan upon detection of 25 ppm of carbon monoxide.
5. Sensors shall be capable of time delayed activation and deactivation excessive cycling of fan.
6. Sensors shall be capable of operating from 5-90% relative humidity and temperature ranges from -20 deg. F to 120 deg. F.
7. Unit shall be manufactured to UL 1244 label and CSA 22.2.
8. Monitor must be manufactured within an ISO 9002 production environment.

F. Status and Safety Switches
1. General Requirements
   a. Switches shall be provided to monitor equipment status, safety conditions, and generate alarms at the BAS when a failure or abnormal condition occurs. Safety switches shall be provided with two sets of contacts and shall be interlock wired to shut down respective equipment.
2. Current Sensing Switches
   a. Acceptable manufacturers: Veris Industries.
      1) Substitutions: Refer to Division 01.
   b. The current sensing switch shall be self-powered with solid-state circuitry and a dry contact output. It shall consist of a current transformer, a solid state current sensing circuit, adjustable trip point, solid state switch, SPDT relay, and an LED indicating the on or off status. A conductor of the load shall be passed through the window of the device. It shall accept over-current up to twice its trip point range.
   c. Current sensing switches shall be used for run status for fans, pumps, and other miscellaneous motor loads.
   d. Current sensing switches shall be calibrated to show a positive run status only when the motor is operating under load. A motor running with a broken belt or coupling shall indicate a negative run status.

2.3 OUTPUT DEVICES

A. Actuators

1. Acceptable manufacturers: Belimo, Johnson Controls or Mamac.
2. General Requirements
   a. Damper and valve actuators shall be electronic and/or pneumatic, as specified in the System Description section.
3. Electronic Damper Actuators
   a. Electronic damper actuators shall be direct shaft mount.
   b. Modulating and two-position actuators shall be provided as required by the sequence of operations. Damper sections shall be sized Based on actuator manufacturer's recommendations for face velocity, differential pressure and damper type. The actuator mounting arrangement and spring return feature shall permit normally open or normally closed positions of the dampers, as required. All actuators (except terminal units) shall be furnished with mechanical spring return unless otherwise specified in the sequences of operations. All actuators shall have external adjustable stops to limit the travel in either direction, and a gear release to allow manual positioning.
   c. Modulating actuators shall accept 24 VAC or VDC power supply, consume no more than 15 VA, and be UL listed. The control signal shall be 2-10 VDC or 4-20 mA, and the actuator shall provide a clamp position feedback signal of 2-10 VDC. The feedback signal shall be independent of the input signal and may be used to parallel other actuators and provide true position indication. The feedback signal of one damper actuator for each separately controlled damper shall be wired back to a terminal strip in the control panel for trouble-shooting purposes.
   d. Two-position or open/closed actuators shall accept 24 or 120 VAC power supply and be UL listed. Isolation, smoke, exhaust fan, and other dampers, as specified in the sequence of operations, shall be furnished with adjustable end switches to indicate open/closed position or be hard wired to start/stop associated fan. Two-position actuators, as specified in sequences of operations as "quick acting," shall move full stroke within 20 seconds. All smoke damper actuators shall be quick acting.
4. Electronic Valve Actuators
   a. Electronic valve actuators shall be manufactured by the valve manufacturer.
   b. Each actuator shall have current limiting circuitry incorporated in its design to prevent damage to the actuator.
   c. Modulating and two-position actuators shall be provided as required by the sequence of operations. Actuators shall provide the minimum torque required for proper valve close-off against the system pressure for the required application. The valve actuator shall be sized Based on valve manufacturer's recommendations for flow and pressure differential. All actuators shall fail in the last position unless specified with mechanical spring return in the sequence of operations. The spring return feature shall permit normally open or normally closed positions of the valves, as required. All direct shaft mount rotational actuators shall have external adjustable stops to limit the travel in either direction.
   d. Modulating Actuators shall accept 24 VAC or VDC and 120 VAC power supply and be UL listed. The control signal shall be 2-10 VDC or 4-20 mA and the actuator shall provide a clamp position feedback signal of 2-10 VDC. The feedback signal shall be independent of the input signal, and may be used to parallel other actuators and provide true position indication. The feedback signal of each valve actuator (except terminal valves) shall be wired back to a terminal strip in the control panel for trouble-shooting purposes.
   e. Two-position or open/closed actuators shall accept 24 or 120 VAC power supply and be UL listed. Butterfly isolation and other valves, as specified in the sequence of operations, shall be furnished with adjustable end switches to indicate open/closed position or be hard wired to start/stop the associated pump or chiller.

B. Control Dampers
   1. The BAS Contractor shall furnish all automatic dampers. All automatic dampers shall be sized for the application by the BAS Contractor or as specifically indicated on the Drawings.
   2. All dampers used for throttling air flow shall be of the opposed blade type arranged for normally open or normally closed operation, as required. The damper is to be sized so that, when wide open, the pressure drop is a sufficient amount of its close-off pressure drop to shift the characteristic curve to near linear.
   3. All dampers used for two-position, open/close control shall be parallel blade type arranged for normally open or closed operation, as required.
   4. Damper frames and blades shall be constructed of either galvanized steel or aluminum. Maximum blade length in any section shall be 60". Damper blades shall be 16-gauge minimum and shall not exceed eight (8) inches in width. Damper frames shall be 16-gauge minimum hat channel type with corner bracing. All damper bearings shall be made of reinforced nylon, stainless steel or oil-impregnated bronze. Dampers shall be tight closing, low leakage type, with synthetic elastomer seals on the blade edges and flexible stainless steel side seals. Dampers of 48"x48" size shall not leak in excess of 8.0 cfm per square foot when closed against 4" w.g. static pressure when tested in accordance with AMCA Std. 500.
   5. Airfoil blade dampers of double skin construction with linkage out of the air stream shall be used whenever the damper face velocity exceeds 1500 FPM or system pressure exceeds 2.5" w.g., but no more than 4000 FPM or 6" w.g. Acceptable manufacturers are Johnson Controls D-7250 D-1250 or D-1300, Ruskin CD50, and Vent Products 5650.
   6. One piece rolled blade dampers with exposed or concealed linkage may be used with face velocities of 1500 FPM or below. Acceptable manufacturers are: Johnson Controls D-1600, Ruskin CD36, and Vent Products 5800.
   7. Multiple section dampers may be jack-shafted to allow mounting of piston pneumatic actuators and direct connect electronic actuators. Each end of the jackshaft shall receive at least one actuator to reduce jackshaft twist.

C. Control Relays
   1. Control Pilot Relays
      a. Acceptable manufacturers: Johnson Controls or Lectro.
         1) Substitutions: Refer to Division 01.
      b. Control pilot relays shall be of a modular plug-in design with retaining springs or clips.
      c. Mounting Bases shall be snap-mount.
      d. DPDT, 3PDT, or 4PDT relays shall be provided, as appropriate for application.
      e. Contacts shall be rated for 10 amps at 120VAC.
      f. Relays shall have an integral indicator light and check button.

D. Control Valves
   1. Acceptable manufacturers: Belimo, Johnson Controls.
   2. All automatic control valves shall be fully proportioning and provide near linear heat transfer control. The valves shall be quiet in operation and fail-safe open, closed, or in their last position. All valves shall operate in sequence with another valve when required by the sequence of operations. All control valves shall be sized by the control manufacturer, and shall be guaranteed to meet the heating and cooling loads, as specified. All control valves shall be suitable for the system flow conditions and close against the differential pressures involved. Body pressure rating and connection type (sweat, screwed, or flanged) shall conform to the pipe schedule elsewhere in this Specification.

3. Heat Pump Loop control valves shall be modulating plug, ball, and/or butterfly, as required by the specific application. Modulating water valves shall be sized per manufacturer's recommendations for the given application. In general, valves (2 or 3-way) serving variable flow air handling unit coils shall be sized for a pressure drop equal to the actual coil pressure drop, but no less than 5 PSI. Valves (3-way) serving constant flow air handling unit coils with secondary circuit pumps shall be sized for a pressure drop equal to 25% the actual coil pressure drop, but no less than 2 PSI. Mixing valves (3-way) serving secondary water circuits shall be sized for a pressure drop of no less than 5 PSI. Valves for terminal reheat coils shall be sized for a 2 PSIG pressure drop, but no more than a 5 PSI drop.
4. Ball valves shall be used for hot and chilled water applications, water terminal reheat coils, radiant panels, unit heaters, package air conditioning units, and fan coil units except those described hereinafter.
5. Modulating plug water valves of the single-seat type with equal percentage flow characteristics shall be used for all special applications as indicated on the valve schedule. Valve discs shall be composition type. Valve stems shall be stainless steel.
6. Butterfly valves shall be acceptable for modulating large flow applications greater than modulating plug valves, and for all two-position, open/close applications. In-line and/or three-way butterfly valves shall be heavy-duty pattern with a body rating comparable to the pipe rating, replaceable lining suitable for temperature of system, and a stainless steel vane. Valves for modulating service shall be sized and travel limited to 50 degrees of full open. Valves for isolation service shall be the same as the pipe. Valves in the closed position shall be bubble-tight.

2.4 MISCELLANEOUS DEVICES

A. Local Control Panels
1. All control panels shall be factory constructed, incorporating the BAS manufacturer's standard designs and layouts. All control panels shall be UL inspected and listed as an assembly and carry a UL 508 label listing compliance. Control panels shall be fully enclosed, with perforated sub-panel, hinged door, and slotted flush latch. Provide common keying for all new panels and match keying when existing panels are present.
2. Control panels shall consist of the DDC controller(s), display module as specified and indicated on the plans, and I/O devices-such as relays, transducers, and so forth-that are not required to be located external to the control panel due to function. Where specified the display module shall be flush mounted in the panel face unless otherwise noted.
3. All I/O connections on the DDC controller shall be provide via removable or fixed screw terminals.
4. Low and line voltage wiring shall be segregated. All provided terminal strips and wiring shall be UL listed, 300-volt service and provide adequate clearance for field wiring.
5. All wiring shall be neatly installed in plastic trays or tie-wrapped.
6. A 120 VAC duplex convenience receptacle and required transformers shall be provided in each enclosure.

B. Power Supplies
1. DC power supplies shall be sized for the connected device load. Total rated load shall not exceed 75% of the rated capacity of the power supply.
2. Input: 120 VAC +10%, 60Hz.
3. Output: 24 VDC.
4. Line Regulation: +0.05% for 10% line change.
5. Load Regulation: +0.05% for 50% load change.
6. Ripple and Noise: 1 mV rms, 5 mV peak to peak.

7. An appropriately sized fuse and fuse block shall be provided and located next to the power supply.
8. A power disconnect switch shall be provided next to each power supply.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Actuation / Control Type
   1. Primary Equipment
      a. Controls shall be provided by equipment manufacturer as specified herein.
      b. All damper and valve actuation shall be electric.

B. HVAC Input Devices - General
   1. All Input devices shall be installed per the manufacturer recommendation.
   2. Locate components of the BAS in accessible local control panels wherever possible.
      a. The mechanical contractor shall install all in-line devices such as temperature wells, pressure taps, air flow stations, etc.
   3. Flow Measuring Devices shall be installed in strict compliance with ASHRAE and ASME guidelines affecting non-standard approach conditions.
   4. Outside Air Sensors
      a. Sensors shall be mounted on the North wall to minimize solar radiant heat impact or located in a continuous intake flow adequate to monitor outside air conditions accurately.
      b. Sensors shall be installed with a rain proof, perforated cover.
   5. Water Differential Pressure Sensors
      a. Differential pressure transmitters used for flow measurement shall be sized to the flow-sensing device.
         1) Differential pressure transmitters shall be supplied with tee fittings and shut-off valves in the high and low sensing pick-up lines.
      b. The transmitters shall be installed in an accessible location wherever possible.
   6. Medium to High Differential Water Pressure Applications (Over 21" w.c.)
      a. Air bleed units, bypass valves and compression fittings shall be provided.
   7. Building Differential Air Pressure Applications (-1" to +1" w.c.)
      a. Transmitters exterior sensing tip shall be installed with a shielded static air probe to reduce pressure fluctuations caused by wind.
      b. The interior tip shall be inconspicuous and located as shown on the drawings.
   8. Air Flow Measuring Stations
      a. Install air flow measuring stations in accordance with manufacturer's instructions at the locations indicated on the plans including clear distances to adjacent fittings, elbows, inlets, or other interference. A written report shall be submitted to the Engineer if any discrepancies exist or if installation cannot be completed per the manufacturer's recommendations.
      b. Station flanges shall be two inch to three inch to facilitate matching connecting ductwork.
   9. Duct Temperature Sensors
      a. Duct mount sensors shall mount in an electrical box through a hole in the duct and be positioned so as to be easily accessible for repair or replacement.
      b. The sensors shall be insertion type and constructed as a complete assembly including lock nut and mounting plate.

c. For ductwork greater in any dimension than 48 inches or where air temperature stratification exists such as a mixed air plenum, utilize an averaging sensor.
d. The sensor shall be mounted to suitable supports using factory approved element holders.

10. Space Sensors
    a. Mounted per ADA requirements.
11. Averaging and Low Temperature Limit Switches
    a. Install as indicated in the control diagram.
    b. Mount element horizontally across duct in a serpentine pattern insuring each square foot of coil is protected by at least 1 foot of sensor.
    c. For large duct areas where the sensing element does not provide full coverage of the air stream, provide additional switches as required to obtain full coverage.
12. Air Differential Pressure Status Switches
    a. Install with static pressure tips, tubing, fittings, and air filter.
13. Water Differential Pressure Status Switches
    a. Install with shut off valves for isolation.

C. HVAC Output Devices
1. All output devices shall be installed per the manufacturer's recommendation. The mechanical contractor shall install all in-line devices such as control valves, dampers, air flow stations, pressure wells, etc.
2. Actuators: All control actuators shall be sized capable of closing against the maximum system shut-off pressure. The actuator shall modulate in a smooth fashion through the entire stroke. When any pneumatic actuator is sequenced with another device, pilot positioners shall be installed to allow for proper sequencing.
3. Control Dampers: Shall be opposed blade for modulating control of air flow. Parallel blade dampers shall be installed for two position applications.
4. Control Valves: Shall be sized for proper flow control with equal percentage valve plugs. The maximum pressure drop for water applications shall be 5 PSI. The maximum pressure drop for steam applications shall be 7 PSI.

3.2 TRAINING

A. The BAS contractor shall provide the following training services:
1. One half day of on-site orientation by a system technician who is fully knowledgeable of the specific installation details of the project. This orientation shall, at a minimum, consist of a review of the project as-built drawings, the BAS software layout and naming conventions, and a walk through of the facility to identify panel and device locations.

3.3 COMMISSIONING

A. Fully commission all aspects of the Building Management System work.

B. Acceptance Check Sheet
1. Prepare a check sheet that includes all points for all functions of the BAS as indicated on the point list included in this specification.
2. Submit the check sheet to the Engineer for approval
3. The Engineer will use the check sheet as the basis for acceptance with the BAS Contractor.

C. Promptly rectify all listed deficiencies and submit to the Engineer that this has been done.

END OF SECTION

SECTION 23 21 13 - HVAC PIPING

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Piping and pipe fittings for:
   1. Condenser Water Piping
   2. Heating Water Piping
   3. Steam Piping
   4. Steam Condensate Piping

1.2 RELATED REQUIREMENTS

A. Section 23 05 00 - Common Work Results for HVAC

B. Section 23 21 16 - Hydronic Piping Specialties

C. Section 23 05 23 - General Duty Valves for HVAC

D. Section 23 07 00 - HVAC Insulation

1.3 REFERENCE STANDARDS

A. ASME B1.1 - Unified Inch Screw Threads; 2008.

B. ASME B16.3 - Malleable Iron Threaded Fittings: Classes 150 and 300; 2011.

C. ASME B16.5 - Pipe Flanges and Flanged Fittings NPS 1/2 Through NPS 24 Metric/Inch Standard; 2013.

D. ASME B16.9 - Factory Made Wrought Buttwelding Fittings; 2012.

E. ASME B16.18 - Cast Copper Alloy Solder Joint Pressure Fittings; 2012.

F. ASME B16.22 - Wrought Copper and Copper Alloy Solder Joint Pressure Fittings; 2013.

G. ASME B18.2 - Square, Hex, Heavy Hex, and Askew Head bolts and Hex, Heavy Hex, Hex Flange, Lobed Head, and Lag Screws; 2013.

H. ASME B31.1 - Power Piping; 2014.

I. ASME B31.3 - Process Piping; 2012.

J. ASME B31.9 - Building Services Piping; 2014 (ANSI/ASME B31.9).

K. ASTM A21.11 - Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings; 2010.

L. ASTM A21.51 - American National Standard for Ductile-Iron Pipe, Centrifugally Cast, for Water; 2002.

M. ASTM A53/A53M - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless; 2012.

N. ASTM A106/A106M - Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service; 2013.

O. ASTM A193 - Standard Specification for alloy Steel and Stainless Steel Bolting Materials for High Temperature Service; 2014.

P. ASTM A194 - Standard Specification for Carbon and Alloy Steel Nuts for bolts for High Pressure or High Temperature Service, or Both; 2014.

Q. ASTM A307 - Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod; 2014.

R. ASTM A563 - Standard Specification for Carbon and Alloy Steel Nuts; 2014.

S. ASTM A449 - Standard Specification for Quenched and Tempered Steel bolts and Studs; 2004.

T. ASTM B88 - Standard Specification for Seamless Copper Water Tube; 2009.

U. AWWA C110/A21.10 - American National Standard for Ductile-Iron and Gray-Iron Fittings, 3 In. Through 48 In. (75 mm Through 1200 mm), for Water and Other Liquids; American Water Works Association; 2012.

V. AWWA C151/A21.51 - Ductile-Iron Pipe, Centrifugally Cast, for Water; American Water Works Association; 2009 (ANSI/AWWA C151/A21.51).

W. MSS SP-25 - Standard Marking System for Valves, Fittings, Flanges, and Unions; 2013.

1.4 SUBMITTALS

A. Submittal data shall include but not be limited to:
   1. Manufacturer of pipe.
   2. Tests or listings by recognized testing laboratory that certifies material composition is in accordance with ANSI/ASTM requirements.
   3. Product data for pipe and fittings to be used on each piping system.
   4. Welding procedures for steel pipe.
   5. Solder and brazing product data and installation procedures for copper pipe.

1.5 QUALITY ASSURANCE

A. Provide all grooved joint couplings, fittings, specialties, and grooving tools from a single manufacturer.

B. Date stamp all castings used for coupling housings, fittings, etc. for quality assurance and traceability.

1.6 DELIVERY, STORAGE AND PROTECTION

A. Provide temporary end caps and closures on piping and fittings. Maintain in place until installation.

B. Protect piping systems from entry of foreign materials by temporary covers, completing sections of the work, and isolating parts of completed system.

PART 2 - PRODUCTS

2.1 STEEL PIPE

A. Black steel: Electric resistance welded or seamless, ASTM A53 or ASTM A106 Grade B. Mill wrap uninsulated underground steel pipe with Republic X-Tru-Coat or equal.
   1. Through 10" standard weight Schedule 40
   2. 12" pipe and larger: standard weight with 0.375" wall thickness

B. Provide for the following services:

C. Schedule 40, A53 or A106 galvanized pipe for:
   1. Cooling Coil condensate drain piping. (Contractor option: Copper; see "COPPER PIPE" below.)
   2. Drain piping from equipment 1-1/2" diameter and smaller.

2.2 STEEL PIPE FITTINGS

A. Flanges, Fittings, and Unions: Mark in accordance with MSS-SP-25.

B. Fittings:
   1. 2-1/2" and larger: Class 150, wrought steel, butt welded fittings, ASME B16.9
   2. 2" and Smaller
      a. Water Service: Class 150, malleable iron, screwed.
      b. Steam, 125 psi and less: Class 150, A53 malleable iron, screwed, ASME B16.3
      c. Steam, 126 psi to 250 psi: Class 300 malleable iron, screwed, ASME B16.3
      d. Condensate: Class 150 malleable iron, A53 screwed, ASME B16.3

C. Flanges, 2-1/2" and larger: Class 150, A53 wrought forged steel, slip-on or weld neck, ASME/ANSI B16.5. Flange faces shall match equipment or mating flanges (i.e. flat-faced flanges shall be used adjacent to equipment with integral flat-faced flanges, such as pumps, control valves, etc.)

D. Gaskets:
   1. Inorganic fibers, 1/16 or 1/8 inch thick, reinforced EPDM binder, 550 deg F (continuous) and 700 psig operation, Garlock 5507 or equal:
      a. Chilled water
      b. Heating water
   2. Spiral wound "chevron" metallic gaskets, flexible graphic filler, class 150 and 300 service, Flexitallic LS, CG or equal
      a. Steam

E. Unions, 2" and smaller: Material as specified under fittings, screwed with brass seat.

F. Branch connections from mains or headers, 2-1/2" and larger: Welded tees or welding outlets, Bonney Forge Weldolets or Threadolets. Use forged outlets only if branch line is at least one pipe size smaller than main or header.

G. Galvanized steel pipe fittings: Same as above, except galvanized coated.
   1. Provide drainage pattern type fittings for drain piping.

H. Bolting Materials: Torque all bolts to 50% of yield strength or per equipment manufacturer's recommendation, whichever is lower. Use anti-seize lubricant on all bolt threads. Same finished carbon steel bolts and hex nuts, ASTM A307. Threads and Dimensions: ASME/ANSI B1.1 and B18.2.
   1. Systems 210 degrees F and less: Use ASTM A449 studs or bolts and ASTM-A563 Grade B hex nuts
   2. Systems above 210 degrees F: Use ASTM-A193 Grade B7 studs or bolts and ASTM-A194 Grade 2 Heavy Hex Nuts
   3. Use galvanized bolts and nuts on piping outside the building, inside tunnels, and inside manholes.

I. Thread Lubricant: Similar to Crane "Formula 425".

2.3 COPPER PIPE

A. Conform to ASTM B-88 specification for wrought seamless copper.

B. Type L, hard for:

C. Type M, hard for:
   1. For non-pressurized drain piping.
   2. Fan coil unit condensate piping.
   3. Cooling coil condensate piping.

2.4 COPPER PIPE FITTINGS

A. Sweat type, wrought copper, ASTM B62, with dimensions conforming to ASTM/ANSI B16.22 and sweep patterns for copper tubing.

B. Dielectric Connections:
   1. Provide at junction of copper pipe and equipment with steel piping systems within the temperature limitations of the product.
   2. Dielectric insulating flanges, as manufactured by George Fischer Central Plastics or CTS Fabrication USA (1-1/2" thru 8"). Provide bolt insulating sleeves and washers as required.
      a. Flanges shall be drilled to ASME B16.5, 150 Standard, powder coated with an EPDM insulator adhered to the plate steel protruding inside to prevent contact with the coppper companion flange adapter. The copper component of the flange adapter shall be manufactured to ASME B16.22.
   3. Provide Watts LF3001A series Lead Free dielectric unions, 1/2" through 1-1/4" and shall consist of a union nut, two tailpiieces and an insulating gasket that separates the tailpieces to prevent an electric current from occurring between the dissimilar materials.
   4. Brass fittings and valves may not be used for dielectric union locations.

C. Unions: Brass ground joint, 250 lb. working pressure.

D. Nipples: Brass.

2.5 STAINLESS STEEL PIPE AND FITTINGS

A. Stainless Steel Pipe: ASTM A312, Type 304/204L, Schedule 10S may be used in lieu of copper piping.

B. Fittings: Precision, cold drawn, stainless steel, suitable for working pressure to 500 psig.

2.6 DUCTILE IRON WATER PIPE AND FITTINGS

A. Manufactured in accordance with latest revision of ANSI A21.51/AWWA C151.

B. Use Class 52 thickness or heavier for 12" diameter and less and Class 51 thickness or heavier for 14" diameter and larger.

C. Furnish pipe with standard thickness cement lining on inside with a bituminous seal coat and a bituminous coating on the outside.

D. Clearly mark pipe exterior to indicate the manufacturer, date of manufacture, pipe class and weight.

E. Provide for the following services:
1. Buried condenser water piping
2. Buried chilled water piping

F. Fittings:
1. Acceptable Manufacturers: Fastite by Acipco, Tyton by U.S. Pipe Co., or Bell-Tite by James B. Clow and Sons.
2. Ductile iron, cement lined, bituminous coated, manufactured in accordance with the latest revision of ANSI/AWWA C110.
3. Furnish with mechanical joints conforming to ANSI A21.11 with 250 psi pressure rating.

2.7 MISCELLANEOUS PIPE ACCESSORIES

A. Escutcheons: Chrome pipe escutcheons, slip-on or split type where pipe passing through finished walls or ceiling may be visible.

B. Exposed Metal Pipe and Trim: Chrome plated.

C. Control System Connectors: Crane No. 386, 1" steel half couplings, or 1" female pipe thread connectors.

D. Install 18 gauge sheetmetal or galvanized steel pipe saddles to protect insulation.

E. Exterior wall and floor penetrations: Install Link Seal Modular Seal by GPT or Flexicraft Industries. Seal shall be suitable for use in direct ground contact, water or atmospheric condiditons with EPDM seal element. Provide Nitrile rubber seal element where subject to oils and fuel. All bolts, nuts and fasteners shall be Steel with 2-part Dichromate corrosion inhibiting coating or Type 316 Stainless steel.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Clean inside of pipe before installation. Keep installed piping clean, and protect ends from foreign matter by capping or plugging them.

B. Install pipe so that it does not interfere with opening of doors or apparatus, access to equipment, or to electrical equipment.

C. Do not install pipes in such a way that they will apply torque to pumps. After pumps have been installed and pumps have been operated, recheck and realign pumps if necessary.

D. Run pipes in straight lines and square with building. Install risers plumb. Make offsets only where indicated and where necessary.

E. Install branch connections using separate tee or lateral fittings for each branch. Do not combine branches into "bullhead tee" arrangement.

F. Do not install water pipes in electric rooms, tele/data and IDF rooms, transformer rooms, audio/visual rooms or elevator equipment rooms. Fire protection piping runouts serving only these rooms shall be installed in these rooms.

G. Do not install piping above electrical equipment such as starters, variable frequency motor controllers, motor control centers, or disconnects. Maintain code required clearance above, below and to sides of electrical equipment.

H. Provide flanges or unions throughout the pipe systems at all equipment. Make provisions for servicing and removal of equipment without dismantling piping.

I. In so far as possible, drainage piping shall not be installed overhead, whether exposed or above ceiling, in operating rooms, delivery rooms, nurseries, food preparation or serving areas, or in rooms listed above. Where unavoidable, provide drain troughs or other means to carry away leakage.
   1. Grading Pipes for Drainage:
   2. Slope cooling coil condensate drains at 1/8" per foot.

J. Slope steam pipes and steam condensate drain pipes at 1/4" per 10 feet. Do not raise condensate pipe except at ends of main drips.

K. Piping Expansion:
   1. Install piping to allow thermal expansion and contraction without injury to piping, equipment or structure.
      a. Use loops or expansion joints where necessary and where detailed.
      b. Provide pipe guides.

L. Branch Lines:
   1. Where possible branch lines shall come off top of mains to prevent sediment, welding slag, or pipe burrs from entering the branch lines and causing valve leakage or failure.

3.2 PIPE JOINTING

A. Preparing Pipe Ends:
   1. Machine cut pipe ends square.
   2. Ream pipe ends, after cutting, to full diameter.
   3. Where pipe is to be threaded, secure pipe in pipe stand, die cut, full depth, right hand threads. Threads to be taper type.
   4. All threaded pipe joints to have suitable pipe sealant applied to threads prior to assembly of joint. Joints shall be leak proof.

5. Where pipe is to be welded, die-cut end of butt joints at 30 degree taper. Weld should have a full penetration with no bubbles or holes. Remove all slag.

B. Welded Steel Piping:
   1. Where welded piping is specified, make welds by oxy-acetylene process or electric process in accordance with ASME/ANSI B31.1.
      a. Welding Rods: Grade recommended for purpose by manufacturer's and identification.
   2. Line welds, single V-butt type:
      a. Mill or machine bevel pipe at 37 1/2 degrees to within 1/16" of inside wall, except that in field limited amount of pipe may be flame beveled.
      b. Pipe with a wall thickness of 3/16" or less need not be beveled but may be welded by melting down into building up over abutting ends.
      c. Separate abutting ends of joints before welding to permit complete fusion to bottom without overlapping.
      d. Tack in two or more points to maintain alignment, and fusion weld.
   3. Make all welds of sound weld metal, thoroughly fused into ends of pipe, and to bottom of vee.
      a. Build in excess of pipe wall to give reinforcement to one fourth pipe wall thickness.
      b. Weld metal shall present a gradual increase in thickness from surface of pipe to center of weld.
      c. Minimum weld width: Two and one half times thickness of pipe wall.
   4. Use welding ells at turns in welded lines
   5. Do not weld pipe couplings in place of welding fittings for any branch connections.
   6. Weld-o-lets and thread-o-lets:
      a. Scribe and cut openings in main pipes for welded branches accurately taking care to remove all of plugs and cuttings from main pipe.
      b. Full weld fillet welds for full depth of fillet, with additional beads to form well rounded connection as recommended by weld-o-let manufacturer.
   7. Cut openings into pipe for welded connections accurately to give matched intersections.
   8. Make welded fittings of same material with same pressure and temperature rating as pipe with which they are used.
   9. Make flanged connections to control valves, pump suction and specialties with ANSI standard welding neck flanges. All other flange connections may be made with slip-on flanges provided they are seal welded on inside.
   10. Fuse all fillet welds for flanges or fittings into pipe and plate for minimum distance of 1-1/2 times pipe wall thickness and depth weld on 1-1/4 times pipe wall thickness.

C. Soldered and Brazed Joints:
   1. Make Type L and M copper pipe joints with suitable flux and 95/5, lead free solder.

D. Bracing Joints:
   1. Provide braces and bridle rods as required to reinforce joints.
   2. If mechanical lock type couplings are used, then prepare pipe ends and make joints in accordance with pipe coupling manufacturer's printed instructions.
   3. Where large pipes underground are subject to shock because of sudden changes in liquid flow rate, provide concrete "kicker" blocks at joints, fittings, and changes of pipe direction. Provide "kicker" blocks in accordance with applicable pipe industry trade or research organization recommendations.
      a. For example, for ductile iron pipe follow recommendations of Ductile Iron Pipe Research Association.

3.3 ESCUTCHEONS

A. Provide chrome plated escutcheons where uninsulated pipes penetrate walls or ceilings of finished spaces.

3.4 STRAINERS

A. Install strainers so the strainer basket can be removed without spilling water on motors and electrical equipment.

3.5 AIR VENTING

A. Provide manually operated air vents at high points in vertical risers and at water coils to eliminate air from systems.

B. Air vents are required at reheat coils. See piping details on drawings.

C. Use ball valves for manual air vents.

3.6 VALVE ACCESS

A. Locate ceiling/wall access panels at shut-off and control valves for proper access and operation. Furnish and install access doors in accordance with Section 23 05 00 and other Divisions as applicable.

3.7 COOLING TOWER BLEED

A. Coordinate bleed off requirements with chemical treatment vendor. Provide piping, fittings, and valves as required.

3.8 CONTROL SYSTEM CONNECTORS

A. Weld connectors at points indicated, and at other points where necessary for installation of thermometers, sensors, and automatic controls.

3.9 TESTING

A. Before piping is concealed or insulated, recheck it for leaks.

B. Rework or replace defective and leaking joints, and joints which are otherwise unsatisfactory. Peening, caulking, and doping are not permitted.

END OF SECTION

SECTION 23 21 16 - HYDRONIC PIPING SPECIALTIES

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. This section includes requirements for:

1.2 RELATED REQUIREMENTS

A. Section 23 21 13 - HVAC Piping

B. Section 23 21 23 - HVAC Pumps

1.3 SUBMITTALS

A. Operation and Maintenence Data

1.4 QUALITY ASSURANCE

A. Manufacturer Qualifications: Company specializing in the manufacture of the products specified herein for a minimum of five years of documented experience.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. As noted in the individual product paragraphs.

2.2 COIL CONNECTION KITS

A. Coil Hook-up Connections: Coil hook-up connections may be used at coil connections consisting of the flow balancing valve, 20-Mesh stainless steel strainer with 8:1 CSAR, union with P/T port fitting, and full port isolation ball valves. Hook-up connections shall be provided by the flow balance valve manufacturer. Flexible braided metal hoses by the balancing valve manufacturer may be used to connect between the coil hook-up isolation valves and the coils for air terminal units.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install hydronic specialty items in locations shown on drawings.

B. Insulate any components subject to sweating or any hot or cold service in accordance with Section 23 07 00.

C. Utilize manufacturer's instructions to install specialty items. Manufacturer's instructions must be adhered to for proper operation of air removal devices and flow control valves.

D. Provide manual air vents at top of pipe risers and other locations where air can be trapped or collected.

E. Pipe relief valve outlets and drain connections from hydronic systems to nearest floor drain.

F. Support pump inlet and strainer fittings with floor mounted pipe and flange supports.

G. Locate thermometers and pressure gauges no higher than 7 feet above finished floor elevation, positioned to be read from the floor.

H. After systems are started up, placed in service and tested/adjusted to perform as designed, contractor shall provide competent representative to demonstrate proper operation and provide instruction to maintenance personnel to include performance on both cooling and heating cycles.

I. At a minimum, pressure gauges and thermometers shall be installed at the following locations:
   1. Suction and discharge of pumps.
   2. Water side, Inlet and outlet of heat exchangers.
   3. Water side, inlet and outlet of air handling units.
   4. Building entrance and exit on chilled water plant and chilled water systems.

END OF SECTION

SECTION 23 21 23 - HVAC PUMPS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Base Mounted End Suction Coupled Pumps

B. In-Line Centrifugal Pumps

1.2 RELATED REQUIREMENTS

A. Section 23 05 00 - Common Work Results for HVAC

B. Section 23 05 13 - Common Motor Requirements for HVAC Equipment

C. Section 23 05 23 - General Duty Valves for HVAC

D. Section 23 07 00 - HVAC Insulation

E. Section 23 21 13 - HVAC Piping

1.3 SUBMITTALS

A. Submit certified pump curves showing pump performance characteristics with pump and system operating point plotted. Include NPSH curve when applicable. Pump curves shall indicate the complete family of impellers available for pump.

1.4 WARRANTY

A. Manufacturer shall warrant equipment for a period of 18 months from date of shipment or 12 month from date of substantial completion.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Allis-Chalmers, Armstrong, Aurora, Bell & Gossett, Buffalo, Paco, Patterson, Peerless, Taco, or Weinman.

2.2 GENERAL REQUIREMENTS

A. Statically and dynamically balance rotating parts.

B. Construction to permit complete servicing without breaking piping connections.

C. Provide flanged pump connections, tapped with pressure gauge ports.

D. Provide heating pumps suitable for handling water at 230 degrees F.

E. Construct pumps of bronze fitted construction with bronze impeller and carbon steel shafts. Ensure shaft deflection does not exceed 0.002" at sealing faces at maximum load.

F. Hydrostatic test pump casings at one and one-half times the design working pressure.

G. Construct pump casings of cast iron with replaceable bronze wearing rings and rated for 150 psig working pressure.

H. Supplied impeller diameter shall not to exceed 90% of the maximum diameter for which pump curves are published.

I. Coupling and Base Plate:
   1. Mount pump and motor on common steel base plate furnished by pump manufacturer.
   2. Manufacturer to furnish and mount steel flexible coupling. Fasten metal coupling guard to pump base plate.

J. Nameplate:
   1. Stainless steel on pump and motor securely fastened to casings.
   2. Provides data necessary for equipment identification and replacement.

2.3 BASE MOUNTED END SUCTION COUPLED PUMPS

A. Type: Horizontal shaft, single stage, centrifugal, direct connected, with resiliently mounted motor for in-line mounting, oil lubricated, for 125 psi (860 kPa) maximum working pressure.

B. Casing: Cast iron, with flanged pump connections.

C. Impeller: Non-ferrous keyed to shaft.

D. Shaft: Alloy steel with bronze sleeve, integral thrust collar.

E. Bearings: Oil or grease lubricated ball bearings.

F. Coupling: Flexible type with OSHA coupling guard.

G. Baseplate: Cast iron or fabricated steel.

H. Seals: Mechanical seal with Ni-Resist stationary seat, carbon washer, ethylene propylene flexible members, brass metal parts and 18-8 stainless steel spring. Mount seals over a bronze shaft sleeve.

2.4 IN-LINE CENTRIFUGAL PUMPS

A. Type: Centrifugal, single stage, close coupled.

B. Casing: Cast iron, with suction and discharge gauge ports.

C. Bearings: Bronze bearings, oil lubricated

D. Seals: Mechanical seal with carbon seal face rotating against a ceramic seat.

PART 3 - EXECUTION

3.1 INSTALLATION

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

B. Provide pumps with soleplates, bedplates, or base plates carefully leveled, grouted, and bolted in place on concrete pads or foundations as shown on drawings. Grout to be expanding type containing catalyzed metallic aggregate. After grout has set, cut flush with bedplate and seal to prevent fraying deterioration at edges. Refer to drawings and Section 23 05 48 for further requirements for piping, pumps, and vibration isolation.

C. Pump manufacturer's authorized representative shall make hot alignment check on couplings between motors and pumps. Operate equipment until components have reached operating temperature before hot check is made. Reposition equipment as required and repeat hot alignment check until parallel and angular alignments in both plan and elevation are within limits set by equipment manufacturers. Alignment to be accomplished with dial indicator.

D. Provide strainer or suction diffuser on each pump as specified in Section 23 21 16.

E. Provide air ventcock in high point of casing.

F. Provide OSHA coupling guard if not furnished by the manufacturer.

G. Refer to Section 23 07 00 for insulation requirements. Insulate all parts subject to heat and condensation. Apply insulation after final alignment and adjustment.

3.2 TESTING, START-UP, DEMONSTRATION

A. Test pumps, valves, piping, and fittings for mechanical tightness, both before start-up and after start-up.

B. Furnish electrical connections for motor drive and to verify proper phasing under Division 26.

C. Start-up pumps, test individually and as a part of the system they serve.

D. Prepare pumps for test and balance as required by Section 23 05 93**.** Correct deficiencies found and retest.

E. Demonstrate and instruct maintenance personnel in the operation of pumps and systems.

END OF SECTION

SECTION 23 25 00 - HVAC WATER TREATMENT

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Water treatment for Boiler System, Chilled Water System, Condenser Water System, and Heating Water System.

1.2 RELATED REQUIREMENTS

A. Section 23 05 00 - Common Work Results for HVAC

B. Section 23 21 13 - HVAC Piping

1.3 REGULATORY REQUIREMENTS

A. Conform to applicable code for addition of non-potable chemicals to building mechanical systems and to public sewage systems.

B. Products Requiring Electrical Connection: Listed and classified by UL as suitable for the purpose specified and indicated.

1.4 SUBMITTALS

A. Product Data: Provide chemical treatment materials, chemicals, and equipment including electrical characteristics and connection requirements.

B. Shop Drawings: Indicate system schematic, equipment locations, and controls schematics, electrical characteristics and connection requirements.

C. Manufacturer's Installation Instructions: Indicate placement of equipment in systems, piping configuration, and connection requirements.

D. Manufacturer's Field Reports: Indicate start-up of treatment systems when completed and operating properly. Indicate analysis of system water after cleaning and after treatment.

E. Certificate: Submit certificate of compliance from authority having jurisdiction indicating approval of chemicals and their proposed disposal.

F. Project Record Documents: Record actual locations of equipment and piping, including sampling points and location of chemical injectors.

G. Operation and Maintenance Data: Include data on chemical feed pumps, agitators, and other equipment including spare parts lists, procedures, and treatment programs. Include step by step instructions on test procedures including target concentrations.

PART 2 - PRODUCTS

2.1 ACCEPTABLE SUPPLIERS

A. Acceptable suppliers include: Anderson Chemical Company, Alken Murray, Alliance Group, Betz Dearborn, Diversey, Garrett Callahan, or Nalco.

B. Chemical water treatment supplier must have qualified service representation within 200 miles of facility, shall render monthly service to facility, and be available for emergency service as required.

2.2 GENERAL REQUIREMENTS

A. Furnish and install chemical water treatment systems complete with equipment, piping, tubing, and interconnection components, electric controls, and water treatment materials and chemicals, and test equipment and chemicals necessary maintaining water treatment program.

B. Equipment, material, and chemicals shall be provided by a single water treatment firm for individual responsibility to insure system compatibility.

C. For additions or renovations requiring water treatment, supplier shall consult with the operating maintenance personnel and obtain services and equipment as requested by them.

D. The products and systems set forth in Part 2 are performance oriented without regard to raw water conditions at the site, existing special conditions or an individual manufacturer's equipment or chemicals. Proposers shall obtain samples of the water to be supplied to the facility, analyze it and submit their proposals for equipment and chemicals based on the water to be treated and any other special conditions. A copy of the water analysis must be furnished with the proposal. The requirements of this paragraph also apply to additions and renovations to existing facilities where the proposer is already rendering chemical water treatment.

E. The chemical water treatment supplier shall provide necessary products for boiler boilout, boiler water treatment, boiler feed system, cooling tower, condenser systems cleanout, initial passivation treatment of galvanized towers, cleaning and operation of closed water systems, and for a maximum of three months treatment of all open and closed water systems during operation of the facility.

F. The chemical water treatment company representative shall develop a program for routine chemical treatment and testing for use of Maintenance Personnel after systems have been placed in operations.

2.3 BOILER SYSTEM

A. Specific chemicals and equipment for the boiler system shall be determined by proposers based on raw water analysis required under Part 1 above.

B. Provide separate equipment for scale control and steam line treatment and oxygen scavenger.
   1. Scale control (phosphate alkalinity) and steam line (neutralizing a mine) treatment shall be injected into the boiler.
   2. Oxygen scavenging shall be injected into the deaeration side of the deaerator, if two compartment, or in the deaerator or feed water heater if single compartment.

C. Chemical feed unit: Packaged unit consisting of mixing tank agitator, chemical feed pump, piping connections, and other accessories Neptune, Model 525-STA.
   1. Mixing tank shall be stainless steel or polyethylene.
      a. Capacity: 50 gallons
      b. Hinged cover
      c. Non-valve type gauge glass
      d. Cast iron or PVC strainer and suction piping
      e. Stainless steel or PVC relief valve and piping
      f. Steel frame with agitator bracket and pump motor
   2. The agitator mounted on mixing tank shall have a stainless steel shaft and impeller.
   3. The chemical feed pump mounted on tank stand shall be duplex positive displacement type.
   4. Provide a separate pump for each boiler.
   5. Provide one chemical feed unit for the boiler and one chemical feed unit for the deaerator.

D. Provide water sample cooler for each boiler, Neptune, Model SC316. The maximum working pressure shall be 300 psi and maximum working temperature of 425 degrees F.

E. Provide an automatic blowdown controller for each boiler, Lakewood, Model 250. The automatic blowdown system shall monitor the boiler water's conductivity and if the conductivity is above a pre-selected setpoint, the blowdown valve will remain open until the conductivity falls below the setpoint level. If the conductivity is below the setpoint level, the blowdown valve will close until the next cycle.
   1. A high alarm shall be provided to warn operators of abnormally high conductivity conditions.
   2. The automatic blowdown control shall to include the controller, sensor, and sensor assembly, including ball valve and orifice union.

F. Corrosion Test Coupons: Provide corrosion coupon rack in condensate return piping at the deaerator/boiler feed unit to facilitate use of corrosion coupons. Provide one set of steel, brass, and copper coupons.

2.4 CONDENSER WATER SYSTEM

A. Specific chemicals and equipment for each condenser water system shall be determined by proposer based on raw water analysis required under Part 1.

B. Provide system to perform functions listed below and include all controls, tanks, pumps, sensors, probe, analyzer, valves, etc., necessary to perform the water treatment functions required. Functions to be performed include:
   1. Automatic control of cooling tower bleed-off.
   2. Automatic control of chemicals for corrosion and scale inhibitor..
   3. Water meter with dry electrical contact, in makeup line to measure water usage in cooling tower. Interlock chemical field equipment with water meter contact.
   4. Automatic control of biocides. Provide timer and feed pump.
   5. Corrosion test rack and coupons for condenser water system.

2.5 HEATING WATER SYSTEMS

A. Provide and install a One Shot Feeder with funnel, an air release valve, sized for each system to be served (minimum size 5 gallons), rated for a pressure of 300 psi.

2.6 TEST CABINET, EQUIPMENT AND TEST CHEMICALS

A. Provide a test cabinet, equipment, and chemicals to place systems in operation and to effect the recommended water treatment and testing program.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install equipment furnished under Part 2 of this specification in locations set forth on the drawings.

B. Furnish and install the necessary piping, valves, fittings, etc., as necessary to place treatment and control equipment in operation.

C. The necessary electrical connections shall be provided under Division 26.

D. Coordinate and schedule the services of the chemical water treatment and HVAC equipment provided for assistance as necessary to complete systems cleaning, flushing, boil out, start-up, treatment, and operation as is necessary, in accordance with the requirements of paragraphs below.

E. The chemical water treatment system representative shall field verify the completed installation, including field calibration of controllers, pumps, and other operating parts. In addition, he shall insure that all necessary chemicals and test equipment is on hand when needed.

3.2 SYSTEM PREPARATION FOR OPERATION

A. Boiler System:
   1. Comply with the requirements and instructions of boiler manufacturer and as specified in other sections.

B. Closed Water Systems: Chilled water, hot water reheat and other closed systems.
   1. Initial Flushing:
      a. Remove loose dirt, mill scale, metal chips, weld beads, rust, and like deleterious substances without damage to any system components.
      b. Bypass factory equipment, unless acceptable means of protection are provided and by subsequent inspection of water boxes and other "hide out" areas takes place.
      c. Isolate or protect "clean" system components including pumps and pressure vessels and any component that may be damaged.
      d. Open all valves, drains, vents, strainers and the like at all system levels.
      e. Remove plugs, caps, spool pieces and components to facilitate early discharge from system.
      f. Sectionalize system to obtain debris carrying velocity of 6 FPS if possible.
      g. Connect dead end supply and return headers and the like, as necessary or provide drains in dead end eccentric caps.
      h. Install temporary strainers where necessary to protect downstream equipment.
      i. Supply and remove "flushing" water and drainage by fire hoses, garden hoses, temporary or permanent piping, or system booster pumps.
      j. Flush for not less than 4 hours.

k. Inspect system including any storage tanks and basins to determine if debris accumulation required dewatering and cleaning prior to the next phase.
l. For systems indicated with glycol, fill system from pre-mixed tanker trucks or barrels at indicated concentrations. Handle glycol in accordance with manufacturer's instructions and regulatory requirements.

2. Cleaning:
   a. Remove adherent dirt (organic soil), oil, grease, hydrocarbons, welding and soldering flux, mill varnish, piping compounds rust (iron oxide), and like deleterious substances not removed in initial flushing without chemical or mechanical damage to any system component.
   b. Utilize defoamers to preclude damage to existing work and, specifically, adjacent electrical equipment.
   c. Utilize heat to maximize effectiveness of compounds or use live steam injection where practical and safe. Do not raise cleaning water temperature in excess of 150 degrees F.
   d. Install temporary strainers, reinforced against blowout, sized to not impair equipment performance, to preclude passing of particles larger than 60% of smallest radial and at a minimum to retain all particles larger than 1000 microns.
   e. Permanent facility pumps shall not be used for circulating cleaning water, except in compliance with the following provisions:
      1) System construction, flow rates and pressure are such that it is impractical for the Contractor to provide temporary pumps and construction procedures, initial flushing workmanship, and cleaning provisions.
      2) Mechanical seal area of each pump stuffing box is continuously flushed, under head in excess of pump internal pressure, at a rate not less than 1/2 gpm with water passing through specified cyclones or a 5 micron filter if other than a protected potable water supply.
      3) The guarantee on the entire pump assembly is unconditionally extended for two years after date of facility acceptance. Leakage from pump seals, scored horizontal turbine pump shafts with vibration in excess of two mils at shutoff head during that period, shall be construed as damage, requiring immediate rectification.
   f. Add a 4% solution by weight of a pulverized acid product for chemical cleaning. As the solution reacts with deposits, the pH of the solution increases. When the solution loses strength, a color change will take place from blue green to blue to purple. Continue to add until color remains blue green for two hours.
   g. Flush system per "flushing instructions".
   h. Next phase is to passivate metal surfaces. Add 5 lbs. (or as specified) per 1000 gallon system capacity. Circulate for 48 hours. Perform total soluble inorganic phosphate (TIP) tests to determine the passivating qualities and make adjustments accordingly. System shall not be on a heat load. Sixty to ninety degrees F is in preferable heat range. After passivation "flush" system and refill with potable Municipal water.
   i. Blowdown all strainers or remove and clean as frequently as possible during cleaning and passivating stages.
   j. Replace all filter elements as necessary.
   k. Prepare system for "final flushing" by displacing all cleaning and passivating solutions and installing primary filter elements in cleaned filter body.

3. Final Flushing:
   a. Return systems to conditions required by "Initial Flushing" after all cleaning and passivating solutions have been displaced by clean make-up disinfected water.
   b. Flush all dead ends and isolated "clean" equipment.
   c. Operate gently, all valves to dislodge any debris in valve body by throttling velocity.

d. Flush for not less than 4 hours.

4. Placing into "Next Phase" Condition:
   a. Clean all "temporary" and permanent strainers. The water treatment supplier shall schedule removal of "temporary" strainers 3 months after final acceptance of facility, at a time approved by the Owner, unless directed otherwise by the Architect.
   b. Dewater and clean all sumps, basins, storage, and pressure vessels and the like.
   c. Disassemble, inspect, clean, repair, replace and re-assemble any critical component or questionable item. Any convoluted flexible connector left in place shall be removed and cleaned.
   d. Preliminarily adjust all control valves.
   e. Close-up and fill system as soon as possible to minimize corrosion of untreated surfaces.
   f. Charge system with next phase chemical treatment compound.
5. Chemical Treatment Compound:
   a. A liquid solution of borate-nitrite with color concentration indicator shall be added to provide protection from corrosion, fouling. Product must contain a scale modifier with borate as the pH buffer. Additions shall be added at 1 gallon per 1000 gallons system capacity (or as required). Nitrite levels shall be maintained at 300-500 ppm in chilled closed systems and 800-1000 ppm in hot closed systems.

3.3 OWNER OPERATOR TRAINING

A. Provide the maintenance personnel with a Program Administration Manual to include operating and maintenance instructions for all equipment furnished under this section, recommended chemical treatment and testing program, and any special safety information.

B. Instruct Owner's operating personnel in the requirements of the treatment and testing program.

C. Service representative shall provide service at the facility on a bi-weekly basis during the first 2 months of building operations and monthly thereafter.

D. At each on site analysis, verbally consult with and advise appropriate maintenance personnel of status of program and recommended changes. Follow the verbal consultation with a written report.

END OF SECTION

SECTION 23 52 16 - CONDENSING BOILERS

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Manufactured units.

B. Boiler construction.

C. Boiler trim.

D. Fuel burning system.

E. Factory installed controls.

1.2 RELATED REQUIREMENTS

A. Section 03 30 00 - Cast-in-Place Concrete.

B. Section 23 09 13 - Instrumentation and Control Devices.

C. Section 23 21 16 - Hydronic Piping Specialties.

D. Section 23 21 13 - HVAC Piping.

E. Section 23 25 00 - HVAC Water Treatment.

F. Section 26 27 17 - Equipment Wiring: Electrical characteristics and wiring connections.

1.3 REFERENCE STANDARDS

A. AHRI Directory of Certified Product Performance - Air-Conditioning, Heating, and Refrigeration Institute (AHRI); current edition at www.ahrinet.org.

B. ASHRAE Std 90.1 I-P - Energy Standard for Buildings Except Low-Rise Residential Buildings; 2013, Including All Amendments and Errata.

C. NBBI Manufacturer and Repair Directory - The National Board of Boiler and Pressure Vessel Inspectors (NBBI); current edition at www.nationalboard.org.

D. NFPA 54 - National Fuel Gas Code; 2015.

E. SCAQMD 1146.1 - South Coast Air Quality Management District Rule No.1146.1; current edition.

F. SCAQMD 1146.2 - South Coast Air Quality Management District Rule No.1146.2; current edition.

1.4 SUBMITTALS

A. Submit product data and drawings in accordance with the requirements of Division 01.

B. Product Data: Provide data indicating general construction assembly, components, venting, controls, safety controls, trim, and wiring diagrams with electrical characteristics and connection requirements, and service connections. Also include efficiencies at varying entering water temperatures and pressure drop curves from 0 GPM to design GPM.

C. Manufacturer's Installation Instructions: Indicate assembly, support details, connection requirements, and include start up instructions.

D. Manufacturer's Factory Inspection Report: Submit boiler inspection prior to shipment.

E. Operation and Maintenance Data: Include manufacturer's descriptive literature, operating instructions, cleaning procedures, replacement parts list, and maintenance and repair data.

F. Warranty: Submit manufacturer warranty and ensure forms have been completed in Owner's name and registered with manufacturer.

G. Software: Copy of software provided under this section.

1.5 QUALITY ASSURANCE

A. Manufacturer Qualifications: Company specializing in manufacturing the type of products specified in this section, with minimum three years of documented experience.

B. ASME Compliance: Condensing boilers must be constructed in accordance with ASME Boiler and Pressure Vessel Code, Section IV "Heating Boilers".

C. I=B=R Performance Compliance: Condensing boilers must be rated in accordance with applicable federal testing methods and verified by AHRI as capable of achieving the energy efficiency and performance ratings as tested within prescribed tolerances.

D. ASHRAE/IESNA 90.1 Compliance: Boilers shall have the minimum efficiency according to "Gas and Oil Fired Boilers-Minimum Efficiency Requirements."

E. DOE Compliance: Minimum efficiency shall comply with 10 CFR 430, Subpart B, Appendix N, "Uniform Test Method for Measuring the Energy Consumption of Furnaces and Boilers".

F. UL Compliance: Boilers must be tested for compliance with UL 795, "Commercial-Industrial Gas Heating Equipment". Boilers shall be listed and labeled by a testing agency acceptable to the authorities having jurisdiction.

G. NOx Emission Standards: When installed and operated in accordance with manufacturer's instruction, condensing boilers shall comply with the NOx emission standards outlined in South Coast Air Quality Management District (SCAQMD), Rule 1146.2; and the Texas Commission on Environmental Quality (TCEQ), Title 30, Chapter 117, Rule 117.465.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Protect boilers from damage by leaving factory inspection openings and shipping packaging in place until final installation.

1.7 WARRANTY

A. See Section 01 78 00 - Closeout Submittals, for additional warranty requirements.

B. Provide a five year warranty to include coverage for heat exchanger.

PART 2 PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Natural Gas, Propane, or Combination Natural Gas/Propane for Indoor Applications:
   1. AERCO International..
   2. Buderus
   3. Viessmann Manufacturing

2.2 MANUFACTURED UNITS

A. Factory assembled, factory fire-tested, self-contained, readily transported unit ready for automatic operation except for connection of water, fuel, electrical, and vent services.

B. Unit: Metal membrane wall, water or fire tube, condensing boiler on integral structural steel frame base with integral fuel burning system, firing controls, boiler trim, insulation, and removable jacket, suitable for indoor application.

C. Unit shall be suitable for individual or multiple boiler operation and be equipped with the required control panel and controls.

2.3 BOILER CONSTRUCTION

A. Conform to the minimum requirements of [] for construction of fully condensing, fire tube design boilers.

B. Assembly to bear the ASME "H" stamp and comply with the efficiency requirements of the latest edition of ASHRAE 90.1.

C. Required Directory Listings:
   1. AHRI Directory of Certified Product Performance - Air-Conditioning, Heating, and Refrigeration Institute (AHRI); current edition at www.ahrinet.org.
   2. NBBI Manufacturer and Repair Directory - The National Board of Boiler and Pressure Vessel Inspectors (NBBI); current edition at www.nationalboard.org.

D. Heat Exchanger: Construct with 316L stainless steel fire tubes and tube sheet for working pressures of not less than 160 psig.

E. Provide adequate tappings; water connections; intake and flue connections; drains; observation ports; removable panels and access doors for entry, cleaning, and inspection.

F. Insulate casing with suitable insulation material, protected and covered by heavy gauge, metal jacket.

G. Factory apply boiler base and other components, that are subject to corrosion, with durable, acrylic, powder coated, painted, or weather-proofed finish.

2.4 BOILER TRIM

A. ASME rated pressure relief valve.

B. Flow switch.

C. Electronic Low Water Cut-off: Complete with test light and manual reset button to automatically prevent firing operation whenever boiler water falls below safe level.

D. Temperature and pressure gauge.

E. Pressure Switches:
   1. High gas pressure.
   2. Low gas pressure.
   3. Air pressure.

F. Manual reset high limit.

G. Boiler Pump (where required by boiler design):
   1. Primary pump, factory supplied and sized for field installation to ensure minimum, continuous circulation through boiler.
   2. Where pump is not provided by boiler manufacturer, provide pump in accordance with boiler manufacturer's recommendations.
   3. Pump time delay.

2.5 FUEL BURNING SYSTEM

A. Provide forced draft automatic burner or pulse combustion, integral to boiler, designed to burn natural gas, and maintain fuel-air ratios automatically.
   1. Blower Design: Statically and dynamically balanced to supply combustion air; direct connected to motor with variable speed centrifugal fan.
   2. Forced Draft Design: Mixes combustion air and gas to achieve 90 percent combustion efficiency.
   3. Pulse Combustion Design: Self-aspirating, not requiring blower for combustion.
   4. Combustion Air Filter: Protects fuel burning system from debris.
   5. 20 to 1 turndown ratio of firing rate without loss of combustion efficiency or staging of gas valves.
   6. Spark ignition, 100% main valve shutoff and electronic flame supervision.

B. Gas Train: Plug valve, safety gas valve, gas-air ratio control valve, and pressure regulator controls air and gas mixture.

C. Emission of Oxides of Nitrogen Requirements: Comply with SCAQMD 1146.1, SCAQMD 1146.2, and TCEQ 117.465 for natural gas fired system, as applicable.

D. Intakes: Combustion air intake capable of accepting free mechanical room air or direct outside air through a sealed intake pipe.

E. Exhaust Manifold: Corrosion resistant cast aluminum or stainless steel with a collection reservoir and gravity drain for condensate drainage.

2.6 FACTORY INSTALLED CONTROLS

A. Option for internal or external (0-10) VDC control.

B. Temperature Controls:

1. Automatic reset type to control fuel burning system on-off and firing rate to maintain temperature.
2. Manual reset type to control fuel burning system to prevent boiler water temperature from exceeding safe system water temperature.
3. Low-fire start time delay relay.

C. Electronic PI setpoint/modulation control system.

D. Microprocessor-based, fuel/air mixing controls.

E. Control panel shall support both RS-232 and RS-435 remote communication.

F. The control panel shall incorporate three self-governing features designed to enhance operation in modes where it receives and external signal or loss of eternal signal including:
1. Setpoint high limit: Allows for a selectable maximum boiler outlet temperature and acts as temperature limiting governor. Setpoint limit is based on a PID function that automatically limits the firing rate to maintain outlet temperature within a 0 to 10 degree selectable band from the desired maximum boiler outlet temperature.
2. Setpoint Low Limit: Allows for a selectable minimum operating temperature.
3. Failsafe Mode: Allows the boiler to switch its mode to operate from an internal setpoint if its external control signal is lost, rather than shut off. This is a selectable mode, enabling the control can shutoff the unit upon a loss of external signal, if desired.

G. The boiler control system shall incorporate the following additional features for enhanced external system interface:
1. System start temperature feature
2. Pump delay timer
3. Auxiliary start delay timer
4. Auxiliary temperature sensor
5. Analog output feature to enable simple monitoring of temperature setpoint, outlet temperature or fire rate
6. Remote interlock circuit
7. Delayed interlock circuit
8. Fault relay for remote fault alarm

H. Each boiler shall include an electric, single-seated combination safety shutoff valve/regulator with proof of closure switch in its gas train. Each boiler shall incorporate dual over-temperature protection with manual reset, in accordance with ASME Section IV and CSD-1.

2.7 **VENTING**

A. The exhaust vent (8" minimum) must be UL Listed for use with Category III and IV appliances and compatible with operating temperatures up to 480 degrees F, positive pressure, condensing flue gas service. UL Listed vents of stainless steel must be used with boilers.

B. Combustion Air Intake: Boilers shall be capable of drawing combustion air from the outdoors through an 8" minimum duct connected between the boiler and outside with an appropriate screened entrance cap or hood.

C. Venting and combustion air shall meet the manufacturer's venting guide and requirements.

PART 3 EXECUTION

3.1 INSTALLATION

A. Install the boiler, piping, controls, wiring, combustion and venting in accordance with manufacturer's written instructions.

B. Install boiler and provide connection of natural gas service in accordance with requirements of NFPA 54 and applicable codes.

C. Coordinate factory installed controls with Section 23 09 13.

D. Coordinate provisions for water treatment in accordance with Section 23 25 00.

E. Pipe relief valves to nearest floor drain.

F. Pipe cooled condensate produced by the combustion process from the boiler condensate connection and/or flue stack with suitable piping material to neutralizer/cooler prior to discharging into nearest floor drain.

G. Provide piping connection and accessories in accordance with Section 23 21 14.

H. Provide for connection to electrical service in accordance with Section 26 27 17.

I. Vent combustion fumes in accordance with manufacturer's recommendations. Refer to Section 23 51 00.

3.2 CLOSEOUT ACTIVITIES

A. Demonstrate proper operation of equipment to Owner's designated representative.

B. Demonstration: Demonstrate operation of system to Owner's personnel.
   1. Use operation and maintenance data as reference during demonstration.
   2. Conduct walking tour of project.
   3. Briefly describe function, operation, and maintenance of each component.

C. Training: Train Owner's personnel on operation and maintenance of system.
   1. Use operation and maintenance manual as training reference, supplemented with additional training materials as required.
   2. Provide minimum of two hours of training.
   3. Instructor: Manufacturer's training personnel.
   4. Location: At project site.

END OF SECTION