DIVISION 15 MECHANICAL SPECIFICATIONS

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1 GENERAL

1.01 GENERAL REQUIREMENTS: Drawings and general provisions of the Contract, including General and other conditions and Instructions to Bidders Sections apply for the work specified in this Section.

1.02 SCOPE OF WORK: The work covered by this Specification shall include furnishing all labor, materials, equipment and services to design, construct and install the complete mechanical controls system as shown on the Drawings and specified herein. Verify all conditions on the job site and lay out work accordingly.

A. Controls portion of the work shall be Design and Build and shall include furnishing all labor, materials, equipment and services to design, construct and install the complete system as specified herein. Verify all conditions on the job site and lay out work accordingly.

B. Coordinate closely with Owner on allowed work schedule and storage requirements.

C. Work with Owner to acquire Energy Trust of Oregon incentives. This project is based on a recent Technical Analysis Study completed by R&W Engineering. Contractor to provide required invoicing, cut sheets and pricing breakdown as required by Energy Trust of Oregon.

D. Order of Work to be as follows: Boiler upgrade work to be done first, prior to onset of heating season. Controls upgrade work to follow boiler work. Closely coordinate and sequence work with Owner to minimize system downtime.

E. Separate out costs in bid for controls upgrade portion of work from boiler upgrade work and for the purpose of reporting to Energy Trust of Oregon.

1.03 CONTROLS DESIGN AND BUILD INSTRUCTIONS

A. This document is issued to give Bidders a basis for preparing a bid to design and install a direct digital control system to replace the existing control system throughout the building. Remove all components of existing control system not required for function of new control system.

B. Use this specification as a guide for design/engineering requirements and workmanship and materials or construction. Utilize Design and Build concept for controls throughout construction phase of project.

1.04 RELATED WORK:

A. The General Provisions apply to this Division, including but not limited to:

1. Drawings and Specifications.

2. Contract Modifications, addendums and change orders.

B. Instructions to Bidders applies to this Division, including but not limited to:

1. Summary of Work.

2. Coordination. In addition, it shall be the responsibility of each trade performing work specified under Division 15 to coordinate with all others for proper and adequate installation clearance.

3. Cutting and Patching. The cost of cutting and patching required work of Division 15 and not shown in other Divisions of Work shall be included in the cost of Division 15.

4. Shop Drawings, Product Data and Samples.

5. Temporary Facilities and Controls.

6. Material and Equipment.

7. Substitutions and Product Options.

8. Contract Closeout.

   a. Project Record Documents. Keep up to date marked up Drawings on site.

   b. Operations and Maintenance Data.

   c. Start-up.

C. Related work provided in other Divisions:

1. Pipe chases and formed concrete work except as specified hereunder.

2. Framed openings in masonry, concrete, wood and other architectural and structural elements.

3. Wood grounds and nailing strips in masonry and concrete.

4. Installation only of access panels in ceilings, walls, etc. Provide access panels as part of mechanical work.

5. Painting except as specified hereunder.

6. Curbs and roof flashings for openings through roofs, except for roof drain and vent pipe flashing.

D. Related Work provided in Division 16:

1. Motor disconnect switches and installation except as specified herein.

2. Motor starters and installation except as herein specified.

3. Power wiring except as specified herein.

1.05 QUALITY ASSURANCE

A. Regulatory Requirements:

1. All work, installations, materials and equipment shall comply with the provision of the following codes, standards and regulations, except where more stringent requirements are shown or specified:

   a. State of Oregon International Mechanical Code. (IMC)

   b. State of Oregon Plumbing Specialty Code. (UPC)

   c. State of Oregon Structural Specialty Code. (IBC)

   d. National Electrical Code. (NEC)

   e. National Fire Protection Agency. (NFPA)

   f. All City, County, State and Federal applicable laws and regulations.

   g. Regulations and standards set forth by ASME, ASHRAE, SMACNA, AGA and ARI.

2. Should there be any direct conflict between Codes and the Drawings and Specifications, the Codes, rules and regulations shall govern.

3. Where two or more codes or regulations apply, the more stringent of the two shall be exercised.

4. Should the Documents indicate a condition, which will conflict with the Codes, the Contractor shall inform the Owner's Representative and refrain from installing that portion until resolved. Any work installed in violation of the Codes will be removed and correctly installed as part of the Contract work.

5. If the Drawings and Specifications indicate a higher quality than code, the Drawings and Specifications shall govern.

6. Electrical products shall bear the U.L. label.

B. The entire mechanical system shall operate correctly at full capacity without objectionable noise, vibration or decrease of efficiency.

C. Materials and Equipments:

1. Equipment furnished shall meet all requirements of the Drawings and Specifications and be suitable for the installation. Equipment not meeting all requirements will not be acceptable.

2. Where two or more units of the same class of equipment are furnished, use products of the same manufacturer.

3. Furnish all materials and equipment, new and of size, type and quality herein specified.

D. Workmanship:

1. Follow manufacturers' instructions. If they are in conflict with the Drawings and Specifications, obtain clarification from the Engineer prior to beginning the work.

E. Cutting and Patching:

1. Provide for cutting, patching and repairing for the installation of the work specified, including masonry work, concrete work, carpentry work and painting. Work shall be performed by skilled craftsmen of the respective trade.

1.06 DRAWINGS:

A. The Drawings and Specifications are complementary and what is called for by one shall be as if called for by both. All items shown on the Drawings are not necessarily included in the Specifications. All directives and instructions to furnish, provide, install, complete and test described in the design documents shall be interpreted as directives unless clearly specified otherwise.

B. Bring obscure or questionable items to the attention of the Owner's Representative prior to bid date. Necessary directions and explanations will be given by the Owner's Representative in Addendum Form.

C. Should the Documents indicate a condition which will conflict with the Governing Codes and Regulations, the Contractor shall refrain from installing that portion of the work until receiving verification from the Owner's Representative. Should rearrangement or rerouting of duct or piping be necessary, provide for approval the simplest layout possible for that particular potion of the work. Any work installed in violation of the Governing Codes will be removed and correctly installed by the Contractor as part of the Contract work.

D. Drawings are diagrammatic. They do not show every offset, bend, tee, or elbow which may be required to install work in the space provided. Do not scale drawings for roughing-in measurements, nor use as shop drawings. Make field measurements and prepare shop drawings as required. Coordinate work with shop drawings of other trades. Provide any bends. Offsets and elbows where required by local conditions from measurements taken at the Building (subject to approval) and without additional cost to the Project. The right is reserved to make any reasonable changes in outlet location prior to rough-in.

E. It is the intent of these specifications that the field wiring of all systems provided and modified under this contract shall be complete and operable. Refer to all drawings and specifications, especially the electrical drawings, to determine voltage, phase, circuit ampacity and number of connections indicated. Bring to the attention of the Engineer all conflicts, incompatibilities and discrepancies prior to bid.

F. Where equipment is shown, dimensions have been taken from typical equipment of the class indicated. Carefully check the Drawings to see that the equipment under consideration for installation will fit the space provided and that all connections may be made thereto without impairment of space and height requirements and of Code required clearances. Contractor is responsible for all changes required by equipment dimensions different than those shown.

G. Where equipment manufacturer and model number are listed it is the most recent and/or desired to describe function and quality of equipment to be supplied and installed. Since manufacturers may change model numbers without notification, should the model specified be unavailable, furnish and install the model number that is equal to or better than the one listed.

H. The location of all utilities, wires, conduits, pipes, duct, or other service facilities are shown in a general way only on the Drawings and are taken from existing public records. Ascertain whether any additional facilities other than those shown on the plans may be present and determine the exact location and elevations of all utilities prior to commencing installation.

I. Prior to bid, contact the local utility companies to verify requirements. Provide all material and labor by utilities.

J. The Contractor, before submitting a Bid on the work, must visit the site to become familiar with all visible existing conditions. As a result of having visited the premises, the Contractor shall be responsible for the installation of the work as it relates to such visible existing conditions. The submission of the bid will be considered an acknowledgement of the part of the Bidder of visitation to the site.

K. The Contractor is responsible to apply for and obtain all necessary permits, fees and inspections required by any public authority having jurisdiction. Refer to General Conditions for additional information.

1.07 SUBSTITUTION AND PRODUCT OPTIONS:

A. See Instructions to Bidders.

B. The use of manufacturer's names, models and numbers in the Drawings and Specifications is intended to establish style, quality, appearance and usefulness. The model numbers listed are the last available to the designer, if no longer current, substitute equipment equal to or better than that represented by the model number listed. Items noted "or equivalent" will require prior acceptance.

C. Submit for the Owner's Representative's review, manufacturer's detailed specifications and data sheets for all proposed substitutions. Submittals shall consist of a single sheet, or specific data need for consideration of approval. All pertinent data listed in the Specifications and on the Drawings shall be furnished, including all special features. See that all submittals are in proper order, and that all equipment will fit the space provided.

D. All requests for approval of substitutions for materials other than those specified must be submitted in accordance with Instruction to Bidder.

E. Substitution products from approved manufacturers do not need prior approval. Ensure substitutions meet all requirements of the Specifications.

F. All changes required due to product substitutions are the responsibility of the Contractor.

1.08 PROJECT RECORD DRAWINGS:

A. Obtain drawings from Owner's Representative.

B. Keep Drawings clean, undamaged and up to date.

C. Record and accurately indicate the following:

1. Depths, sizes and locations of all buried and concealed piping.

2. Locations of all clean-outs.

3. Changes, additions and revisions due to contract modifications.

4. Locations of tracer wire terminal points.

D. Drawings to be available for Owner's review.

E. Submit as a part of Project Closeout Documents

1.09 PROJECT CONDITIONS:

A. Existing Conditions: Prior to bidding, verify and become familiar with all existing conditions by visiting the site and include all factors which may affect the execution of this work. Include all related costs in the initial bid.

B. Coordinate exact requirements governed by actual job conditions. Check all information and report all discrepancies before fabrication work. Report changes in the time to avoid unnecessary work. Make changes as directed by Owner's Representative.

1.10 CONTRACT MODIFICATIONS:

A. In addition to the requirements of the General provisions, all supplemental cost bids for this Division of work shall be accompanied by a complete itemized breakdown of labor and materials for each item. No exceptions will be made. Contract's estimating sheets for supplemental cost bids shall be made available upon request. Labor must be separated and allocated to each item of work. Changes or additions subject to additional compensation made without written authorization based on agreed price shall be at Contractor's own risk and expense.

1.11 STORAGE AND HANDLING

A. Delivery: Deliver to project site with manufacturer's labels intact and legible.

B. Handling: Avoid damage.

C. Storage: Store material inside, protected from weather, dirt and construction dust. Where necessary to store outside, elevate well above grade and enclose with durable, waterproof wrapping.

1.12 WARRANTY:

A. Provide a written guaranty covering the work of this Division for a period of one calendar year from the date of acceptance of the entire project as required by the General Provisions.

B. Provide manufacturer's written warranties for material and equipment furnished under this Division insuring parts and labor for a period of one year from the date of acceptance of the entire project.

C. Correct warranty items promptly upon notification.

1.13 OPERATIONS AND MAINTENANCE DATA:

A. Prior to final inspection, provide three (3) copies of manufacturer's maintenance manuals for each piece of equipment or items requiring service. Manual shall include manufacturer's operation and maintenance instruction manuals and parts list for each piece of equipment or item requiring servicing. Include in the manual manufacturer's service data, wiring diagrams and parts lists for all major items of equipment, valve charts, balancing data, final control diagrams showing final set points and any additional equipment added by contract modification. Comply with provisions of Section 01700 where applicable.

B. Submit bound in 8-1/2 x 11 inch text pages, three ring binders with durable plastic covers.

C. Prepare binder covers with printed title "OPERATION AND MAINTENANCE INSTRUCTIONS", title of project, and subject matter of binder when multiple binders are required.

D. Internally subdivide the binder contents with permanent page dividers, logically organized with tab titling clearly printed under reinforced lamented plastic table.

1.14 SUBMITTALS:

A. Shop Drawings: The Contract Drawings indicate the general layout of the piping, ductwork and various items of equipment. Prepare and submit for review Shop Drawings of all installation not detailed on the Contract Drawings and all changes to the Contract Drawings.

B. Product Data:

1. Submit for review manufacturer's detailed shop drawings, specifications and stat sheets for all equipment to be furnished, as well as any wiring diagram showing field installed wiring and devices. Arrangement of mechanical equipment has been based on items of specific manufacturer intended as somewhat typical of several makes, which may be approved.

2. Indicate construction, capacities, accessories, etc. Manufacturer's abbreviations or codes are not acceptable.

3. List the name of the motor manufacturer for each piece of equipment.

C. Submission Requirements:

1. Shop Drawings and Product Data:

a. Submit all equipment and product data for Work of Division 15 together in a group in a 3-ring loose-leaf binder, with each item field under a tab, and labeled with its respective speciation section number, article and paragraph, and mark if applicable.

b. Include a complete index in the original submittal. Indicate both original items submitted and note stragglers that will be submitted at a later date to avoid delay in submitting.

c. Additional product data submitted after return of the original binder shall include a tab similar to the originally submitted. Upon receipt of the return submittal, insert them in the previously submitted binder.

d. Refer to Instructions to Bidders for number of shop drawing copies to be submitted.

2. Sample: Submit samples required by each Section of Division 15 at the same time that shop drawings and product data are submitted.

D. It shall be the Contractor's responsibility to:

1. See that all submittals are in proper order.

2. Insure that all equipment will fit in the space provided.

3. Assure that all deviation from Drawings and Specification are specifically noted and called to the attention of the Engineer/Contracting Officer in the submittals. Failure to comply will void approval automatically.

4. Deviation, discrepancies, and conflicts between the submittals and the contract documents discovered prior to or after the review process shall not relieve the Contractor of this responsibility to comply with the contract documents.

1.15 START-UP:

A. Coordinate schedule for start-up of various equipment and systems.

B. Notify Owner's Representative seven days prior to start-up of each item.

C. Verify that each piece of equipment of system has been checked prior to start-up for proper lubrication, drive rotation, belt tension, control sequence, or other conditions, which may cause damage.

D. Verify that tests, meter readings and specified electrical characteristics agree with those required by the equipment or system manufacturer.

E. Verify that wiring and support components for equipment are completed and tested.

F. Execute start-up under supervision of responsible manufacturer's representative or Contractor's personnel in accordance with manufacturer's instructions.

1.16 FEES, PERMITS AND INSPECTIONS: The Contractor is responsible to apply for and obtain all necessary permits, fees and inspections required by any public authority having jurisdiction. Refer to General Conditions for additional information.

1.17 DEFINITIONS

A. “Furnish: Means to supply and deliver to the project site, ready for unloading, unpacking, assembly, installation and similar operations.

B. “Install”: Describes operations at project site including actual unloading, temporary storage, unpacking, assembling, erecting, placing, anchoring, applying, working to dimension, finishing, curing, protecting, cleaning and similar operations.

C. “Provide”: Means to furnish and Install, complete and ready for intended use.

2 PRODUCTS

2.01 MATERIAL:

A. All materials and products used for construction shall be new, of the best grade, and latest products as listed in printed catalog data. All articles of a kind shall be the standard product of a single manufacturer. Trade names and manufacturers names denote a character and quality of equipment desired and shall no be construed as limiting competition.

B. Asbestos: Do not use products made of or containing asbestos.

2.02 QUALITY ASSURANCE

A. Refer to Section 01640 Material and Equipment for information regarding available alternatives to materials and equipment specified herein. Product listings are for informational purposes only and establish a general standard of quality.

B. Provide products which are compatible with other portions of the work and provide products with the proper and correct power and fuel burner characteristics and similar adaptations for the project.

2.03 INSPECTION:

A. All work and materials are subject to field observation at any and all times by the Owner’s Representative.

B. The Contractor shall notify the Owner’s Representative a minimum of two days prior to testing any piping system which must be witnessed and accepted before it is covered up or enclosed.

C. If an observer finds any material or work not conforming to these Specifications, within three days after being notified, remove the materials from the premises and replace with approved materials. If the material has been installed, the entire expense of removing and replacing shall be borne of the Contractor.

3 EXECUTION

3.01 EQUIPMENT PROTECTION

A. Keep pipe, ductwork and conduit openings closed by means of plugs or caps to prevent the entrance of foreign matter. Protect piping, conduit, ductwork, fixtures, equipment and apparatus against dirty water, chemical or mechanical damage both before and after installation. Restore damaged or contaminated fixtures, equipment or apparatus to original conditions or replace at no cost to the Owner.

B. Protect bright finished shafts, bearing housings, and similar items until in service. No rust will be permitted.

C. Cover or otherwise suitably protect equipment and materials stored on the job site.

3.02 CLEANING

A. General: Clean mechanical and plumbing equipment, fixtures, piping and ductwork of stampings and markings (except those required by codes), iron cuttings, and other refuse.

B. Painted Surfaces: Clean scratched or marred painted surfaces of rust or other foreign mater and paint with matching color industrial enamel, except as otherwise noted.

C. Before operating any equipment or systems, make thorough check to determine that systems have been flushed and cleaned as required and equipment has been properly installed, lubricated and serviced. Check factory instructions to see that installations have been made accordingly and that recommended lubricants have been used.

D. Use particular care in lubricating bearings to avoid damage by over-lubrication and blowing out seals. Check equipment for damage that may have occurred during shipment, after delivery or during installation. Repair damaged equipment as approved or replace with new equipment.

3.03 LAYOUT AND COORDINATION

A. Site Examination: Before starting work, carefully examine site and all contract Drawings so as to become thoroughly familiar with conditions governing work on this project. Verify all indicated elevations, building measurements, roughing-in dimensions and equipment locations before proceeding with any of the work.

B. The existence of any wires, conduits, pipes, ducts or other service facilities are shown in a general way only. It will be the duty of the Contractor to visit the site and make exact determination of the existence of any such facilities prior to submitting a bid. It is understood that the Contractor will be responsible for making the exact determination of the location and condition of these facilities.

C. The location of all utilities indicated on the plans is taken from existing public records. The exact location and elevation of all public utilities must be determined by the Contractor It shall be the duty of the Contractor to ascertain whether any additional facilities other than those shown may be present.

D. Sleeves, Insets, Cast-in-Place Work: provide sleeves, inserts, anchoring devices, cast-in-place work, etc. which must be set in concrete sequenced at the proper time for the project schedule.

E. Coordination:

1. Where the work must be sequenced and positioned with precision in order to fit into the available space, prepare accurate scale shop drawings showing the actual physical dimensions required for the installation and submit prior to purchase-fabrication-installation of any of the elements involved in the coordination.

2. Cooperate with other trades in furnishing material and information for sleeves, bucks, chases, mountings, backing, foundations and wiring required for installation of mechanical items.

3. Coordinate all work with other trades and determine in advance where interfacing of the mechanical work and other work are required to be connected together. Provide all materials and equipment to make those connections. Submit shop drawings showing required connections where special conditions exist.

F. Discrepancies: Report immediately any error, conflict or discrepancy in Plans, Specifications and/or existing conditions. Do not proceed with any questionable items of work until clarification of same has been made. Should rearrangement or re-routing of ducts or piping be necessary, provide for approval the simplest layout possible for that particular portion of the work.

3.04 TEMPORARY FACILITIES AND CONTROLS

A. Comply with Instructions to Bidders requirements.

B. Permanent mechanical systems' equipment utilized for temporary heating, ventilating and cooling shall be started with all controls and safeties installed and operational. Start-up shall be done by a factory approved mechanic only.

C. Owner's warranties shall not be abridged by Contractor's use of the permanent systems' equipment prior to final acceptance. Warranty period shall begin at final completion.

3.05 MECHANICAL WORK CLOSEOUT

A. General: Refer to the Instructions to Bidders for general closeout requirements. Calibrate all equipment requiring same.

B. Record Drawings: Submit record set of drawings required in Instructions to Bidders and as previously specified in this Section.

C. Closeout Equipment/Systems Operations: Sequence operations properly so that work of project will not be damaged or endangered. Coordinate with seasonal requirements. Operate each item of equipment and each system in a test run of appropriate duration with the Owner's Representative present, and with the Owner's operating personnel present, to demonstrate sustained, satisfactory performance. Adjust and correct operations as required for proper performance. Clean and lubricate each system, and replace dirty filters, excessively worn parts and similar expendable items of the work.

D. Operation and Instruction: Provide twenty-four (24) hours of on-site training to Owner's personnel on all mechanical systems and equipment. Training shall include maintenance, lubrication, troubleshooting and repair. Contractor shall provide necessary written manuals and training aides explaining operational diagrams, emergency and alarm provisions, sequencing requirements, seasonal provisions, security, safety and similar features of the installed system. Three (3) copies of written manuals shall be left with Owner at end of training.

END OF SECTION

1 GENERAL

1.01 SECTION INCLUDES:

A. Items common to more than one section of Division 15 and general construction procedures and products. Work described in this Section applies to all Sections of Division 15.

1.02 STORAGE AND HANDLING

A. Deliver materials to the project site with manufacturer's labels intact and legible. Handle materials with care to avoid damage. Store materials inside protected from weather, dirt and construction dust. Where necessary to store outside, elevate well above grade and enclose with durable, waterproof wrapping. Label equipment as soon as it arrives at job site.

1.03 SUBMITTALS

A. Submit product data under provisions of Section 15010 and Instructions to Bidders.

B. Provide submittals for:

1. Motors.
2. Starters.
3. Alarm Panels.
4. Piping and Equipment Identification.
5. Valve Schedule.

2 PRODUCTS

2.01 QUALITY ASSURANCE

A. Refer to Instructions to Bidders for information regarding available alternatives to materials and equipment specified herein. Product listings are for informational purposes only and establish a general standard of quality.

B. Provide products which are compatible with other portions of the work and provide products with the proper and correct power and fuel burner characteristics and similar adaptations for the project.

2.02 MATERIALS

A. All materials and products used for construction shall be new, of the best grade, and the latest products as listed in printed catalog data.

B. All articles of a kind shall be the standard product of a single manufacturer.

C. Provide products which are compatible with other portions of the work and products which have the proper electrical power and fuel-burning characteristics

for this project.

D. Trade names and manufacturers names denote the character and quality of equipment desired and shall not be construed as limiting competition.

2.03 ELECTRIC MOTORS

A. Enclosure Type: Open drip-proof for normal concealed indoor use, guarded where exposed to employees or occupants. Type II for outdoor use, except weather-protected Type I where adequately housed.

B. Bearings: Ball or roller bearings, and design for thrust where applicable; permanent or pressure lubricated anti-friction. Sleeve-type bearings permitted only where indicated for light-duty fractional horsepower motors.

C. Construction: General purpose, continuous duty; NEMA design "B", except "C" for high starting torque applications.

D. Frames: For single phase motor sizes NEMA No. 48, except 56 for heavy-duty applications. NEMA "T" frames for 1 horsepower and larger polyphase motors.

E. Phases and Current: 1/3 horsepower and smaller capacitor-start single-phase; ½ horsepower and larger, squirrel-cage induction polyphase. Coordinate with actual current characteristics; specified in Division 16 and do not use 230/460 voltage motors on 208 voltage power or vise versa.

F. Service Factor: 1.35 for single-phase; 1.15 for polyphase.

G. Overload Protection: Built-in thermal with internal sensing device for stopping motor, and for signaling where indicated on single phase motors.

H. Speed: Not faster than synchronous speeds of 1800 RPM except where otherwise indicated.

I. Temperature Rating: Class B insulation, except where otherwise indicated or required for service indicated.

J. Starting Capability: As required for service indicated, but not less than 5 starts per hour.

K. Efficiency: The manufacturer's highest efficiency motors tested under procedures recommended by NEMA (IEEE Standard 112, Test Method B). Minimum 84% efficiency at 3 HP increasing to 90% above 15 HP. Submit manufacturer's data if motor nameplate does not indicate minimum efficiency.

L. Manufacturers: Century, General Electric, Lincoln, Louis Allis, Baldor, Wagner, Westinghouse or accepted substitute. Where selection of motor manufacturer is within Contractor's control (independent of mechanical equipment selection), provide motors produced by a single manufacturer.

2.04 STARTERS AND SWITCHES

A. General: Provide each motor with starter or switch as approved and recommended by manufacturer of motor or equipment of which motor is a part.

B. Magnetic Starters: Provide for ½ horsepower and larger motors, and for smaller motors on automatic control or with interlock switch. Include pilot lights, reset, trip-free relay on each phase, Hand-Off-Auto switch in cover, and devices for coordination with control system (including transformer for control circuit, verify holding coil voltage requirements with control system design). Provide automatic ambient temperature compensation for starter heaters.

C. Manual Switches: Provide on motors 1/3 horsepower and smaller except where automatic control or interlock is indicated. Include pilot light. Provide overload protection where not protected by panel board circuit breaker or fused disconnect switch.

D. Starter Characteristics: Type I general purpose enclosure with padlock ears and mounting supports. Starter type and size as recommended by motor manufacturer.

E. Manufacturers: General Electric, ITE, Allen Bradley, Cutler-Hammer, Square D or accepted substitute.

2.05 ELECTRICAL EQUIPMENT

A. Equipment Wiring: Interconnecting wiring within or on a piece of mechanical equipment shall be provided with the equipment unless required otherwise. Provide all necessary field wiring and devices from the point of connection indicated on the electrical drawings to each equipment item.

B. Control Wiring: All control wiring for mechanical equipment shall be provided under Section 15900, Controls and Instrumentation.

C. Codes: All electrical equipment and products shall bear the U.L. and/or C.S.A. label as required by governing codes and ordinances. Refer to paragraph 1.3, Quality Assurance for definition of testing agency certification requirements.

2.06 DRIVES

A. General: “V” section belt drives, multiple as required, sized on 1.5 times installed motor horsepower. Provide variable pitch motor sheaves on all one or two belt drives and standard slide rails or approved means of adjustment for each motor with belt drive. Use standard section belts and no sheave smaller than cataloged industry standard; provide countersunk center on shaft ends to receive speed counter tip.

B. Manufacturers: Dayton, Gates, Browning, or accepted substitute.

2.07 ACCESS PANELS

A. Access panels shall have same fire rating as surface where mounted.

B. Provide flush key cylinder locks on all access panels less than 8 feet above the floor in public spaces. Turn keys over to Owner at project completion. Screwdriver latches on all others.

C. Steel, 24” x 24” or as required. Complete with steel frame, hinged locating door, and prime coat finish. Type to match building construction.

D. Manufacturers: INRYCO/MILCOR Style DW, K or M panels as required by construction. Bilco, Potter-Roemer or accepted substitute.

2.08 UNIONS

A. Steel pipe union shall be 150-pound malleable iron, brass to iron seat, ground joint, black or galvanized to match pipe.

B. Copper pipe union shall be 200 psig working pressure. Bronze body. Solder ends.

C. Insulating unions shall be 250 psig working pressure. Pipe ends and material to match piping. Electric current below 1% of galvanic current. Gasket material as recommended by manufacturer. Epco or approved.

2.09 MISCELLANEOUS STEEL

A. Provide steel as required for adequate support of all mechanical equipment, angle or channel, I or H sections as required by application. Provide suitable base plates for stands and anchors for hanging equipment. Drill support holes only in flanges of structural center of length as possible. Apply on coat of black rust inhibitive enamel primer to shop fabricated items before delivery to job; other painting as specified herein. Provide shop drawings of supports especially constructed for this project. Burning of holes is not permitted.

2.10 PAINTING

A. Apply one coat of black rustoleum primer to shop fabricated items before delivery to job. Other painting as specified herein.

2.11 IDENTIFICATION MARKERS

A. Pipe Markers:

1. Adhesive pipe markers of width, letter size and background color conforming to ANSI A13.1.

2. Acceptable Manufacturers: Brady B350 with banding tape. Seaton, Zeston, Porter or accepted substitute.

B. Nameplates:

1. Engraved nameplates, 1/16 inches thick, laminated 3-ply plastic, center ply white, outer ply black, letters formed by exposing center ply.

2. Size: 3 inches by 5 inches nameplates with 1/4-inch high letters.

3. Manufacturers: Lamicoid. Seaton, Brady, Zeston or accepted substitute.

C. Valve Tags:

1. 1-1/2 inches diameter, 18-gauge polished brass tags with 3/16-inch chain hole and 1/4 inch high stamped, black-filled service designation.

2. Manufacturers: Seaton Style 250-BL, Brady, Zeston or accepted substitute.

D. Lettering and Graphics:

1. Coordinate names, abbreviations and other designations used in mechanical identification work with designations shown or scheduled. Provide numbers, lettering and wording as indicated for identification of mechanical systems and equipment.

2. Multiple Systems: Where multiple systems of same name are shown provide identification which indicates individual equipment number as well as service (examples: Chiller (CH) No. 1, Chiller (CH) No. 2, Air Conditioning Unit No. 1 (AC) No. 1, Air Conditioning Unit (AC) No. 2.)

2.12 VALVE SCHEDULES

A. Schedules: Modify Owner's existing valve schedules for each piping system to reflect current work. Indicate valve number, piping system, location of valve (room or space) and normal setting (open, closed, etc.). Mark valves which are intended for emergency shutoff and similar uses by special notation. In addition to mounted copies, furnish five (5) extra copies for maintenance manuals.

2.13 CONCRETE FOR MECHANICAL WORK

A. Provide strength classes per Uniform Building Code Chapter 19.

3 EXECUTION

3.01 ACCESS PANELS

A. Furnish and install access panels required for mechanical work. Access panels shall have same fire ratings as surface where mounted. Furnish panels of adequate size for valves and equipment requiring service and installed above ceilings, behind walls or in furring, complete with correct frame for type of building construction involved. Exact size, number and location of access panels are not necessarily shown. Use no panel smaller than 12 inches by 12 inches for simple manual access or smaller than 16 inches by 20 inches where personnel must pass through. Paint with color and finish to match surrounding architectural features, where exposed.

3.02 MECHANICAL EQUIPMENT WIRING

A. Provide all mechanical equipment motors, automatic temperature, limit, float and similar control devices required, with wiring complete from power source.

B. Provide properly rated motor overload and under voltage protection and all manual or automatic motor operating devices for all mechanical equipment.

C. Equipment and systems shown on the Drawings and/or specified, are based upon requirements of specific manufacturers which are intended as somewhat typical of several makes which may be approved. Provide all field wiring and/or devices necessary for a complete and operable system including controls for the actual selected equipment/system.

D. Provide all starters for mechanical motors**.**

3.03 PAINTING

A. General: Coordinate painting of mechanical equipment and items with products and methods specified under ESD requirements.

B. Painting Materials: material shall comply with ESD requirements.

C. Iron Work: Paint hangers, rods, anchors, guides, threads of galvanized pipe, bases, supports, uncoated sheet metal and other iron work without factory finish, exposed to weather, located in moist concealed spaces and moist equipment rooms one coat acid-resisting black paint. Apply one (1) coat Dixon's Aluminum Graphite No. 209 paint over the (1) coat primer as recommended by paint manufacturer to all hot metal surfaces.

D. Sheet Metal: Apply one coat of zinc chromate to mechanical sheet metal exposed to weather, except no painting required on aluminum or stainless steel. Apply one coat of flat black paint to the inside of unlined ducts behind all grilles and registers.

E. Insulated Piping and Other Insulated Surfaces: Paint insulated piping in half-round, split tile, or other inaccessible locations, one (1) coat asphalt emulsion.

3.04 MECHANICAL SYSTEM IDENTIFICATION

A. Piping System: Indicate each pipe system by its generic name (abbreviated) as shown; except vent and drainage piping. Comply with ANSI A13.1 for marker locations, letter sizes, and colors. Include arrows to show direction of flow and "Electric Traced" signs to identify heat cable wrapped piping.

B. Valve Identification: Tag all valves with brass disc and chain. Modify Owner’s existing valve charts indicating valve number, size, location, function and normal position. Use no duplicate numbers in Plumbing and Heating systems. Mount glazed frames containing one set of valve charts in the building as directed.

C. Each new piece of equipment shall bear a permanently attached identification plate, listing the manufacturer’s name, capacities, sizes and characteristics. In addition to the manufacturer’s identification plate, provide nameplates of black phenolic resin laminate and identify new equipment by name and number ½” high letters.

D. Mount valve schedule(s) as directed by Owner.

3.05 ACCESSIBILITY

A. Locate valves, thermometers, cleanout fittings and other indicating equipment or specialties requiring frequent reading, adjustments, inspection, repairs and removal or replacement conveniently and accessibly with reference to the finished building.

B. Thermometers and Gages: Install thermometers and gages so as to be easily read from the floors, platforms and walkways.

3.06 INSTALLATION

A. Locating and Positioning Equipment: Comply with all Codes, Regulations and observe good common practice in locating and installing mechanical equipment and material so that completed installation presents the least possible hazard. Maintain adequate clearances for repair, service and operation to all equipment and comply with Code requirements. Set all equipment level or as recommended by manufacturer.

B. Arrangement: Arrange ductwork and piping parallel with primary lines of the building construction, and with a minimum of 7' overhead clearance in all areas where possible. Conceal all piping and ductwork. Locate operating and control equipment properly to provide easy access. Give right-of-way to piping which must slope for drainage. Set all equipment level as recommended by manufacturer. Under no conditions shall beams, girders, footings or columns be cut for mechanical items. Casting of pipes into concrete is prohibited unless so shown on Drawings.

C. Anchorage: Anchor and/or brace all mechanical equipment, piping and ductwork to resist displacement due to seismic action, include snubbers on equipment mounted on spring isolators.

D. Adjusting: Adjust and calibrate all automatic mechanical equipment, mixing valves, flush valves, float devices, etc. Adjust flow rates at each piece of equipment or fixture.

E. Building Vapor Barrier: Wherever the building insulation vapor barrier is penetrated by mechanical piping, hangers, conduits, ductwork, etc., provide clear self-adhesive tape recommended by the insulation manufacturer around the penetrations.

3.07 SYSTEM ADJUSTMENT

A. Adjust and calibrate all automatic mechanical equipment, mixing valves, flush valves, float devices, etc. Adjust flow rates at each piece of equipment or fixture. Open and close all shutoff and control valves several times to insure tight glands.

3.08 CUTTING AND PATCHING

A. General: Comply with the requirements of Instructions to Bidders for the cutting and patching of other work to accommodate the installation of mechanical work. Do all necessary cutting and patching of existing yard surfaces required for completion of the mechanical work. Patch to match finish and color of adjacent surfaces.

END OF SECTION

1 GENERAL

1.01 WORK INCLUDED

A. Provide all pipe, piping fittings and all related components required for complete piping system. Refer to each specification section for each system (plumbing, hydronic, etc.) for pipe application.

1.02 REFERENCES

A. ANSI/ASME Sec. 9 - Welding and Brazing Qualifications.

B. ANSI/ASTM B32 - Solder Metal.

C. ANSI/AWS D1.1 - Structural Welding Code.

D. ASME - Boiler and Pressure Vessel Code.

E. ASTM A53 - Pipe, Steel, Black and Hot-Dipped Zinc Coated, Welded and Seamless.

F. ASTM A120 - Pipe, Steel, Black and Hot-Dipped Zinc Coated (Galvanized), Welded and Seamless, for Ordinary Uses.

G. ASTM A536 – Ductile Iron Castings.

H. ASTM F477 - Elastomeric Seals (Gaskets) for Joining Plastic Pipe.

I. AWS A5.8 - Brazing Filler Metal.

J. AWWA C601 - Standard Methods for the Examination of Water and Waste Water.

K. AWWA C606 – Standard Specification for Grooved and Shouldered Joints.

L. ASTM D1784 – PVC Piping.

M. ASTM D2661 – ABS Piping.

1.03 QUALITY ASSURANCE

A. Conform to ANSI/ASME B31.9 for pressurized system as well as all applicable codes.

B. Welding Materials and Procedures: Conform to ASME Code and applicable state labor regulations.

C. Welders Certification: In accordance with ANSI/ASME Sec 9. and ANSI/AWS D1.1.

D. All grooved joint couplings, fittings, valves, and specialties shall be the products of a single manufacturer. Grooving tools shall be of the same manufacturer as the grooved components.

E. All castings used for coupling housings, fittings

1.04 SUBMITTALS

A. Submit product data under provisions of Section 15010 and Instructions to Bidders.

B. Include data on pipe materials, pipe fittings and accessories.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Deliver products to site under provisions of Section 15010.

B. Store and protect products under provisions of Section 15010 and provide factory applied end caps each length of pipe and tubes to prevent damage to pipe-ends and eliminate dirt and moisture from inside of pipes and tubes.

2 PRODUCTS

2.01 WATER PIPING, ABOVE GRADE

A. Copper Tubing: ASTM B88, Type L, hard drawn. Fittings: ANSI/ASTM B16.22, cast brass, or ANSI/ASME B16.29, wrought copper. Joints (less than 3-inch): ANSI/ASTM 16.22 solder, Grade 95TA. Joints (greater than 3-inch): brazed.

1. At the contractor's option for sizes 1-1/2 inch and smaller, ANSI/ASTM B16.22, cast bronze or ANSI/ASME B16.29, wrought copper fittings with push-to-connect ends, 301 stainless steel internal components, and EPDM seals may be used for services to 200 PSI. Victaulic Permalynx.

B. At contractor's option with no additional cost to owner: for sizes larger than 2 inches, copper-tube dimensioned roll grooved copper tube with CIvtaulic style 607 installation-ready couplings with grade "EHP" gaskets and "Copper-Connection" fittings.

2.02 NATURAL GAS PIPING, ABOVE GRADE

A. ABOVE GRADE

1. Steel Pipe: ASTM A53 or A120, Schedule 40 black. Fittings: ANSI/ASME B16.3, malleable iron, or ASTM A234, forged steel welding type. Joints: Screwed for pipe two inches and under; ANSI/AWS D1.1, welded, for pipe over two inches.

B. BELOW GRADE (Natural Gas Only)

1. Polyethylene Pipe: PE pipe, supplied under this specification shall conform to the current edition of the specification for Thermoplastic Gas Pressure Pipe, Tubing and Fittings (ASTM D2513). The PE plastic compound shall be either Phillips TR-418 or Plexco P24BC and shall meet the requirements of Type II, Class B, Category 3, Grade P24, in ASTM D-1248 "Standard Specification for Polyethylene Plastics Molding and Extrusion Materials:.

2. Marking: Pipe and tubing furnished under this specification shall be marked in accordance with the current edition of the Specification for Thermoplastic Gas Pressure Pipe, Tubing and Fittings (ASTM D2513).

   a. The following information shall be included:

      1) Manufacturer

      2) Type of Pipe or Type of Tubing

      3) Nominal Size (e.g. 1-1/4", 2" etc.) or OD

      4) Wall Thickness or SDR

      5) Code No. Identifying Month of Production and Resin

      6) The words "Gas Pipe or "Gas Tubing"

   b. A code system which can be used to identify the above information in the records may be used.

3. Fittings: ASTM D2513 socket type. Joints: fusion welded. Provide minimum 14 gauge single strand, copper wire with orange color insulating coating.

C. ABOVE GRADE, FLEXIBLE

1. Standards & Certifications

   a. CSA International Certified Corrugated Stainless Steel Tubing (CSST) Flexible Gas Piping with Mechanical Attachment *AutoFlare*® Fittings that conform to the latest ANSI Standards for safe performance ANSI/CSA LC-1.

   b. Underwriters Laboratories Classification Listed for Thru Penetration Fire Stop Requirements Ratings to include one, two and four hour tests.

   c. Listed with FM (Factory Manual) requirements for Flammable Gas Piping Systems.

2. Stainless Steel Tubing

   a. Tubing shall be made from 300 series Stainless Steel Strip conforming to ASTM A240.

   b. Tubing shall be suitable for operation with Natural Gas and LP Gas (Propane).

   c. Tubing is rated for 25-PSI.

   d. Tubing must have elevated pressure ratings of 125G for sizes up to 1-1/4 inches and 25G for 1-1/2 and 2-inch sizes for high-pressure applications permitted by the Local Distribution Utility.

These elevated pressure ratings shall be demonstrated by test reports from the certification agency.

3. Plastic Jacket

   a. The jacket shall be extruded from fire-retarded Polyethylene.

   b. Chlorinated plastics such as PVC are not permitted.

   c. ASTM E-84 flame spread rating shal not exceed 25.

   d. ASTM E84 smoke density rating shall not exceed 50.

   e. Polyethylene is to be resistant to UV.

4. *AutoFlare*® Mechanical Attachment Fittings.

   a. Fittings shall be made from yellow brass.

   b. Fittings shall be equipped with a stainless steel insert to pioot on the tubing ID and provide a reliable flaring operation.

   c. AutoFlare fittings are tested and listed by CSA International for concealed use where required.

   d. Fittings shall provide a metal-to-metal seal (no gaskets).

5. Protective Devices

   a. Striker plates shall be listed as part of the OMEGAFLEX, INC. Trac Pipe system and shall be marked with the symbol of the Manufacturer (OMEGAFLEX, INC.) and the listing Agency (CSA International).

   b. Striker plates shall be made from carbon steel, heat-treated to RB40. Striker Plates are available in Quarter, Half, Three Quarter, Full and 6 x 17 Configurations.

6. Accessories

   a. Termination Mount Fittings are to be used to provide a secure termination for the tubing at moveable appliance locations and other “stub-out” points depending on building construction. Termination mount accessories consist of a plated carbon steel plate or brass mounting flange and an AutoFlare fitting. Fittings at termination mounts must be accessible and provide a fitting joint exterior to the building floor or wall.

   b. Meter Termination Fittings may be used for exterior wall penetrations at meter locations and other penetrations such as roof tops units. Meter termination consists of a plated carbon steel mounting plate and sleeve and an AutoFlare fitting. Fittings at meter termination outlets must be accessible and provide a fitting joint exterior to the building.

c. Shut-off valves must be approved for fuel gas service and must be rated for the pressure of the gas piping system installed. For elevated pressure sections an approved valve must be located upstream from the pounds-to-inches regulator.

d. Electrical Bonding/Grounding

1) The TracPipe flexible gas piping system must be bonded to an effective ground-fault current path per NFPA 70 and NFPA 54 in accordance with the instructions contained in this section.

2.03 ACID RESISTANT WASTE/VENT PIPING

A. Pipe: Schedule 40 flame retardant polypropylene or silicon alloyed cast iron pipe and fittings with caulked, mechanical or thermal fusion type joints. Make caulked joints with specially treated jute and poured lead. Connect mechanical joints with stainless steel couplings having 1-piece, sintered, nonporous Teflon liners. Make fusion joints in accordance with manufacturer's instructions. Union nut/compression ring mechanical joints for polypropylene piping may be used in waste and vent piping installations above finish floor; subject to approval be jurisdictional authority.

B. Manufacturers: Duriron, Enfield, Nalgene or accepted substitute.

2.04 HEATING WATER PIPING, ABOVE GROUND

A. Steel Pipe: ASTM A53 or A120, Schedule 40, black. Fittings: ANSI/ASTM B16.3, malleable iron or ASTM A234, forged steel welding type fittings. Joints: Screwed for pipe 2 inches and under, or ANSI/AWS D1.1, welded for pipe over 2 inches.

B. Copper Tubing: ASTM B88, Type L, hard drawn. Fittings: ANSI/ASTM B16.22 cast brass or ANSI/ASME B16.29 solder wrought copper. Joints: ASTM B32, Grade 95TA or ANSI/AWS A5.8, BCuP silver braze. Brazed for pipe 2 inches and over, soldered for pipe under 2 inch.

C. At contractor's option with no additional cost to owner: for sizes larger than 3 inch, cut grooved black steel pipe with Victaulic style 77 couplings with grade "E" gaskets and appropriate fittings. Type "L" copper Victaulic approved as optional material.

2.05 EQUIPMENT AND COOLING COIL DRAINS AND OVERFLOWS

A. Copper Tubing: ASTM B88, Type L, hard drawn. Fittings: ANSI/ASTM B16.22, cast brass, or ANSI/ASME B16.29 solder wrought copper. Joints: ASTM B32, solder, Grade 95TA or ANSI/AWS A5.8, BCuP silver braze.

2.06 MISCELLANEOUS PIPING MATERIAL

A. Welding Materials: Provide welding materials as determined by the installer to comply with installation requirements. Comply with Section 2-C, ASME Boiler Code for welding materials.

B. Soldering and Brazing Materials: Provide soldering materials as determined by the installer to comply with installation requirements.

1. Tin-Antimony Solder: ASTM B32, Grade 95TA.

2. Lead-Free Solder: ASTM B32, Grade HB. Harris "Bridgit" approved.

3. Silver Solder: ASTM B32, Grade 96.5TS.

C. Gaskets for Flanged Joints: ANSI B16.21; full-faced for cast-iron flanges; raised-face for steel flanges. Pressure and temperature rating required for the service indicated.

D. Sleeve Seal: Rubber-link pipe wall and casing closure. Thunderline Link-Seal. For fire rated wall, floor or ceiling penetrations, 3-M "CP-25" caulk, "No. 303" putty and/or "PSS 7904" sealing system.

E. Tracer Wire: 14 gauge, single strand, copper wire with blue insulation for water, green for sanitary and storm sewers, and orange for gas. 3M "DBY" direct bury splice kit required at all splices.

2.07 FLANGES, UNIONS, AND COUPLINGS

A. Pipe Size 2 Inches and Under: 150 psig malleable iron unions for threaded ferrous piping; bronze unions for copper pipe, soldered joints.

B. Pipe Size Over 2 Inches: 150 psig forged steel slip-on flanges for ferrous piping; bronze flanges for copper piping; neoprene gaskets for gas service; 1/16 inch thick performed neoprene bonded to asbestos.

C. Grooved and Shouldered Pipe End Couplings: Malleable iron housing clamps to engage and lock, designed to permit some angular deflection, contraction, and expansion; "C" shape composition sealing gasket; steel bolts, nuts, and washers; galvanized couplings for galvanized pipe.

D. Dielectric Connections: Union with galvanized or plated steel threaded end, copper solder end, water impervious isolation barrier. Victaulic "Clear Flow", Epco or accepted substitute.

2.08 PIPE SLEEVES

A. Minimum 20 gauge galvanized steel in concrete, 18 gauge in all other construction. Provide ½-inch clearance around pipe or insulation. Provide UL approved fire-rated assemblies/caulking. 3M or accepted substitute.

2.09 GLYCOL

A. Inhibited propylene glycol.

2.10 HEAT TRACE

A. Provide UL or CSA certified, self regulating, pipe heat trace heating cable on all outside pipe exposed to outside air temperature. Provide outside air thermostat control of heat trace that turns heat trace on, only when outside temperature is

below 40^0F. Submit schedule for each pipe indicating pipe size, insulation thickness, heat trace watt per foot and wrapping pitch (inches of lineal pipe for complete wrap of heat trace), based on 50^0F pipe temperature and 0^0F outside air temperature.

B. Acceptable Manufacturers: Raychem, Chromalox, or accepted substitute.

3 EXECUTION

3.01 PREPARATION

A. Ream pipe and tube ends. Remove burrs or bevel plain end ferrous pipe.

B. Remove scale and dirt, on inside and outside, before assembly.

C. Prepare piping connections to equipment with flanges or unions.

3.02 INSTALLATION

A. Provide non-conducting dielectric connections wherever jointing dissimilar metals.

B. Route piping in orderly manner, maintain gradient and conceal all piping unless otherwise indicated.

C. Install piping to conserve building space, not to interfere with use of space or access panels and parallel with walls.

D. Group piping whenever practical at common elevations.

E. Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment. Provide loops, swing joints, pinchers, runouts and spring pieces to prevent damage to piping or equipment.

1. For water systems, use adequate numbers of Victaulic Style 177/77 flexible couplings in header piping to accommodate thermal growth and contraction, and for the elimination of expansion loops. (In accordance with Victaulic instructions and as approved by the engineer). Where expansion loops are required, use Victaulic Style 177/77 couplings on the loops.

F. Provide clearance for installation of insulation and access to valves and fittings.

G. Slope water piping and arrange to drain at low points and provide drain valve.

H. Where pipe support members are welded to structural building framing, scrape, brush clean, and apply one coat of zinc rich primer to welding.

I. Prepare pipe, fittings, supports, and accessories not prefinished, ready for finish painting. Refer to Section 15050.

J. Establish invert elevations, slopes for drainage to 1/4 inch per foot minimum. Maintain gradients.

K. Pitch vent piping at 1/4 inch per 10 feet minimum.

L. Establish elevations of all heating piping to ensure minimum of 1 inch pitch for every 40 feet to low point drip or drains.

M. Unions and Flanges: At all equipment to permit dismantling and elsewhere as consistent with good installation practice.

N. Tracer Wire: Provide tracer wire as close to underground non-metallic water, sanitary and storm sewers and gas pipe in the trench as possible. Tracer wire shall be accessible at grade via all services, valve and meter boxes, curb cocks, cleanouts at the building, manholes (inside the cover near the top), etc. Locate all points on the record as-installed drawings. Splice into utility tracer system where available. Comply with code requirements.

O. Pipe Sleeves: Lay out work in advance of pouring concrete and furnish and set sleeves necessary to complete work.

1. Floor Sleeves: Provide sleeves on pipes passing through concrete construction. Extend sleeve 2-inches above finished floor. Caulk all pipes passing through floor with nonshrinking grout or approved caulking compound. Provide Link-Seal sleeve sealing system for slab on grade. Caulk/seal all piping passing through fire rated building assemblies with UL rated assemblies. Provide fire-rated assemblies per local code requirements.

2. Wall Sleeves: Provide sleeves on pipes passing through concrete or masonry construction. Provide sleeve flush with finished face of wall. Caulk all pipes passing through walls with nonshrinking caulking compound. Caulk/seal all piping passing through fire rated building assemblies with UL rated assemblies. Provide fire-rated assemblies per local code requirements.

P. Expansion and Flexibility: Install all work with due regard for expansion and contraction to prevent damage to piping, ductwork, equipment, building and its contents. Provide piping offsets, loops, approved type expansion joints, anchors or other means to control piping movement and to minimize pipe forces.

Q. Escutcheons: Install on all exposed pipes passing through wall or floors and on fixture stops and waste connections to wall.

3.03 EXCAVATION

A. General: Do not excavate for mechanical work until the work is ready to proceed without delay, to minimize the total time lapse from excavation to completion of backfilling. Comply with all applicable Federal and state safety regulations.

B. Width: Excavate for piping with 6 inches to 9 inches clearance on both sides of pipe, except where otherwise shown or required for proper installation of pipe joints, fittings, valves and other work. Excavate for other mechanical work to provide minimum practical but adequate working clearances.

C. Depth for Direct Support: For work to be supported directly on undisturbed soil, do not excavate beyond indicated depths, and hand-excavate the bottom cut to accurate elevations. Support the following work on undisturbed soil at the bottom of the excavations:

1. Piping of 5 inches and less pipe/tube size.

2. Cast-in-place concrete.

D. Depth for Subbase Support: For large piping (6 inches pipe size and larger), tanks and where indicated for other mechanical work, excavate for installation of subbase material in the depth indicated, or, if not otherwise indicated, 6 inches below bottom of work to be supported.

E. Depth for Unsatisfactory Soil Conditions: Where unsatisfactory soil condition at the bottom of excavation exists, excavate additional depth as directed to reach satisfactory soil-bearing condition. Backfill with subbase material, compacted as directed, to indicated excavation depth.

F. Excavated Materials: Store excavated material (temporarily) near the excavation, in a manner which will not interfere with or damage the excavation or other work. Do not store under trees (within the drip line). Retain excavated material which complies with the requirements for backfill material. Dispose of excavated material which is either in excess of quantity needed for backfilling or does not comply with requirements for backfill material.

3.04 BASE PREPERATION

A. Subbase Installation: Where indicated, install subbase material to receive mechanical work, and compact by tamping to form a firm base for the work. For 4 inches and larger piping, horizontal cylindrical tanks and similar work, shape and subbase to fit the shape of the bottom 90 degrees of the cylinder, for uniform continuous support. Provide finely-graded subbase material for wrapped, coated and plastic pipe and tank. Shape subbases and bottoms of excavation with recesses to receive pipe bells, flanges connections, valves and similar enlargements in the piping systems and set bottom of trench at proper pitch and correct elevations with subbase material.

3.05 BACKFILLING

A. Do not backfill until installed mechanical work has been tested and accepted wherever testing is indicated. Install drainage fill where indicated, and tamp to a uniform firm density. Backfill with finely-graded subbase material to 6 inches above wrapped, coated and plastic piping and tanks, and to center line of other tanks (where recommended by tank manufacturer, use "pea gravel" backfill). Condition backfill material by either drying or adding water uniformly, to whatever extent may be necessary to facilitate compaction to the required densities. Do not backfill with frozen materials.

3.06 DISINFECTION OF DOMESTIC WATER PIPING SYSTEM

A. Prior to starting work, verify system is complete, flushed and clean.

B. Comply with all applicable code requirements including procedure outlined by Health Department.

3.07 CLEANING

A. General: Clean all dirt and construction dust and debris from all mechanical piping systems and leave in a new condition. Touch up paint where necessary.

B. Gas Piping: Blow clear of debris with nitrogen or oil free air. Clean all low point strainers and pockets.

C. Heating Water Systems:

1. Use one pound of trisodium phosphate per 50 gallons in the system, or one pound of sodium carbonate for each 30 gallons in the system or one pound of sodium hydroxide (lye) for each 50 gallons in the system.

2. Fill, vent and circulate the system with this solution at design operating temperature. After circulating for four hours, drain and fill with fresh water including glycol.

3. Test for pH and add sufficient amount of the cleaning chemical to obtain a pH between 7 and 8.

4. Clean all strainers and remove start-up strainers (from suction diffusers) after the system has operated for one week.

3.08 TEST

A. General

1. Minimum duration of two hours or longer, as directed for all tests. Furnish report of test observation signed by qualified inspector. Make all tests before applying insulation, backfilling, or otherwise concealing piping or connecting fixtures or equipment. Where part of the system must be tested to avoid concealment before the entire system is complete, test that portion separately, same as for entire system.

B. Water Piping: Hydrostatic pressure of 100 psig without loss for four hours.

C. Natural Gas Piping: One half hour minimum air at 60 psig for 2 psig gas, and 15 minutes at 10 psig for 7 inch water gauge natural gas or as approved and certified by serving utility.

D. Heating Water Piping: 75 psig hydrostatic for 30 psig systems without loss for four hours.

END OF SECTION

1 GENERAL

1.01 WORK INCLUDED

A. The requirements of this Section apply to the valving for the systems specified elsewhere in Division 15.

1.02 QUALITY ASSURANCE

A. Provide valves from a single manufacturer where possible with manufacturer's name and pressure rating marked on valve body.

B. All castings used for valve bodies shall be date stamped for quality assurance and traceability.

C. Valve size shall be the same as connecting pipe size unless otherwise noted.

D. Grooved end valves shall be of the same manufacturer as the adjoining couplings.

1.03 SUBMITTALS

A. Submit product data under provisions of Section 15010.

B. Include data on valves and accessories.

2 PRODUCTS

2.01 BALL, CHECK, STOP CHECK, NON SLAM CHECK, BUTTERFLY, GATE, GLOBE, LUBRICATED PLUG VALVE TYPES

A. Manufacturers: Crane, ITT, Grinnell, Hammond, Jenkins, Kennedy, Mueler, Lunkenheimer, Milwaukee, Nibco, Powell, Appolo, Stockham, Walworth, Legend or accepted substitute. Grooved end valves Victaulic, Gustin-Bacon or accepted substitute. Victaulic (grooved end) and Grinnell (screwed/flanged) numbers are given except as noted.

B. Domestic Water Systems:

1. Valves 2 inches and smaller.

a. Ball:

1) Victaulic Series 589 (brass body) and 569 (stainless steel body).

2) Fig. 3500. 125 psi, bronze body, full port.

b. Check, Fig. 3300. Class 125, bronze body, horizontal swing.

c. Gate, Fig. 3050. 150 psi, bronze body, non-rising stem.

2. Valves 2 inches and larger:

a. Butterfly Valve:

1) (<250 deg. F), Victaulic MasterSeal; Stem shall be offset from the disc centerline to provide full 360-degree circumferential seating, pressure responsive seat, 300 psi, ductile iron body.

2) (<230 deg. F), Victaulic Series 608; copper-tube dimensioned grooved ends, 300 psi, cast bronze body.

3) (<200 deg. F), Fig. 8000. 150 psi, cast iron body.

b. Check:

1) Victaulic Series 716, 300 psi, ductile iron body, horizontal or vertical, with stainless steel spring.

2) Fig. 6300 A. Class 125, cast iron body, horizontal swing.

c. Gate, Fig. 6020 A. Class 125, cast iron body, non-rising stem.

d. Globe, Fig. 6200 A. Class 125, cast iron body, renewable seat, bronze mounted.

C. Heating Water System:

1. Valves 2 inches and smaller:

a. Ball:

1) (<230 deg. F)Victaulic Series 589 (brass body, standard port) and 569 (stainless steel body, full port), 300 psi.

2) (<200 deg. F), Fig. 3500 (for hot water only). 125 psi, bronze body, full port.

b. Check, Fig. 3300. Class 125, bronze body, horizontal swing.

c. Gate, Fig. 3050. 150 psi, bronze body, non-rising stem.

d. Globe, Fig. 3240. 150 psi, bronze body.

2. Valves 2-1/2 inches and larger:

a. Butterfly

b. Butterfly Valve: Stem shall be offset from the disc centerline to provide full 360-degree circumferential seating.

1) (<250 deg. F), Victaulic MasterSeal (pressure responsive seat) / AGS-Vic300 (disc mounted seal); 300 psi ductile iron body.

2) (<200 deg. F), Fig. 8000 (for hot water only). 150 psi,

cast iron body.

c. Check:

1) Victaulic Series 716 (300 psi) and Series W715 (230 psi), ductile iron body, horizontal or vertical, with stainless steel spring.

2) Fig. 6300 A. Class 125, cast iron body, horizontal swing.

d. Gate, Fig. 6020 A. Class 125, cast iron body, non-rising stem.

e. Globe, Fig. 6200 A. Class 125, cast iron body, renewable seat, bronze mounted.

D. Natural Gas:

1. 5 psig or less, 2 inches and smaller ball valves, Watts 6000UL. Threaded, 250 psi, 2 piece, bronze..

2. 5 psig or less, 2-1/2 inches and larger, 125 psi, all bronze or cast iron body/bronze trim. AGA approved.

2.02 WATER PRESSURE REDUCING VALVES

A. Up to 2 inches : Bronze body, stainless steel and thermoplastic internal parts, threaded ends.

B. Over 2 inches: Cast iron body , bronze fitted, elastomer diaphragm and seat disc, flanged ends.

C. Provide each pressure reducing valve with strainer on inlet or internal strainer.

D. Manufacturers: Cash-Acme, Fisher, Foster, Leslie, McAlear, Spence, Watts or accepted substitute.

2.03 RELIEF VALVES

A. Bronze body, teflon seat, steel stem and springs, automatic, direct pressure actuated, capacities ASME certified and labeled.

B. Manufacturers: Cash-Acme, Fisher, Foster, Spence, Watts or accepted substitute.

2.04 REDUCED PRESSURE BACKFLOW PREVENTER

A. Reduced pressure backflow preventer complete with shutoff valves, two separate check valves, differential relief valve and test cocks. USC Foundation for Cross Connection Control, State Health officials and serving utilities approved. Bronze bodies on units 2 inches and smaller, and cast iron bodies with bronze trim on units 2-1/2 inches and larger.

B. Manufacturers: Febco, Conbraco, Wilkins, Watts or accepted substitute.

2.05 DOUBLE CHECK BACKFLOW PREVENTER

A. Provide a double check valve assembly complete with isolation valves, check module assembly, test cocks, and strainer. USC Foundation for Cross Connection Control, State Health officials and serving utilities approved. Bronze bodies on units 2 inches and smaller, and cast iron bodies with bronze trim on units 2-1/2 inches and larger.

B. Manufacturers: Febco, Conbraco, Wilkins, Watts or accepted substitute.

2.06 GAS PRESSURE REGULATORS

A. Size and capacity as required for connected load. Style and model as approved by gas supplier.

B. Manufacturers: Maxitrol, Rockwell, Fisher, Reliance, or accepted substitute.

2.07 WATER BALANCING VALVE

A. Balancing fitting with differential pressure taps, flow setting indicating pointer, brass or bronze body and trim with orifice flow restriction. 300 psi rated.

B. Manufacturers: Victaulic / Tour Anderson, B&G "Circuit Setter", Taco, Armstrong, Thrush, Wheatley, Flow Design or accepted substitute. At contractor's option, balancing valves 3 inches and larger may be butterfly style, Victaulic MasterSeal, Jenkins No. 222 EL, or accepted substitute as specified in Section 15050.

C. Packaged coil components consisting of required coil valving, strainers, unions, hoses, etc., may be supplied. Victaulic Koil-Kit Series 799 or 79V, with Series 78U Union Port Fitting, Series 78Y Strainer/Ball Valve, Series 78T Union/Ball Valve, required braided hoses, and Series 793/794 Differential Pressure Controllers. The coil packaged shall be provided with a meter to be left with the owner after installation.

2.08 VALVE OPERATORS

A. Butterfly Valve Operators: Locking lever for shut-off service; "Memory Stop" for lever handle and slotted index plate for infinite number of settings for throttling service; gear operator with babbitt sprocket rim for chain operated valves and gear operators on all 6 inches or larger valves.

B. Butterfly Valve Style: Grooved end type or lug type with cap screws, for all valves utilized for equipment isolation for servicing.

2.09 GAS EARTHQUAKE VALVE

A. Gas valve providing automatic shutoff in case of earthquake. UL listed, AGA certified and FM approved. The sensing means of the valve or system to actuate shutoff within 5 seconds when subjected to a horizontal, sinusoidal oscillation having a peak acceleration of 0.3G (2.94m/s^2) for a period of 0.4 seconds. The sensing means of valve or system not to actuate the shutoff means when subjected for 5 seconds to horizontal, sinusoidal oscillations having

1. A peak acceleration of 0.4G (3.94 m/s^2) with a period of 0.1 second,

2. A peak acceleration of 0.08G (0.078 m/s^2) with a period of 0.4 second, and

3. A peak acceleration of 0.08G (0.078 m/s^2) with a period of 1.0 second.

B. Valve requires manual reset. Provide all required spare parts to allow resetting after being activated. Valve to be same size as line size installed. Pacific Seismic or accepted substitute.

3 EXECUTION

3.01 INSTALLATION

A. Provide clearance for installation of insulation and access to valves and fittings.

B. Provide access where valves and fittings are not exposed. Coordinate size and location of access door with Section 15050.

C. Install valves with stems upright or horizontal, not inverted.

D. Provide one plug cock wrench for every five plug cocks sized 2 inches and smaller. Provide each plug cock sized 2-1/2 inches and larger with a wrench with set screw.

E. Mechanical Actuators: Install mechanical actuators with chain operators where indicated, where valves 4 inches and larger are mounted more than 7 feet above the floor, and where manual operation is difficult because of valve size, pressure differential or other operating conditions. Drop chains to 6 feet, 6 inches above the floor.

F. Lubricant-Seal: Select and install plug valves with lubricant-seal except where frequent usage is indicated or can be reasonably expected to occur.

G. Grooved joint valves shall be installed in accordance with the manufacturer's latest published installation instructions. The seat material shall be suitable for the intended service. The coupling manufacturer's factory-trained representative shall provide on-site training for the contractor's field personnel in the proper use of grooving tools and installation of grooved joint products. The representative shall periodically visit the job site to ensure best practices in grooved joint installations are being followed. (A distributor's representative is not considered qualified to conduct the training.)

H. Fluid Control: Install gate, ball, globe, plug, and butterfly valves to comply with ANSI B31. Install check valves where indicated and where flow reversal is obviously not desirable and can be reasonably expected to occur, including piping at the discharge of pumps. Install silent check valves where necessary to eliminate water hammer occurring from reversal of flow.

I. Application: Valve type and style as shown on the Drawings. Where style is not indicated, use the following:

1. Domestic Water: Ball valves for 2 inches and smaller and butterfly for 2 inches and over.

2. Heating Water: Use gate valves in mechanical and/or boiler rooms and globe valves for throttling service. For temperatures up to 230 deg. F, ball and butterfly valves may be used with lever operators with infinite number of settings up to 4 inch sizes and gear operator with setting indictor on larger sizes.

3. Use non-rising stem gate valves.

END OF SECTION

1 GENERAL

1.01 WORK INCLUDED

A. Provide pipe and equipment hanger, support, anchors and all related items for complete systems.

1.02 QUALITY ASSURANCE

A. Provide pre-manufactured horizontal piping and ductwork hangers, clamps, hanger rod, shields, supports, etc.

B. Seismic requirements: Provide seismic restraints in accord with the latest edition of "Seismic Restraint Manual Guidelines" as published by SMACNA. Seismic Hazard Level (SHL) of "A". A lower SHL will be allowed provided the contractor provides calculations stamped by a registered professional structural engineering in the state the project is located indicating a lower SHL is acceptable.

1.03 SUBMITTALS

A. Submit product data under provisions of Section 15050.

B. Submit construction details, and performance characteristics for each type and size of anchor, hanger and support.

2 PRODUCTS

2.01 HANGERS AND SUPPORTS

A. Listed Types: The Manufacturers Standardization Society (MSS) Piping Types listed with Grinnell figure numbers in parentheses where applicable (or other manufacturer's as noted). ITT Grinnell, Elcen, Michigan, Super Strut, Kindorf, Unistrut or accepted substitute.

B. Horizontal Piping Hangers and Supports:

1. Adjustable Clevis Hanger: MSS Type 1 (Fig. 260).

2. Adjustable Band Hanger: MSS Type 7 (Fig. 97), fabricated from steel.

3. Adjustable Swivel-Band Hanger: MSS Type 10 (Fig.70).

4. Clamp: MSS Type 4 (Fig. 212, 216).

5. Double-Bolt Clamp: MSS Type 3 (Fig. 295A, 295H), including pipe spacers.

6. Pipe Anchors: (Carpenter & Peterson Fig. 145CI) Steel weld type to pipe for sizes up to 20 inches in diameter.

7. Single-Roll Support: MSS Type 42 (Fig. 174), including axle-roller and threaded sockets.

8. Adjustable Roller Hanger: MSS Type 43 (Fig. 181), including axle-roller and clevis.

9. Adjustable Roll/Base: MSS Type 46 Fig. 274), including roller, adjustable base and stand.

10. Rollers for Channel Support Systems: Grinnell Fig. 1901, 1902, 1911, 815, or 816 for pipe sizes up to 18 inches in diameter.

11. Sliding Support Base: MSS Type 35 (Grinnell 600 series). Base and guide.

12. Adjustable Saddle-Support: MSS Type 36 (Fig. 258) and MSS Type 37 (Fig. 259), including saddle, pipe and reducer. Fabricate base-support from steel pipe and include cast-iron flange or welded-steel plate.

C. Equipment and Piping Supports

1. Channel Support System: Galvanized, 12 gauge channel and bracket support systems, single or double channel as indicated on the Drawings or as required by piping and equipment weights. Grinnell "Power "Strut" channel.

2. Steel Brackets: Welded structural steel shapes complying with one of the following:

a. Light Duty: MSS Type 31 (Fig. 194).

b. Medium Duty: MSS Type 32 (Fig. 195).

c. Heavy Duty: MSS Type 33 (Fig. 199).

D. Vertical Pipe Clamps

1. Two-Bolt Riser Clamp: MSS Type 8 (Fig. 261).

2. Four-Bolt Riser Clamp: MSS Type 42 include pipe spacers at inner bolt-holes.

E. Hanger Rod Attachment

1. Hanger Rod: Right hand threaded, (Grinnell Fig. 140 or 146 for all sizes).

2. Turnbuckles: MSS Type 13 (Fig. 230).

3. Weldless Eye-Nut: MSS Type 17 (Fig. 290).

4. Malleable Eye-Socket: MSS Type 16 (Fig. 110R).

5. Clevises: MSS Type 14 (Fig. 299).

F. Building Attachments

1. Concrete Inserts: MSS Type 18 (Fig. 282), steel or Grinnell Power-Strut PS349 continuous channel.

2. Clamps: MSS Type 19 (Fig. 285, 281), Type 20, 21 (Fig. 225, 226, 131), Type 23 (Fig. 86, 87,88), Type 25 (Fig. 227), Type 27 through 30 where applicable.

2.02 SADDLES AND SHIELDS

A. Listed Types: The Manufacturers Standardization Society (MSS) Piping Types listed with Grinnell figure numbers in parentheses where applicable (or other manufacturer's as noted).

B. Protection Saddles: MSS Type 39 (Fig. 160).

C. Protection Shields: MSS Type 40 (Fig. 167).

D. Preinsulated Pipe Supports: Pipe Shields Inc. or accepted substitute.

1. Pipe supported on rods - Model A1000, through A4000 and A9000.

2. Pipe supported on flat surfaces - Model A1000, A2000, A5000 through A7000.

3. Pipe supported on pipe rolls - Model A3000 through A6000 and A8000.

2.03 MISCELLANEOUS HANGER MATERIALS

A. Metal Framing: Provide products complying with NEMA STD ML 1.

B. Steel Plates, Shapes and Bars: ASTM A-36.

C. Cement Grout: Portland Cement (ASTM C-150, Type I or Type III) and clean uniformly graded, natural sand (ASTM C-404, Size No. 2). Mix at a ratio of 1.0 part cement to 3.0 parts sand, by volume with only the minimum amount of water required for placement and hydration.

D. Heavy Duty Steel Trapezes: Fabricate from steel shapes selected for the loads required; weld steel in accordance with AWS Standards.

E. Pipe Guides: Provide factory-fabricated guides, of cast semi-steel or heavy fabricated steel, consisting of a bolted two-section outer cylinder and base with a two-section guiding spider bolted tight to the pipe. Size guide and spiders to clear pipe and insulation (if any), and cylinder. Provide guides of the length recommended by the manufacturer to allow indicated travel.

F. Standard Bolts and Nuts: ASTM A 307, Grade A.

G. Concrete Anchors: Rawl Lok/Bolt, Hilti "HSL," ITT Phillips, Red Head Wedge Anchors, Ramset Trubolt or Dynabolt or accepted substitute.

H. Shop Primer: Manufacturer's standard rust inhibitive primer.

3 EXECUTION

3.01 INSTALLATION OF HANGERS AND SUPPORTS

A. General: Proceed with the installation of hangers, supports and anchors only after the required building structural work has been completed in areas where the work is to be installed. Correct inadequacies including (but not limited to) the proper placement of inserts, anchors and other building structural attachments.

1. Install hangers, supports, clamps, and attachments to support piping and equipment properly from the building structure. Use no wire or perforated metal to support piping, and no supports from other piping or equipment. For exposed continuous pipe runs, install hangers and supports of the same type and style as installed for adjacent similar piping.

2. Prevent electrolysis in the support of copper tubing by the use of hangers and supports which are copper plated, or by other recognized industry methods.

3. Support fire sprinkler piping independently of other piping and in accordance with NFPA Pamphlet 13.

4. Arrange supports to prevent eccentric loading of joists and joist girders. Locate supports at panel points only.

5. Install hangers and supports to provide the indicated pipe slopes, and so that maximum pipe deflections allowed by ANSI B31 are not exceeded. Comply with the following installation requirements:

a. Clamps: Attach clamps, including spacers (if any), to piping outside the insulated piping support. Do not exceed pipe stresses allowed by ANSI B31.

b. Insulated Pipe Supports: Insulated pipe supports shall be supplied and installed on all insulated pipe and tubing.

c. Load Rating: All insulated pipe supports shall be load rated by the manufacturer based upon testing and analysis in conformance with ASME B31.1, MSS SP-58, MSS SP-69 and MSS SP-89.

d. Support Type: Manufacturer's recommendations, hanger style and load shall determine support type.

e. Insulated Piping Supports: Where insulated piping with continuous vapor barrier or where exposed to view in finished areas is specified, install hard maple wood insulation shields (Elcen Fig. 216) or steel pipe covering protection shields (MSS type 39) at each hanger.

B. Provisions for Movement:

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

2. Install hangers and supports so that equipment and piping live and dead loading and stresses from movement will not be transmitted to connected equipment.

C. Pipe Hangers and Supports:

1. Vertical Spacing: Support at base, every floor height not exceeding 10 feet and required by Code and just below roof line.

2. Screwed or Welded Steel or Copper Piping: Maximum hanger spacing shall be as follows:

	i. Steel		Copper
3.	1-1/4 inches and smaller	6 foot span	5 foot span
4.	1-1/2 inch pipe	9 foot span	6 foot span
5.	2 inch pipe	10 foot span	10 foot span
6.	2-1/2 inch	11 foot span	10 foot span
7.	4 inches and larger	12 foot span	10 foot span

8. Install additional hangers or supports at concentrated loads such as pumps, valves, etc. to maintain alignment and prevent sagging.

9. Install hangers to provide minimum 1/2 inch space between finished covering and adjacent work.

10. Place a hanger within 12 inches of each horizontal elbow.

11. Support Rod: Hanger support rods sized as follows:

12.	Pipe Size	Rod Diameter	Max. Load
13.	2 inches and smaller	3/8 inch	610 lb.
14.	2-1/2 to 3 inches	1/2 inch	1130 lb.
15.	4 inches	5/8 inch	1810 lb.
16.	6 inches	3/4 inch	2710 lb.
17.	8 through 12 inches	7/8 inch	3770 lb.

D. Adjust hangers and supports to bring piping to proper levels and elevations.

E. Provide all necessary structural attachments such as anchors, beam clamps, hanger flanges and brackets in accordance with MSS SP-69. Attachments to beams wherever possible. Supports suspended from other piping, equipment, metal decking, etc., are not acceptable.

F. Horizontal banks of piping may be supported on common steel channel member spaced not more than the shortest allowable span required on the individual pipe. Maintain piping at its relative lateral position using clamps or clips. Allow lines subject to thermal expansion to roll axially or slide. Size channel struts for piping weights.

3.02 INSTALLATION OF ANCHORS

A. Install anchors at the proper locations to prevent stresses from exceeding those permitted by ANSI B31, where recommended in SMACNA "Seismic Restraint Manual" or exceeding manufacturer's recommended loading, and to prevent the transfer of loading and stresses to connected equipment.

B. Welding: Provide anchor by welding steel shapes, plates and bars to the piping and/or equipment and to the structure. Comply with ANSI B31 and AWS standards and SMACNA "Seismic Restraint Manual."

C. Bolting: Provide standard plate washers under heads and nuts of bolts bearing on wood. Soap threads of lag bolts prior to installing.

D. Structural Blocking: Locate as indicated and as required to support mechanical piping and equipment.

E. Where expansion compensators are indicated, install anchors in accordance with the expansion unit manufacturer's written instructions, to limit movement of piping and forces to the maximums recommended by the manufacturer of each unit.

F. Anchor Spacings: Install anchors at the ends of principal pipe runs, at intermediate points in pipe runs between expansion loops and bends. Make provisions for presetting of anchors as required to accommodate both expansion and contraction of piping.

G. Painting: Refer to Section 15050.

END OF SECTION

1 GENERAL

1.01 WORK INCLUDED

A. Provide seismic, sound and vibration isolation with all related components for mechanical equipment specified elsewhere.

1.02 REFERENCES, CODES AND STANDARDS

A. ASHRAE - Guide to Average Noise Criteria Curves.

B. Seismic Requirements: Seismic restraint manual, latest edition, SMACNA.

C. IBC.

D. State and local codes.

E. NFPA.

1.03 QUALITY ASSURANCE

A. Maintain ASHRAE criteria for average noise criteria curves for all equipment at full load condition.

1.04 SUBMITTALS

A. Submit shop drawings and product data under provisions of section 15010.

B. Provide submittals for products as follows:

C. Descriptive Data: Catalog cuts or data sheets on vibration isolators and specific restraints detailing compliance with the specification. Detailed schedules of flexible and rigidly mounted equipment, showing vibration isolators and seismic restraints by referencing numbered descriptive drawings.

D. Shop Drawings: Submit fabrication details for equipment bases including dimensions, structural member sizes and support point locations. Provide all details of suspension and support for ceiling hung equipment. Where walls, floors, slabs or supplementary steel work are used for seismic restraint locations, details of acceptable attachment methods for ducts, conduit and pipe to be included. Restraint manufacturers' submittals must include spacing, static loads and seismic loads at all attachment and support points. Provide specific details of seismic restraints and anchors; include number, size and locations for each piece of equipment.

E. Seismic Certification and Analysis: Seismic restraint calculations to be provided for all connections of equipment to the structure. Calculations must be stamped by a registered professional engineer licensed in Oregon. Analysis to indicate calculated dead loads, static seismic loads and capacity of materials utilized for connections to equipment structure. Analysis to detail anchoring methods, bolt diameter, embedment and/or welded length. All seismic restraint devices shall be designed to accept, without failure, the seismic force level per code requirements.

1.05 CERTIFICATES

A. Submit manufacturer's certificate that isolators are properly installed and properly adjusted to meet or exceed specified requirements.

2 PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Manufacturers:

B. Equipment: Amber/Booth, Mason, Vibrex or accepted substitute.

C. Ductwork and piping: Amber/Booth, Mason, Vibrex, I.S.A.T. or accepted substitute.

D. Mason numbers used as basis of design.

2.02 NEOPRENE PAD (NP)

A. 5/16"" thick neoprene pad consisting of square waffle modules minimum size 2-inch x 2-inch. Load distribution to be sized as required. Mason "W".

2.03 SPRING ISOLATORS WITH NEOPRENE (SIN)

A. Free standing and laterally stable without any housing and complete with a molded neoprene cup or 1/4" neoprene acoustical friction pad between the baseplate and the support. All mountings shall have leveling bolts that must be rigidly bolted to the equipment. Spring diameters to be no less than 0.8 of the compressed height of the spring at rated load. Springs to have a minimum additional travel to solid equal to 50% of the rated deflection. Mason “SLF”.

2.04 SPRING ISOLATORS WITH NEOPRENE, LIMITED TRAVEL (SINLT)

A. Restrained spring mountings to have an SLF mounting as described in B above, within a rigid housing that includes vertical limit stops to prevent spring extension when weight is removed. The housing to serve as blocking during erection. Steel spacer to be removed after adjustment. Limit stops to be out of contact during normal operation. Provide an internal isolation pad. Mason “SLR”.

2.05 SPRING HANGERS AND NEOPRENE (SHN)

A. Hangers to consist of rigid steel frames containing minimum 1-1/4" thick neoprene elements at the top and a steel spring. Seated in a steel washer reinforced neoprene cup on the bottom. The neoprene element and the cup to have neoprene bushings projecting through the steel box. Spring diameters and hanger box lower hole sizes to be large enough to permit the hanger rod to swing through a 30 degree arc from side to side before contacting the rod bushing. Mason “30N”.

2.06 SEISMIC SWAY BRACE (SSB)

A. Seismic Cable Restraints to consist of galvanized steel aircraft cables sized to resist seismic loads with a minimum safety factor of two and arranged to provide all-directional restraint. Cable end connections to be steel assemblies that swivel to final installation angle and utilize clamping bolts to provide proper cable engagement. Cable assemblies Mason “SCB”,”SSB”, “SCBH” and “SCBV”.

B. Seismic solid braces to consist of steel angles or channels to resist seismic loads with a minimum safety factor of 2 and arranged to provide all directional restraint. Seismic solid brace end connectors to be steel assemblies that swivel to the final installation angle and utilize two through bolts to provide proper attachment. Mason “SSB”.

C. Steel angles, sized to prevent buckling, to be clamped to pipe or equipment rods utilizing a minimum of three ductile iron clamps at each restraint location when required. Welding of support rods is not acceptable. Mason “SRC”.

D. Pipe clevis cross bolt braces are required in all restraint locations. Preformed channels deep enough to be held in place by bolts passing over the cross bolt. Mason “CCB”.

2.07 SNUBBERS (SN)

A. All-directional seismic snubbers to consist of interlocking steel members retrained by a one-piece molded neoprene bushing of bridge bearing neoprene. Bushing to be replaceable and a minimum of 1/4 inch thick. Rated loadings shall be exceed 100 psi. Snubber end caps to be removable to allow inspection of internal clearances. Mason “Z-1225”.

2.08 FLEXIBLE EXPANSION JOINTS (FEJ)

A. Flexible spherical expansion joints to employ peroxide cured EPDM in the covers, liners and tire cord frictioning. Solid steel rings shall be used within the raised face rubber ends to prevent pullout. Sizes 2" and larger to have two spheres reinforced with a ring between spheres to maintain shape and complete with split ductile iron and steel flanges with hooked or similar interlocks. Sizes 3/4" to 1-1/2" may have threaded bolted flange assemblies, one sphere and cable retention. 14" and smaller connectors to be rated at 250 psi up to 190 degrees F. with a uniform drop in allowable pressure to 190 psi at 250 degrees F. 16" and larger connectors are rated 180 psi at 190 degrees F. and 135 psi at 250 degrees F. Safety factors to burst and flange pullout to be a minimum of 3/1. All joints must have permanent markings verifying a 5 minute factory test at twice the rated pressure.

B. Expansion joints to be installed in piping gaps equal to the length of the expansion joints under pressure.

C. Submittals shall include test reports showing minimum reductions of 20 dB in vibration accelerations and 10 dB in sound pressure levels at typical blade passage frequencies on this or a similar product by the same manufacturer. Mason “SAFEFLEX”, “SFDEJ”, “SFEJ”, “SFDCR” or “SFU” and “CR” control rods.

2.09 FLEXIBLE STEEL HOSE (FSH)

A. Flexible stainless steel hose shall have stainless steel braid and carbon steel fittings. Sizes 3" and larger to be flanged. Smaller sizes to have threaded couplings. Minimum lengths to be 7 inches for ½” piping up to 16 inches for 8” piping. Mason “BBS”.

B.	Flanged		Male Nipples	
C.	3 x 14	10 x 26	½ x 9	1-1/2 x 13
D.	4 x 15	12 x 28	3/4 x 10	2 x 14
E.	5 x 19	14 x 30	1 x 11	2-1/2 x 18

F.	6 x 20	16 x 32	1-1/4 x 12
G.	8 x 22		

3 EXECUTION

3.01 GENERAL

A. All vibration isolators, sound isolators and seismic restraint systems must be installed in strict accordance with the manufacturers written instructions and all certified submittal data.

B. Installation of vibration isolators and seismic restraints must not cause any change of position of equipment, piping or duct work, resulting in stresses or misalignment.

C. Coordinate work with other trades to avoid rigid contact with the building.

D. Overstressing of the building structure must not occur because of overhead support of equipment. Contractor to submit loads to the structural engineer or record for review.

E. Drill-in concrete anchors for ceiling and wall installation to be full diameter and the standard product of the manufacturer.

F. Vibration isolation manufacturer to furnish integral structural steel bases as required.

G. Where piping passes through walls, floors or ceilings the vibration isolation manufacturer to provide split wall seals.

H. Locate isolation hangers as near to the overhead support structure as possible.

3.02 VIBRATION ISOLATION PIPING

A. Horizontal Pipe Isolation: The first three pipe hangers in the main lines near the mechanical equipment to be SHN type. SHN hangers to be used in all transverse braced isolated locations. Brace hanger rods with clamps. Horizontal runs to be isolated by SHN type hangers. Floor supported piping to rest on SINLT isolators. If piping is connected to equipment located in basements and hangs from ceilings under occupied spaces the first three hangers to have 0.75" deflection for pipe sizes up to and including 3", 1-1/2" deflection for pipe sizes up to and including 6", and 2-1/2" deflection thereafter. Hangers shall be located as close to the overhead structure as practical. Where piping connects to mechanical equipment install “FEJ” expansion joints or stainless hoses.

B. Riser Isolation: Risers to be suspended from SHN hangers or supported by SIN mountings, anchored with pipe guides. Steel springs to be a minimum of 0.75" except in those expansion locations where additional deflection is required to limit load changes to plus or minus 25% anticipated expansion and construction at each support point, initial and final loads on the building structure, spring defection changes and seismic loads.

3.03 SEISMIC RESTRAINT OF PIPING

A. Seismically restrain all piping listed as .1, 2. or 3. below. Use SSB cables.

B. Fuel oil piping, gas piping, medical gas piping, and compressed air piping that is 1" or larger.

C. Piping located in boiler rooms, mechanical equipment rooms, and refrigeration equipment rooms that is 1-1/4" and larger.

D. All other piping 2-1/2" and larger.

E. Transverse piping restraints to be at 40' maximum spacing for all pipe sizes, except where lesser spacing is required to limit anchorage loads.

F. Longitudinal restraints to be at 80' maximum spacing for all pipe sizes, except where lesser spacing is required to limit anchorage loads.

G. Where thermal expansion is a consideration, guides and anchors may be used as transverse and longitudinal restraints provided they have a capacity equal to or greater than the restraint loads in addition to the loads induced by expansion or contraction.

H. For fuel oil and all gas piping transverse restraints must be a 20' maximum and longitudinal restraints at 40' maximum spacing.

I. Transverse restraint for one pipe section may also act as a longitudinal restraint for a pipe section of the same size connected perpendicular to it if the restraint is installed within 24" of the elbow.

J. Hold down clamps must be used to attach pipe to all trapeze members before applying restraints.

K. Branch lines may not be used to restrain main lines.

3.04 VIBRATION ISOLATION OF DUCTWORK

A. All discharge runs for a distance of 50' from the connected equipment to be isolated from the building structure by means of SHN hangers or SIN floor isolators. Spring deflection to be a minimum of 0.75".

B. All duct runs having air velocity of 1000 fpm or more to be isolated from the building structure by SHN hangers or SIN floor supports. Spring deflection to be a minimum of 0.75".

C. Flexible Duct Connections: Squarely align sheet metal ducts with the fan prior to installation of the flexible connection. Install connections so the fan is able to move 1-inch in any direction without causing metal-to metal contact or stretching taught the flexible connection. Install the connections so that the clear space is minimum 4-inches and the connection has a minimum of 1-1/2-inch of slack material. Install flexible connections per SMACNA.

3.05 SEISMIC RESTRAINT OF DUCTWORK

A. Seismically restrain all duct work with SSB restraints as listed below:

B. Restrain rectangular ducts with cross sectional area of 6 sq. ft. or larger.

C. Restrain round ducts with diameters of 28" or larger.

D. Restrain flat oval ducts the same as rectangular ducts of the same nominal size.

E. Ductwork suspended by hangers 12 inches or less from the structure is excluded from isolation.

F. Transverse restraints to occur at 30' intervals or at both ends of the duct run if less than the specified interval. Transverse restraints to be installed at each duct turn and at each end of a duct run.

G. Longitudinal restraints to occur at 60' intervals with at least one restraint per duct run. Transverse restraints for one duct section may also act as a longitudinal restraint for a duct section connected perpendicular to it if the restraints are installed within 4' of the intersection of the ducts and if the restraints are sized for the larger duct. Duct joints to conform to SMACNA duct construction standards.

H. The ductwork must be reinforced at the restraint locations. Reinforcement to consist of an additional angle on top of the ductwork that is attached to the support hanger rods. Ductwork is to be attached to both upper and lower trapeze.

I. Walls, including gypsum board non bearing partitions, which have ducts running through them may replace a typical transverse brace. Provide channel framing around ducts and solid blocking between the duct and frame.

3.06 MECHANICAL EQUIPMENT

A. All mechanical equipment to be vibration isolated and seismically restrained as per the schedule.

B. Equipment Schedule

	Equipment:	Type:
D.	Boilers	NP
E.	Expansion Tanks	NP
F.	Piping, ducts, flues	SHN
G.	Motors:	
H.	<10 HP	¾ inch deflection
I.	>15 HP	1-1/2 inch deflection
J.	>50 HP	2 inch deflection

END OF SECTION

1 GENERAL

1.01 WORK INCLUDED

A. Provide piping, ductwork and equipment insulation including jacketing, adhesive and all related accessories for complete insulated system.

1.02 QUALITY ASSURANCE

A. Applicator: Company specializing in piping insulation application with three years minimum experience.

B. Insulation, Jacket and all Related Materials: Flame spread rating of 25 and smoke developed rating of 50.

C. Codes: Comply with all applicable codes.

D. Installation: Install in accordance with Manufacturer's recommendations.

E. Prohibited substances: The following substances are prohibited in the State of Oregon for use in manufacturing duct insulation, wraps, or covers and pipe insulation, wraps or covers. Products containing these substances are not allowed for use.

1. Pentabrominated diphenyl ether CAS#32534-81-9.

2. Octobrominated diphenyl ether CAS#32536-52-0.

3. Decabrominated dphenyl ether CAS#1163-19-5.

1.03 SUBMITTALS

A. Submit product data and installation instructions under provisions of Section 15010.

B. Include product description, list of materials and thickness for each service, and locations.

1.04 DELIVERY, STORAGE AND HANDLING

A. Deliver product to site under provisions of Section 15010.

B. Store and protect product under provisions of Section 15010.

C. Store insulation in original shipping container with labeling in place. Do not install damaged insulation.

1.05 FIRE HAZARD CLASSIFICATION

A. Maximum fire hazard classification of the composite insulation to be not more than a flame spread of 25, fuel contributed of 50 and smoke developed of 50 as tested by ASTM E84, NFPA 255 and UL 723 method.

B. Test pipe insulation in accordance with the requirements of UL “Pipe and Equipment Coverings R5583 400 8.15.”, ASTM C1136 and ASTM C547.

C. Test duct insulation in accordance with ASTM E84 and ASTM C1071 and bear the UL label.

1.06 LINING MATERIALS

A. Materials to be mold, humidity, and erosion resistant surface to meet the requirements of UL 181.

2 PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Insulating Manufacturers: Johns Manville, Knauf, Armstrong, Owens-Corning, Pabco, IMCOA, Certain Teed or accepted substitute.

B. Adhesive Manufacturers: Benjamin Foster, 3M, Borden, Kingco or Armstrong.

2.02 PIPING INSULATION, JACKETING AND ACCESSORIES

A. Fiberglass Pipe Insulation:

1. Fiberglass™ Evolution™ Paper-free ASJ Pipe Insulation.

2. Pipe system to minus 10 to 55 deg. F: Flexible, preformed, pre-slit, self-sealing elastomeric, thermal conductivity of 0.27 Btu/hr. sq. ft./in. at 75 deg. F and vapor transmission rating of 0.2 perms/inch. Apply in thickness necessary to prevent condensation on the surface.

3. Piping Systems 55 to 600 deg. F: Glass fiber preformed pipe insulation with a minimum K-value of 0.23 at 75 deg. F, a minimum density of 3.5 pounds per cubic foot.

4. Pipe System Up to 1200 deg. F: High temperature molded calcium silicate insulation with factory applied aluminum metal jacket. Furnish with aluminum snap straps.

B. Elastomeric Foam: ASTM C534; flexible, cellular elastomeric. Thermal Conductivity value: 0.27 at 75°F. Maximum Flame Spread: 25. Maximum Smoke Developed: 50 (3/4-inch thick and below). Connection: Waterproof vapor retarder adhesve as needed. UV Protection: UV outdoor protective coating as needed.

C. Heat Tracing Protection: Provide heat trace on piping subject to freezing. Provide electrical connections. Chromalox or approved self-regulating type with 15AWG copper wires, semi-conductive polymer core and flame retardant jacket. Provide power connection kit, thermostat and all devices required for proper operation.

D. Calcium Silicate: Hydrous calcium silicate, tested in accordance with ASTM C533 Type I with minimum of 1200 PSI at 5 percent compression. Factory applied jacket, Class II. Maximum 1200°F temperature limit.

E. Plastic Pipe Insulation: Flexible unicellular polyolefin foam insulation complying to ASTM C534, ASTM E84 (25/50), UL 723 (25/50). Thermal conductivity of 0.24 (BTU/in)/(hr/sq.ft./deg. F) at 75°F. Preslit longitudinal seam. Imoca.

F. Fiberglass Insulation: Flexible Fiber Glass Blanket: ASTM C612; flexible. Thermal Conductivity Value: 0.24 at 75°F. Maximum Service Temperature: 450°F.

G. Jackets:

1. Interior Applications:

a. Vapor Barrier Jackets: Kraft reinforced foil or vinyl vapor barrier with self-sealing adhesive joints or pressure sensitive seal.

b. PVC Jackets: One piece, premolded type. "

H. Accessories:

1. Insulation Bands: 3/4 inch wide; 16 gauge stainless steel.

2. Metal Jacket Bands: 0.25 thick stainless steel.

3. Insulating Cement: ANSI/ASTM C195; hydraulic setting mineral wool.

4. Finishing Cement: ASTM C449.

5. Fibrous Glass Cloth: Untreated; 9 oz/sq yd (305 g/sq m) weight.

2.03 DUCT INSULATION AND JACKETS

A. Duct Wrap: 1 1/2 inch flexible glass fiber; ANSI/ASTM C612; commercial grade; 'k' value of 0.27 at 75 degrees F. 1.0 pcf.

B. Duct liner: ASTM 1071; flexible blanket. ‘K’ Value: ASTM C518, 0.25 at 75°F. Noise Reduction Coefficient: 0.65 or higher based on “Type A mounting.” Maximum Velocity on Mat or Coated Air Side: 5,000 FPM. Adhesive: UL listed waterproof type. Fasteners: Duct liner galvanized steel pins, welded or mechanically fastened. Mold, humidity, and erosion resistant surfaces: UL 181.

C. Jacketing and Fasteners:

1. Indoor Jacket: Foil-Skrim-Kraft.

2. Outdoor Jacket: Coated glass fiber sheet, 30 lb/sq yd.

3. Lagging Adhesive: Fire resistive to ASTM E84, NFPA 255, and UL 723.

4. Impale Anchors: Galvanized steel, 12 gauge, self-adhesive pad.

5. Joint Tape: Glass fiber cloth, open mesh.

6. Tie Wire: Annealed steel, 16 gauge (1.5 mm).

D. SoftR® Duct Wrap Paper-free ASJ and VaporWick® or equal approved.

2.04 EQUIPMENT INSULATION

A. Equipment Temperatures Below 70 deg. F: Flexible, closed cell, elastomeric sheet insulation of 5.5 #/cubit feet density and 0.27 thermal conductivity at 75 deg. F.

B. Equipment Temperatures from 70 deg. F to 450 deg. F: Glass fiber 3 pound density insulation with a 0.23 thermal conductivity at 75 deg. F. Foil jacket or finished as recommended by manufacturer.

C. Exterior Tanks and Equipment Insulation Covering: Same as interior insulation with weatherproof metal or finished as recommended by insulation manufacturer.

2.05 PIPE FITTING INSULATION COVERS

A. PVC preformed molded insulation covers. Zeston or accepted substitute.

2.06 DUCT INSULATION ACCESSORIES

A. Staples, bands, wires, tape, anchors, and accessories as recommended by insulation manufacturer.

2.07 DUCT INSULATION COMPOUNDS

A. Cements, adhesives, coatings, sealers, finishes and accessories as recommended by insulation manufacturer.

3 EXECUTION

3.01 PREPARATION

A. Install materials after piping, ductwork and equipment has been tested and approved.

3.02 PIPING INSULATION INSTALLATION

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

B. Continue insulation with vapor barrier through penetrations.

C. In exposed piping, locate insulation and cover seams in least visible locations.

D. Provide an insert, not less than 6 inches long, of same thickness and contour as adjoining insulation, between support shield and piping, but under the finish jacket, on piping 2 inches diameter or larger, to prevent insulation from sagging at support points. Inserts shall be cork or other heavy density insulating material suitable for the planned temperature range. Factory fabricated inserts may be used.

E. Neatly finish insulation at supports, protrusions, and interruptions.

F. Jackets:

1. Indoor Applications: Insulated pipes conveying fluids above ambient temperature shall have standard jackets, with vapor barrier, factory-applied or field applied. Insulate fittings, joints, and valves with insulation of like material and thickness as adjoining pipe, and finish with glass cloth and adhesive.

G. Piping Insulation Schedule:

	PIPING	PIPE SIZE	INSULATION
1.	Domestic Cold	All	½” fiberglass
2.	Heating Water Supply		
3.	and Return	2" and Smaller	1-1/2” fiberglass
a.	2-1/2" to 4"		1-1/2” fiberglass
b.	4" and Larger		1-1/2” fiberglass
4.	Piping Exposed to Freezing		All Sizes 1-1/2” fiberglass

H. Pipe Fittings:

1. Insulate and finish all fittings including valve bodies, bonnets, unions, flanges and expansion joints with precut fiberglass insulation and preformed PVC covers sealed to adjacent insulation jacket for continuous vapor barrier covering over all fittings.

I. Piping Insulation Lap Seams and Butt Joints: Install insulation jacket in accordance with manufacturer's recommendation. Where jacket joint and lap seams have not adhered, remove affected section of insulation and reinstall.

J. Heat Tracing: Where electric heat tape is to be installed on piping, insulate over the tape.

K. Where piping is installed in the exterior building envelope or in any component of the exterior building envelope it shall be located on the warm building interior side of the building envelope insulation.

3.03 DUCTWORK INSULATION INSTALLATION

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

B. Installation:

1. Butt insulation joints firmly together and install jackets and tapes securely.

2. Apply duct insulation continuously through sleeves and openings. Apply vapor barrier materials to form a vapor seal over the insulation.

3. Cover breaks in the jacket material with patches of the same material as the vapor barrier. Extend the patches 2-inches beyond the break in all directions and secure with adhesive.

4. Seal insulation terminations and pin punctures with a reinforced vapor barrier coating.

5. Continue insulation at fire dampers up to and including those portions of the fire damper frame which are visible at the outside of the rated barrier.

6. Do not conceal duct access doors with insulation.

7. Duct Liners: Install mat finish surface on air stream side. Secure insulation on sheet metal duct with a continuous 100 percent coat of adhesive. For widths over 20-inch, additionally secure the liner with mechanical fasteners15-inch on center. Cut liner and coat ends with adhesive. Butt joint tightly. Top and bottom sections of insulation overlap sides. Keep duct liner clean and free from dust. If insulation is installed without horizontal, longitudinal and end joints butted together, installation will be rejected.

8. Duct Wrap: Cover supply air ducts except ducts internally lined or where fiberglass ductboard is utilized. Wrap tightly with all circumferential joints butted and longitudinal joints overlapped minimum of 2-inch. Adhere insulation with 4-inch strips of insulating bending adhesive at 8-inch on center. On ducts over 24-inch wide, additionally secure insulation with suitable mechanical fasteners at 18-inch on center. Circumferential and longitudinal joints stapled with flare staples 6-inch on center and covered with 3-inch wide foil reinforced tape.

C. Continue insulation with vapor barrier through penetrations.

D. Internally Lined Ductwork: Where internally lined ductwork is indicated, no exterior insulation is required. Lap the ends of the exterior insulation a minimum of 6 inches past the interior insulation unless otherwise shown. Seal the end of vapor barrier jacket to the duct with mastic where the vapor barrier is required.

3.04 DUCTWORK SURFACES TO BE INSULATED

4	Ductwork	4.01	Duct Size	5	Insulation 5.01 Thickness
6	Supply and return ductwork (except where duct is lined or where ductboard is utilized)	7	all	8	1-1/2” Duct wrap
9	Supply and return ductwork (exposed to weather and in unheated areas)	10	all	11	2” Duct wrap
12	Outside air ducts	13	all	14	2” Duct liner
15	HVAC plenums	16	all	17	2” Duct liner

17.01 INSULATED PIPE EXPOSED TO WEATHER

A. Cover insulation with aluminum jacket. Seal water tight jacket per manufacturer's recommendation. Provide heat tracing on piping subject to freezing.

17.02 PLASTIC PIPE INSULATION

A. Slip insulation on pie prior to connection. Butt joints sealed with manufacturer's adhesive. Insulate fitting with miter-cut pieces. Cover all insulation exposed to the weather and under grade with 2 coats of finish as recommended by manufacturer.

17.03 FLEXIBLE ELASTOMERIC TUBING

A. Slip insulation over piping or if piping is already installed, it should be slit and snapped over the piping. All joints and butt ends must be adhered with adhesive.

17.04 CALCIUM SILICATE PIPE INSULATION

A. Install in accordance with manufacturer's instructions. Seal canvas jacket tight to insulation at lap joints. Continuous insulation over pipe, fittings and all supports or hangers. No exposed pipe permitted.

17.05 STORAGE TANKS

A. Cover with hydrous calcium silicate, 2-inch thick. Finish with canvas jacket and adhesive. Overlap joints a minimum of 4 inches. Apply 2 coats latex paint. Color by Architect.

17.06 FIBERGLASS FLEXIBLE BOARD

A. Fiberglass insulating flexible boards with thermal conductivity of 0.230 (BTU/in)/(hr/sq.ft./deg. F) at 75°F mean temperature. Minimum density or 3.00 lbs. psf. Field applied canvas jacket.

17.07 INSULATION SHIELDS

A. Provide full size diameter hangers and shields (18 gauge minimum) for all cold piping. Hot water piping hangers may penetrate insulation to contact piping directly.

END OF SECTION

1 GENERAL

1.01 DESCRIPTION

A. The requirements of this section apply to the Heating Equipment.

1.02 SUBMITTALS

A. Submit in accord with Instructions to Bidders.

B. Submit catalog data, construction details, performance characteristics for each type and size of equipment.

C. Shop Drawings: Prove boiler(s) will fit space allocated. Submit complete shop drawings and/or technical brochures of all work prior to fabrication. Indicate size, design, dimensional and capacity characteristics, structural supports required and component parts. Also submit with shop drawings all equipment wiring and control diagrams, installation instructions.

D. Test Reports: Submit four (4) certified copies of test on boilers showing percent of carbon dioxide, stack temperature, gas firing rate, and heat output for each boiler.

E. Submit operating and maintenance data.

F. Provide submittals for the following:

1. Boilers.

2. Pumps.

3. Hydronic Specialties.

4. Water treatment.

5. Piping drawings of mechanical room(s) and pump room(s). Provide piping drawings, to scale. Drawings to indicate routing of piping, equipment locations, fittings, valves and other piping devices and hanger locations.

1.03 QUALITY ASSURANCE

A. Acceptable Manufacturers: standard, nationally recognized manufacturers of products listed by ANSI or ASTM quality standards as specified or approved.

B. Labels: Underwriters Laboratories (UL) labeled or certification by a nationally recognized electrical testing laboratory having the facilities for testing, factory inspection and field inspection as required by the National Electrical Code is required for all fans, controls, all electrically-operated equipment and other electrical items incidental to the work specified, as required by code.

C. Air Conditioning and Refrigeration Equipment Rating: Rated in accordance with ARI certified rating procedures and bear the ARI label.

D. Codes: Comply with applicable sections of the State Mechanical Code. Comply with National Electrical Code (NEC), State of Oregon modifications to the NEC, and all local ordinances applicable to electrical wiring, contacts, controls, etc., included with or contained within manufactured items.

E. Field Wiring: It is the intent of these specifications that all systems shall be complete and operable. Refer to all drawings and specifications, especially the electrical drawings, to determine voltage, phase, circuit ampacity and number of connections provided. Provide all necessary field wiring and devices from the point of connection indicated on the electrical drawings. Bring to the attention of the Architect in writing, all conflicts, incompatibilities, and/or discrepancies prior to bid or as soon as discovered. Comply with requirements of Section 15010, Field Wiring requirements.

F. Installation Contractor: Manufacturer's authorized installation and start-up agency normally engaged and experienced in air conditioning/refrigeration work.

1.04 DELIVERY, STORAGE AND HANDLING

A. Handle piping and equipment carefully to prevent damage. Store in area protected from weather, moisture and possible damage at all times prior to installation.

B. Seal all openings in pipes and/or pipe connecting fittings with caps or plugs, as required to prevent entry of foreign matter.

C. Comply with all manufacturers installation instructions.

2 PRODUCTS

2.01 SPECIALTIES AND EQUIPMENT

A. Air Vents:

1. Manual Air Vents: Install at all system high points whether shown or not; fabricate of 2" diameter or larger pipe at least 12" long. Manually operated.

2. Automatic Air Vents: float type with pressure rating equal or grater than system pressure.

3. Manufacturers: Bell & Gossett, Armstrong, Hoffman, Spirotherm or approved substitute.

B. Triple Duty Valve: Combination spring loaded vertical check, calibrated balancing and shut off valve with balance point memory in angle or straight pattern as required or as shown on the Drawings. B&G, Taco, Armstrong, Thrush, Wheatley or accepted substitute.

C. Thermometers:

1. Non-mercury type, adjustable stem, separable sockets, 0-120^{0}F range for chilled water, 30-240^{0}F range for heating water (unless indicted otherwise). Weiss numbers are listed, equivalent Marshalltown, Palmer, Taylor, Trerice, Weksler or accepted substitute.

2. Wide case 9" in equipment rooms and all major equipment items.

3. Narrow case 7" in all other locations.

D. Pressure Gauges: Install on discharge of all pumps and where shown on Drawings 4-1/2" dial, 0-100 psig graduation pressure gauges with Ashcroft No. 1106 pulsation dampers and stop cocks. Weiss UGE-1 or equivalent Marshalltown, Ashcroft, Marsh, Trerice, Weksler.

E. Compound Gauges: Install on suction side of all pumps and where shown on Drawings, 4-1/2" dial, 0"-30" mercury and 0-100 psig pressure graduation compound gauges with Ashcroft No. 1106 pulsation dampers and stop cocks. Weiss UGE-1 or equivalent Marshalltown, Ashcorft, Marsh, Trerice, Weksler.

F. Pressure-Temperature Test Plugs:

1. 1/4" or 1/2" NPT fitting of solid brass capable of receiving either an 1/8" OD pressure or temperature probe and rated for zero leakage from vacuum to 1000 psig. Neoprene valve core for temperatures to 200 deg. F. Nordel to 350 deg. F. Provide each test plug with a pressure gauge adapter with 1/16" or 1/8" OD pressure probe.

2. Furnish a test kit containing one 2-1/2" dial pressure test gauge of suitable range, one gauge adapter with 1/16" or 1/8" OD probe and two 5" stem pocket test thermometers - one 0 to 220 deg. F and one 50 to 550 deg. F. Turn the kit over to the Architect. The system balancing firm may use this kit to complete the balancing.

3. Sisco "P/T Plugs," Peterson "Pete's Plug," or accepted substitute.

G. Circuit Setter and Balancing Valves: Balancing fitting with differential pressure taps, brass or bronze body and trim. B & G "Circuit Setter" or Taco, Armstrong, Wheatley or accepted substitute.

H. Bypass Chemical Feeder: 20 quart capacity, steel body with minimum fell opening or funnel. 175 PSI pressure rating.

I. Strainers:

1. Provide strainers preceding each pressure reducing valve and where indicated on drawings. Full line size. Strainer bodies high-grade cast iron or bronze. Each strainer equipped with easily removable cover and stainless steel screen suitable for service intended with net free area at least four times that of entering pipe. Gasket shall seal against machined seat both in body and cap. Gasket seal between cap and strainer body. Provide valved blowoff for each strainer of same size as plugs with maximum size of 1-1/2 inch. Pipe blowoff full size and terminate over floor drains except at fin tube, reheat coils, fan coil units, convectors, induction units, terminal units, and unit heaters, provide bronze hose adapter for standard 3/4 inch garden hose with cap and chain. Body pressure ratings in accordance with scheduled working pressure for equipment service.

2. Heating, Ventilating and Air Conditioning: Y type Strainer: Strainers 2 inch and smaller, perforations 1/16 inch; strainers 2-1/2 inch and larger, perforations 1/8 inch; 250 psi.

3. Manufacturer: Screwed bronze strainers 2 inch and smaller, flanged cast iron 2-1/2 inch and larger, as manufactured by Armstrong Machine Works, Sarco, Mueller, R.P. & C. Co. or as scheduled herein.

2.02 IN-LINE PUMPS

A. Pipe mounted, in-line arrangement with mechanical seals with ceramic seal seats, suitable for continuous operation at 225 deg. F at head and capacity stated on Drawings. Cast iron impeller casing, oil lubricated bronze journal and thrust bearings or regreasable ball bearings (manufacturer's standard). Impeller size not to exceed 90% of largest diameter impeller which will fit pump casing. Minimum horsepower as indicated on Drawings and not less than will be required at any point of the impeller curve. Provide pressure gauge tappings on suction and discharge flanges. Bell & Gossett, Thrush, Paco, Taco, Armstrong or accepted substitute.

2.03 SUCTION DIFFUSER

A. Provide at each pump inlet where indicated, a suction diffuser size as required for pump and piping. Diffuser shall consist of angle type body rated for 175 psi and 250 degrees F temperature and pressure, with inlet vanes, combination diffuser-strainer-orifice cylinder, removable permanent magnet in flow stream, disposable start up strainer, adjustable support foot, pressure gage tapping and strainer blowdown tapping. Strainer cylinder with 3/16" diameter openings, free area equal to five times cross sectional area of pump connection, designed to withstand pressure differential equal to pump shutoff head, and easily removed through end flange equipped with reusable ring seal. Vane length shall be no less than 2-1/2 times pump connection diameter. Bell & Gossett, Armstrong, Paco, Thrush, Mueller, Victaulic, Taco.

2.04 FIRE-TUBE CONDENSING BOILER

A. MANUFACTURERS

1. Basis-of-Design Product: Lochinvar Crest Boiler or Approved Equal.

B. CONSTRUCTION

1. Description: Boiler shall be natural gas fired, fully condensing, and fire tube design. The boiler shall be factory-fabricated, factory-assembled, and factory-tested, fire-tube condensing boiler with heat exchanger sealed pressure tight, built on a steel base; including insulated jacket; flue-gas vent; combustion-air intake connections; water supply, return, and condensate drain connections; and controls.

2. Heat Exchanger: The heater exchanger shall bear the ASME “H” stamp for 160 psi working pressure and shall be National Board listed. The heat exchanger shall be constructed of a fully welded 316L stainless steel and of fire tube design. Fire tube shall be of the Wave Fire Tube design and capable of transferring 30,000 to 40,000 Btu’s per tube. The heat exchanger shall be designed for a single-pass water flow to limit the

water side pressure drop. There shall be no banding material, bolts, gaskets or “O” rings in the heat exchanger design. Cast iron, aluminum, or condensing copper tube boilers will not be accepted.

3. Condensate Collection Basin: Fully welded 316L stainless steel.

4. Intake Filter and Dirty Filter Switch: Boiler shall include an intake air filter with a factory installed air pressure switch. The pressure switch will alert the end user on the screen of the boiler that the intake filter is dirty and needs to be changed.

5. Pressure Vessel: The pressure vessel shall be in accordance with ASME Section IV pressure vessel code. The pressure vessel shall be designed for a single-pass water flow to limit the water side pressure drop. Pressure drop shall be no greater than 2.4 psi at 180 gpm.

6. Burner: Natural gas, forced draft single burner premix design with an upper and lower chamber supplied by individual combustion systems. The burner shall be high temperature stainless steel with a woven Fecralloy outer covering to provide modulating firing rates. The burner shall be capable of the stated gas train turndown without loss of combustion efficiency. The burner shall have an independent laboratory rating for Oxides of Nitrogen (NOx) to meet requirements of South Coast Air Quality Management District (SCAQMD) as compliant with Rule 1146.2 (FB1500-FB2000), San Diego Air Control Pollution District as compliant with Regulation 69.2.1 (FB1500-FB5000), Bay Area Quality Management District as compliant with Regulation 9 Rule 7 (FB1500-FB5000) and Texas Commission on Environmental Quality (FB1500-FB2000) as being compliant with Section 117.465.

7. Blower: Boiler shall be equipped with a pulse width modulating blower system to precisely control the fuel/air mixture to provide modulating boiler firing rates for maximum efficiency. The burner firing sequence of operation shall include pre-purge, firing, modulation, and post-purge operation.

8. Gas Train: The boiler shall be supplied with two gas valves designed with negative pressure regulation and shall be capable of a 25:1 minimum turndown.

9. Ignition: Spark ignition with 100 percent main-valve shutoff with electronic flame supervision.

10. High Altitude: Boiler shall operate at altitudes up to 4,500 feet above sea level without additional parts or adjustments.

11. Casing:

    a. Jacket: Heavy gauge primed and painted steel jacket with snap-in closures.

    b. Control Compartment Enclosures: NEMA 250, Type 1A.

c. Insulation: Minimum ½ inch thick, mineral fiber insulation surrounding the heat exchanger.

d. Combustion-Air Connections: Inlet and vent duct collars.

12. Characteristics and Capacities:

a. Heating Medium: Hot water.

b. Design Water Pressure Rating: 160 psi working pressure.

c. Safety Relief Valve Setting: 50 psig

d. Minimum Water Flow Rate: 25 gpm.

C. TRIM

1. Safety Relief Valve:

a. Size and Capacity: 50 lb.

b. Description: Fully enclosed steel spring with adjustable pressure range and positive shutoff; factory set and sealed.

2. Pressure Gage: Minimum 3-1/2 inch diameter. Gage shall have normal operating pressure about 50 percent of full range.

3. Drain Valves: Minimum NPS 3/4 or nozzle size with hose-end connection.

4. Condensate Neutralization Kit: Factory supplied condensate trap with condensate trip sensor, high capacity condensate receiver prefilled with appropriate medium.

D. CONTROLS

1. Boiler controls shall feature a standard, factory installed 8” LCD screen display with the following standard features:

a. Variable Speed Boiler Pump Control: Boiler may be programmed to send a 0-10V DC output signal to an ECM or VFD boiler pump to maintain a designed temperature rise across the heat exchanger. The boiler shall be able to operate in this mode with a minimum temperature rise of 20 degrees F and a maximum temperature rise of 60 degrees F.

b. Password Security: Boiler shall have a different password security code for the User and the Installer to access adjustable parameters.

c. Outdoor air reset: Boiler shall calculate the set point using a field installed, factory supplied outdoor sensor and an adjustable reset curve.

d. Pump exercise: Boiler shall energize any pump it controls for an adjustable time if the associated pump has been off for a time period of 24 hours.

e. Ramp delay: Boiler may be programmed to limit the firing rate based on six limits steps and six time intervals.

f. Boost function: Boiler may be programmed to automatically increase the set point a fixed number of degrees (adjustable by installer) if the setpoint has been continuously active for a set period of time (time adjustable by installer). This process will continue until the space heating demand ends.

g. PC port connection: Boiler shall have a PC port allowing the connection of PC boiler software.

h. Time clock: Boiler shall have an internal time clock with the ability to time and date stamp lock-out codes and maintain records of runtime.

i. Service reminder: Boiler shall have the ability to display a yellow colored service notification screen based upon months of installation, hours of operation, and number of boiler cycles. All notifications are adjustable by the installer.

j. Pump control: Boiler shall have the ability to control the boiler pump and system pump.

k. Anti-cycling control: Boiler shall have the ability to set a time delay after a heating demand is satisfied allowing the boiler to block a new call for heat. The boiler will display an anti-cycling blocking on the screen until the time has elapsed or the water temperature drops below the anti-cycling differential parameter. The anti-cycling control parameter is adjustable by the installer.

l. Night setback: Boiler may be programmed to reduce the space heating temperature set point during a certain time of the day.

m. Freeze protection: Boiler shall turn on the boiler and system pumps when the boiler water temperature falls below 45 degrees. When the boiler water temperature falls below 37 degrees the boiler will automatically turn on. Boiler and pumps will turn off when the boiler water temperature rises above 43 degrees.

n. Isolation valve control: Boiler shall have the ability to control a 2-way motorized control valve. Boiler shall also be able to force a fixed number of valves to always be energized regardless of the number of boilers that are firing.

o. BMS integration with 0-10V DC input: The Control shall allow an option to Enable and control set point temperature or control firing rate by sending the boiler a 0-10V input signal.

p. Data logging: Boiler shall have non-volatile data logging memory including last 10 lockouts, hours running and ignition attempts and should be able to view on boiler screen.

2. The boiler shall have a built in Cascade controller to sequence and rotate lead boiler to ensure equal runtime while maintaining modulation of up to 8 boilers of different btu inputs without utilization of an external controller. The factory installed, internal cascade controller shall include:

   a. Lead lag:

   b. Efficiency optimization: The Control module shall allow multiple boilers to fire at minimum firing rate in lieu of Lead/Lag.

   c. Front end loading:

   d. Rotation of lead boiler: The Control module shall change the lead boiler every hour for the first 24 hours after initializing the Cascade. Following that, the leader will be changed once every 24 hours.

3. Boiler operating controls shall include the following devices and features:

   a. Set-Point Adjust: Set points shall be adjustable.

   b. Sequence of Operation: Electric, factory-fabricated and factory-installed panel to control burner firing rate to reset supply-water temperature inversely with outside-air temperature for maximum energy efficiency.

4. Burner Operating Controls: To maintain safe operating conditions, burner safety controls limit burner operation.

   a. High Temperature Limit: Automatic and manual reset stops burner if operating conditions rise above maximum boiler design temperature. Limit switch to be manually reset on the control interface.

   b. Low-Water Cutoff Switch: Electronic probe shall prevent burner operation on low water. Cutoff switch shall be manually reset on the control interface.

   c. Blocked Inlet Safety Switch: Manual-reset pressure switch field mounted on boiler combustion-air inlet.

   d. High and Low Gas Pressure Switches: Pressure switches shall prevent burner operation on low or high gas pressure. Pressure switches to be manually reset on the control interface.

   e. Blocked Drain Switch: Blocked drain switch shall prevent burner operation when tripped. Switch to be manually reset on the control interface.

f. Low air pressure switch: Pressure switches shall prevent burner operation on low air pressure. Switch to be manually reset on the control interface.

g. Audible Alarm: Factory mounted on control panel with silence switch; shall sound alarm for any lockout conditions.

5. Building Automation System Interface: Factory installed interface to enable building automation system to monitor, control, and display boiler status and alarms. Boiler start/stop, pump start/stop, boiler isolation valve position, hot water reset schedule, outside air temperature, outside air temperature lockout, lead/lag controls, hot water return and supply temperatures, boiler staging and all setpoints for above items as applicable may be set and verified at operator terminal.

E. ELECTRICAL POWER

1. Single-Point Field Power Connection: Factory-installed and factory-wired switches, motor controllers, transformers, and other electrical devices necessary shall provide a single-point field power connection to boiler.

2. Electrical Characteristics:

a. Verify requirements with existing conditions

b. Voltage

1) 120V / 1PH - FBN751 through FBN3500

c. Frequency: 60 Hz

B. VENTING

1. Combustion Vent: Complete system, ASTM A 959, Type 29-4C stainless steel pipe, or Sch 40 CPVC piping pipe, vent terminal, thimble, indoor plate, vent adapter, condensate trap and dilution tank, and sealant. Boilers exhaust vent length must be able to extend to 100 equivalent feet.

2. Combustion-Air Intake: Complete system, stainless steel or Sch 40 CPVC, pipe, vent terminal with screen, inlet air coupling, and sealant. Boilers intake pipe length must be able to extend to 100 equivalent feet

3. Boiler shall come standard with a flue sensor to monitor and display flue gas temperature on factory provided LCD display.

4. Boilers using common venting must contact the factory for sizing.

5. Refer to manufacturer’s Installation and Operations manual for detailed venting instructions and approved manufacturers.

C. SOURCE QUALITY CONTROL

1. Burner and Hydrostatic Test: Factory adjust burner to eliminate excess oxygen, carbon dioxide, oxides of nitrogen emissions, and carbon monoxide in flue gas and to achieve combustion efficiency; perform hydrostatic test.

2. Test and inspect factory-assembled boilers, before shipping, according to ASME Boiler and Pressure Vessel Code.

3.02 PIPING SYSTEMS

A. Applies to hot water boiler and heating water.

B. Flush the closed loop water immediately after pressure testing and chemically clean, passivate and treat. There is to be no delay in the cleaning procedure which may cause corrosion problems in the loop.

C. Cleaning Treatment:

1. Prior to precleaning chemical addition to the loop, the low point drain is to be utilized for discharge and the loop is to be flushed free of construction dirt and debris. After the initial flush, the strainers if present, are to be cleaned.

2. Precleaner to be added into the loop. The water quality to be calculated and add an appropriate amount of cleaner recommended by water treatment representative.

3. Circulate the cleaning agent for no less than 4 and no more than 24 hours. At this point the water treatment representative adjusts the pH of the loop water to ensure the water can be discharged to sanitary in accordance with local guidelines for discharge.

4. Discharge 100 percent of the systems water. All strainers are to be cleaned. Refill and discharge the loop as a rinse flush. The loop to be refilled.

5. The loop to be charged with 500 to 1000 PPM of Polyquest to ensure proper passivation. Circulate the loop for a period of 4 to 24 hours with the Polyquest. The loop to be discharged and strainers cleaned.

6. The loop will then be charged by water treatment representative with 800 to 1200 PPM of Corstop or Inhibitor No. 34. This borate Nitrite solution is to be retested monthly for a period of the 1-year warranty. If levels are found low, the Water Treatment Representative is to recharge the loop, insuring the levels stay within Specification.

7. Chemicals: Closed loop corrosion control. Perlolin 336, Mogul, Chemax, or approved.

8. Equipment: One-shot feeder of 2 gallon capacity supplied with fill and drain valves, filling funnel and miscellaneous fittings for connection of fill and drain accessories. 1-inch pipe connection for inlet and outlet piping. 125 PSI maximum operating pressure.

4 EXECUTION

4.01 PIPING INSTALLATION

A. Refer to applicable Sections for Piping, Valves, Insulation, Painting, etc.

B. Chemical Treatment

1. Engage water treatment company, subject to review of Architect, to provide preservice cleaning of piping systems, chemicals, and supervised water treatment program for following systems:

   a. Heating water system.

2. Chemical treatment company shall:

   a. Submit written recommendations for water treatment which will fall within intent of specifications, including complete analysis of makeup water to be used, recommendations for treatment materials and dosage levels, and specific operating procedures.

   b. Provide all necessary testing equipment and reagents.

   c. Provide all chemical formulations required for startup and 90 days thereafter.

   d. Supervise cleaning of all piping systems including flushing, testing, special filters, etc.

3. Cleaning of Piping Systems

   a. Provide complete preservice cleaning of new heating water piping, boiler and all other miscellaneous mechanical systems. Provide all chemicals, equipment and personnel.

   b. Cleaning compound to be composed of 90% by wt. trisodium phosphate (dodecahydrate), 9% sodium hydroxide, and 1% nonyl phenol 4ethoxylate (with 9 moles ethylene oxide.)

   c. Determine volume of water in system to be cleaned. Calculate amount of cleaning compound to be used (to be used at 0.5% by wt. of water in system).

   d. Completely dissolve the cleaning compound prior to injecting into system.

   e. For closed systems with closed system circulating pump operating, inject cleaning solution into system. If proper amount of chemical has been used, P-alkalinity test should now read between 1500 and 1700 ppm. Continue to circulate cleaning solution for four (4) hours.

   f. Clean boiler per manufacturer's specific instructions.

g. Drain system, clean all strainers and flush with fresh water. Repeat procedure until P-alkalinity test equals zero.

h. Cleaned systems shall be filled with fresh water and appropriate closed water corrosion inhibitors added.

i. Confirm all chemicals specified and used are acceptable to all governing agencies, prior to use of any cleaning or treatment materials.

4.02 EQUIPMENT INSTALLATION

A. Lubrication: Lubricate all moving and rotating parts in accordance with the manufacturer's recommendations prior to start-up.

B. Automatic Vent Valves: Install on each hydronic terminal at highest point and on each hydronic piping drop in direction of flow for mains, branches and runouts and elsewhere as indicated. Pipe to approved discharge location.

C. Air separators: Install in pump suction lines and as indicated. Connect inlet and outlet piping. Run piping to expansion tank with ¼-inch per foot (2 percent) upward slope towards tank. Install drain valve on units 2-inch and over.

D. Expansion Tanks: Install tank in accordance with manufacturer’s instructions. Charge tank with air per manufacturer’s instructions. Insulate per Section 15250, Insulation. Provide vibration isolation per Section 15240, Mechanical Equipment Sound, Vibration and Seismic Control.

E. Shot Feeders: Install on each hydronics system at pump discharge and elsewhere as indicated. Install in upright position with top of funnel not more than 48-inches above floor. Install globe valve in pump discharge line between recirculating lines. Pipe drain to nearest plumbing drain or as indicated.

F. Liquid Flow Switches: Install on inlet to water chiller as indicated. Install in horizontal pipe with switch mounted in tee on top of pipe with minimum of 24-inch of straight pipe with no fitting both upstream and downstream of switch. Remove segments if paddle to fir in accordance with manufacturer’s instructions.

G. Water Relief Valves: Install as indicated and on hot water tanks and pressure vessels. Pipe discharge to floor drain. Comply with ASME and Pressure Vessel Code.

H. Pressure reducing Valves: Install as indicated and in accordance with manufacturer’s instructions.

I. Installation of Temperature Gauges:

1. Install in vertical upright position.

2. Thermometer Wells: Install in piping in vertical upright position. Provide cap.

J. Installation of Pressure Gauges:

1. General: Install pressure gauges in piping tee with pressure gauge cock.

2. Locations: Install in the following locations and elsewhere as indicated:

   a. Pump inlet and outlet.

   b. Inlet and discharge of each pressure reducing valve.

   c. Inlet and outlet of condenser water and chilled water at chillers.

   d. Inlet and outlet of boilers and heat exchangers.

   e. Provide Pete's Plug at inlet and outlet of each hydronic coil.

K. Expansion Joints: Provide where required to allow pipe expansion due to thermal stresses. Provide locations per manufacturer's recommendations. Provide a pipe guide on each side of each expansion joint, located per manufacturer's recommendations. Provide guides in addition to all other pipe supports and hangers.

L. Pumps: Mount per manufacturer's recommendations in a manner to allow disassembly of pump and motor without disturbing piping. Align flexible connectors. Local manufacturer's representative to provide factory authorized service technician, without additional charge, to align all pumps provided. Alignment shall not occur before all pump components and piping are in place and piping filled with water.

M. Boiler Installation:

1. Install boiler in accordance with the manufacturer's recommendation including wiring refractory lining and insulation.

2. Anchor boiler to floor.

3. Full-time, factory trained service technician to provide start-up, balancing and owner operating and maintenance instruction. In addition, provide one (1) year manufacturer's warranty service from date of start-up for beneficial use by the owner.

4. Obtain certification of inspection from the State Boiler Inspector at completion and turn the certificate over to the Owner.

END OF SECTION

1 GENERAL

1.1 WORK INCLUDED

A. Furnish a complete and fully operating Microsoft Windows based Direct Digital Control system (DDCS) in accordance with this specification section. All components of system shall conform to most recent open protocol requirements of BACnet by ASHRAE. BACnet gateways, integration modules and portals are not allowed. Items of work included are as follows.

1. Provide all necessary hardware and software to meet the specified functional requirements.

2. System architecture shall fully support a multi-vendor environment and be able to integrate third party systems via existing vendor protocols.

3. System architecture shall provide secure Web access using MS Internet Explorer from any computer on the owner's LAN.

4. The Owner shall have full ownership and full access rights for all network management, operating system server, engineering and programming software required for the ongoing maintenance and operation of the BMS. Provide all software keys needed so Owner is not locked into any one service contractor or vendor for future work on system.

5. Prepare individual hardware layouts, interconnection drawings and control loop configuration data from project design data.

6. Implement the detailed design for all system input/output points, distributed control and system data bases, graphic displays, logs, and management reports based on control descriptions, logic drawings, configuration data, and bid documents.

7. Design all equipment cabinets, panels, and the data communication network cables including all associated hardware.

8. Provide and install all cabinets, panels, and data communication network cables including all associated hardware.

9. Provide and install all interconnecting cables between supplied cabinets, controllers, and output devices.

10. Provide and install all interconnecting cables between all operator terminals and peripheral devices (such as printers, etc.) supplied under this section.

11. Provide complete specifications for all items supplied by the Vendor from others (such as printers, instruments, etc.).

12. Provide supervisory specialists and technicians at the job site to assist in all phases of system installation, start-up and commissioning. Existing and new systems shall be commissioned to follow Sequence of Operations below.

13. Provide a comprehensive operator and technician training program as described herein.

14. Provide as-built documentation, software, and all DDC control logic and all associated support documentation on approved media which accurately represents the final system.

15. Provide CO2 sensors as shown on Drawings for demand control ventilation.

16. Remove all components of existing control system not needed for new controls. Do not abandon in place.

1.2 RELATED WORK

A. Related work in other sections of the specifications:

1. Section 15050 Basic Materials and Methods

1.3 SYSTEM DESCRIPTION

A. General Requirements

1. Provide a Distributed Processing System complete with Direct Digital Control (DDC) and Direct Analog Control (DAC) software. This system is to control all HVAC items throughout the building, including but not limited to: air handling units, mixing boxes, boilers, chiller, cooling tower, pumps, control valves, dampers, supply fans and exhaust fans without intervening conventional controls.

2. New DDC system components shall replace existing pneumatic system components.

3. All DDC Controllers for mixing boxes, air handling units, central mechanical equipment, supply fans, exhaust fans, unit heaters, valves and dampers and Windows based operators' terminal(s) shall communicate with each other and share information.

4. The controls contractor shall assume complete responsibility for the entire controls system as a single source and shall certify that he has on staff under his direct employ on a day to day basis, factory trained technical personnel, qualified to engineer, program, debug, and service all portions of the DDC control system, including central system Operators terminal, global controllers, terminal unit controllers, and all other portions of the DDC control system.

5. Bring all existing software resident on Owner’s existing operator’s terminal onto new operator’s terminal.

B. Basic System Features:

1. Zone by zone DDC control of space temperature, usage scheduling, optimum starting, equipment failure reporting, and override timers for off-hours usage. A zone is the area served by one HVAC terminal unit (mixing box, damper, heat pump, fan coil, etc.)

2. Operator Terminal software shall be latest Windows application program. Software shall be multitasking, capable of executing and displaying multiple instances in individual windows while running concurrently with other Windows programs such as word processors or database programs. Software shall completely support Windows Dynamic Data Exchange (DDE) and Object Linking and Embedding (OLE) interfaces. Software shall strictly follow Microsoft Windows API guidelines. Systems using proprietary software or Windows formats other than above are strictly prohibited. Operation of the terminal software shall be simple and intuitive. Provide a complete, on-line, context sensitive help system. Help system shall contain all of the information contained in the system manuals, so that hard copies of the system manual are not required for operation.

3. Complete energy management firmware, including self adjusting optimum start, demand limiting, global control strategies and logging routines for use with total control systems. All energy management firmware shall be resident in field hardware and not dependent on the Operators Terminal for operation. Operator's terminal software is to be used for access to field based energy management control firmware only.

4. Match existing system access security features for new equipment. Each user shall have an individual password. Each user shall be assigned which control functions they have access to.

5. Equipment monitoring and alarm function including information for diagnosing equipment problems.

6. The complete system including but not limited to terminal unit controllers, Global controllers and Operator terminals shall Auto-restart, without operator intervention, on resumption of power after a power failure. Database stored in Global Controller memory shall be battery backed up for a minimum of 30 days. Unitary controllers shall utilize EEPROM for all variable data storage. Battery backed up unitary controllers shall not be allowed.

7. Modular system design of proven reliability.

8. Each field panel capable of independent control.

9. All software and/or firmware interface equipment for connection to remote monitoring station from field hardware or the Operators Terminal.

10. Equipment runtime totalization of fans, heaters, boilers, etc., capable of alarm generation and alarm dial out to remote sites.

11. Room sensors with bias levers and unoccupied schedule override

12. All DDC hardware and software shall be designed and manufactured by U.S. corporations. All hardware shall be U.L. listed with integral labels showing rating.

1.4 QUALITY ASSURANCE

A. Responsibility: The supplier of the DDCS shall be responsible for inspection and Quality Assurance (QA) for all materials and workmanship furnished by him.

B. Component Testing: Maximum reliability shall be achieved through extensive use of high-quality, pre-tested components. Each and every controller, sensor, and all other DDC components shall be individually tested by the manufacturer prior to shipment.

C. Tools, Testing and Calibration Equipment: Provide all tools, testing and calibration equipment necessary to ensure reliability and accuracy of the DDCS.

D. System shall be installed by a local authorized representative, providing sales and service in the local area for no less than the last five years. Installation Contractor shall have a minimum of 5 certified AX technicians within a 75-mile radius of project site.

1.5 REFERENCE STANDARDS

A. The latest edition of the following standards and codes in effect and amended as of date of Supplier's Bid, and any subsections thereof as applicable, shall govern design and selection of equipment and material supplied:

1. ASHRAE: American Society of Heating, Refrigerating and Air Conditioning Engineers

2. IBC: International Building Code, including local amendments

3. UL 916 Underwriters Laboratories Standard for Energy Management Equipment

4. NEC: National Electrical Code

B. City, county, state, and federal regulations and codes in effect as of date of purchase.

C. Except as otherwise indicated, vendor shall secure and pay for all permits, inspections, and certifications required for his work and arrange for necessary approvals by the governing authorities.

1.6 SUBMITTALS

A. Drawings:

1. Within four weeks after award of contract, the Supplier shall submit review drawings, installation and operation instruction and a recommended spare parts list.

2. Drawings shall be standard sizes (24 inches x 36 inches) or (11 inches x 17 inches).

3. Provide three copies of submittal drawings.

B. System documentation by the Vendor shall include the following as a minimum:

1. System configuration diagrams in simplified block format.

2. Input/Output point and alarm point summary listing.

3. Electrical drawings showing all system internal and external connection points, terminal block layouts and terminal identification.

4. Complete written description of system sequence of operation.

5. Manufacturer's instructions and drawings for installation, maintenance and operation of all purchased items.

6. Overall system operation and maintenance instructions, including preventive maintenance and troubleshooting instructions.

7. Complete recommended spare parts list.

1.7 SCHEDULING AND COORDINATION

A. The Vendor shall provide a detailed project design and installation schedule with time markings and details for hardware items and software development phases.

B. The schedule shall show all the target dates for transmission of project information and documents and will indicate system installation, debug, and commissioning timing dates.

C. Contractor shall work closely with Owner to verify that work shall not interfere with Owner’s operation requirements for building.

1.8 WARRANTY

A. Warranty shall cover all costs for parts, labor, and associated travel, and expenses for a period of one year from completion of system demonstration.

B. Hardware and software personnel supporting this warranty agreement shall provide on-site or off-site service in a timely manner after failure notification to the Vendor. The maximum acceptable response time to provide this service at the site shall be 24 hours.

C. This warranty shall apply equally to both hardware and software.

2 PRODUCTS

2.1 SYSTEM MANUFACTURER

A. DDC control system shall be BACnet MS/TP system with Niagara AX front-end (web-based, open protocol, etc.) and installed by a local authorized representative, providing sales and service in the local area for no less than the last five years. Installation Contractor shall have a minimum of 5 certified AX technicians within a 75-mile radius of project site. Manufacturers: Automated Logic, Tridium, Honeywell WEBS, Distech, JCI MX, Schneider, Building Logix or Approved Equal.

B. The intent of this specification is to provide a peer-to-peer networked, stand-alone, distributed control system utilizing the BACnet technology communication protocol in one open, interoperable system.

2.2 SYSTEM TERMINAL

A. Displays:

1. Operator Terminal shall display all data associated with project as specified. Terminal software shall accept either PCX or Windows BITMAP format graphic files for display purposes. Graphic files shall be created utilizing scanned full color photographs of system installation, Autocad drawing files of field installation drawings and wiring diagrams from as-built drawings. System shall be capable of displaying graphic file, text and dynamic point data together on each display. Information shall be labeled with descriptors and shall be shown with the appropriate engineering units. Terminal shall allow user to change all field resident EMS functions associated with the project such as set points, time schedules, holiday schedules, etc.. This shall be done without any reference to point addresses or other numeric/mnemonic indications.

2. All displays shall be generated and customized in such a manner by the local DDCS supplier that they fit the project as specified. Canned displays shall not be acceptable. Displays shall use standard English (or specified language) for labeling and readout. Systems requiring factory programming for graphics or DDC logic are specifically prohibited. All graphics and DDC programming shall be supported locally by the installing contractor without factory dependency or assistance.

3. Digital points shall be displayed as On/Off or with customized text. Text shall be justified Left, Right or Center. Also allow digital points to be displayed as individual bitmap objects on the display screen as an overlay to the system graphic. Each digital point displayed in this manner shall be assigned up to three bitmap files for display when the point is On, Off or in Alarm. For Digital Output points, toggle the points commanded status when the bitmap is selected with the system digitizer (mouse) by the operator (i.e. selecting a picture of a switch or light with the mouse shall toggle the points status and display a different picture). Also allow digital points to be displayed as an animated graphic. Animated graphic points shall be displayed as a sequence of multiple bitmaps to simulate motion (i.e. when a pump is in the OFF condition, display a stationary picture of the pump. When the operator selects the picture with the mouse, the points status is toggled and the picture of the pump rotates the vanes in a time based animation). Allow operator to change bitmap file assignment and also create new and original bitmaps on line. System shall be supplied with a library of standard bitmaps which may be used unaltered or be modified by the operator. Systems that do not allow customization or creation of new bitmap objects by the operator shall not be allowed.

4. Analog points shall be displayed with operator modifiable units. Analog Input points may also be displayed as individual bitmap objects on the display screen as an overlay to the system graphic. Each analog input point may be assigned to a minimum of five bitmap files each with High/Low limits for automatic selection and display of the bitmaps. As an example, a graphic representation of a thermometer would rise and fall in response to either the room temperature or its deviation from the controlling setpoint. Analog Output points, when selected with the mouse, shall be displayed as a prompted dialog box, adjustable knob or slide bar. Selection for display type shall be individual for each point.

5. Analog points may also be assigned to an area of a system graphic,

where the color of the defined area would change based on the analog points value. As an example, an area of a floor plan graphic served by a single control zone would change color respective to the temperature of the zone or its deviation from setpoint. Selection of the graphic area to be done using a "Roller Brush Flood Fill" tool similar to ones used in painting programs. All editing and area assignment shall be created or modified on-line, using simple icon tools.

6. A Customized Menu Label shall be used for display selection. Menu items on a display shall allow penetration to lower level displays or additional menus. Dynamic point information and menu items may be mixed on the same display to allow sub displays to exist for each item. Each display may be protected from viewing unless operator has appropriate security level. A separate display security level may be assigned to each display and system point.

7. All dynamic point information shall be updated on the Operators terminal display CRT once every 1 second. Any changes by the operator shall be acted on by devices in the field within 2 seconds maximum.

8. A Mouse or other form of digitizer shall be used to move pointer arrow to desired item for selection of new display or to allow the operator to make changes to point data.

9. Displays may be modified on site or via remote communications.

10. Display resolution shall be limited by the physical monitor properties and software driver. A minimum resolution of 1024x768 @16bit (65,536 colors). Entire system shall operate without dependency on the Operator's terminal.

11. Entire system shall operate without dependency on the Operator's terminal.

B. Security System:

1. Provide security system that prevents unauthorized use unless operator is logged on. Access shall be limited to operator terminal's functions unless user is logged on. This includes displays as outlined above.

2. Each Operators Terminal shall provide security for 100 users minimum. Each user shall have an individual password. Password and User name shall each be up to 30 alpha numeric characters, case sensitive. Each User shall be individually assigned which control functions and menu items the user has access to. All passwords, user names and access assignments shall be adjustable on-line, at the operators terminal.

3. System shall maintain a log of all user activities while logged onto the system. Provide for easy viewing of all items in user log, including time and date of login, logoff and all activities in between.

C. Display of Scheduling Information:

1. Display of Weekly schedules shall show all information in easy to read 7 day (week) format for each schedule. This includes all on/off times for each day along with all optimum start information.

2. Holiday schedules shall show all dates that are to be holidays. Holidays shall be shown on the terminal in a graphical calendar format showing all scheduled days for a given month. User shall be able to easily scroll through the months for each year for up to 20 years into the future as a minimum. Each day assigned as a holiday shall display as "All Off" or show the times scheduled for that day.

3. Event schedules shall be shown in the same graphical calendar format and manner as Holiday schedules. Event schedules allow for scheduling of special events up to 20 years into the future. After event has elapsed, control returns to normal schedule.

4. Operator shall be able to change all information for a given Weekly, Holiday or Event schedule if logged on with the appropriate security access. This includes all information that has to do with optimum start assignments such as sensors to use and heating/cooling factors.

D. Alarm Indication

1. System Terminal shall provide audible, visual and printed means of alarm indication. The Alarm Dialog box shall always become the Top Dialog box regardless of the application(s) being run at the time (such as a word processor). Printout of alarms shall be sent to the assigned terminal and port.

2. Provide log of alarm messages. Alarm log shall be archived to the hard disk of the system terminal. Each entry shall include point descriptor and address, time and date of alarm occurrence, point value at time of alarm, time and date of point return to normal condition, time and date of alarm acknowledge.

3. Alarm messages shall be in plain English (or specified language) and shall be user definable on site or via remote communication. System shall provide a minimum of 20 user definable messages for each zone controlled.

E. Trend Log Information:

1. System shall periodically gather samples of point data stored in the field equipment (see section 2.2.D) and archive the information on the Operator terminals hard disk. Archive files shall be appended with new sample data, allowing samples to be accumulated over several years. Systems that write over archived data shall not be allowed. Samples may be viewed at the operators terminal in a Trend Log. Trend log displays shall be in spreadsheet format. Provide a minimum of 100 Trend Log displays at each terminal. Each trend log display shall be capable of a minimum of 100 trended points, with a minimum of 10,000 samples for each trended point. Provide capability for operator to scroll through all trend log data vertically (time axis) and horizontally (point sample columns). System shall automatically open archive files as needed to display archived data when operator scrolls through the data vertically. Display all trend log information in standard engineering units.

2. System software shall be capable of graphing the trend log point data. Software shall be capable of creating graphs in the following forms as a minimum:

a. Bar charts, Log/Linear graphs, Bubble graphs,

b. x-y graphs, Log/Log graphs, Area graphs(2D or 3D),

c. Pie charts, Scatter graphs, Polar graphs,

d. High-Low-Close graphs

3. Operator shall be able to change trend log setup information as well. This includes information to be trend logged as well as interval at which information is to be logged. All points in the system may be logged. All operations shall be password protected.

F. Energy Log Information:

1. System shall periodically gather energy log data stored in the field equipment (see section 2.2.H) and archive the information on the Operator terminals hard disk. Archive files shall be appended with the new data, allowing data to be accumulated over several years. Systems that write over archived data shall not be allowed. Log data may be viewed at the operators terminal in a spreadsheet format. Provide a minimum of 100 Energy Log displays at each terminal. Provide capability for operator to scroll through all Energy log data vertically (time axis) and horizontally (point sample columns). System shall automatically open archive files as needed to display archived data when operator scrolls through the data vertically. Display all Energy log information in standard engineering units.

2. System software shall be capable of graphing the Energy log data. Software shall be capable of creating graphs in the following forms as a minimum:

a. Bar charts, Log/Linear graphs, Bubble graphs,

b. x-y graphs, Log/Log graphs, Area graphs(2D or 3D),

c. Pie charts, Scatter graphs, Polar graphs,

d. High-Low-Close graphs

3. Operator shall be able to change the Energy log setup information as well. This includes which meters to be logged and meter pulse value. All meters monitored in the system may be logged. All operations shall be password protected.

G. Controller Status:

1. Provide means for operator to view communication status of all controllers connected to the system. Display shall include controller, status and error count. Status will show if controller is communicating or not. Error count shall show actual count of communication errors between system and controllers in the field.

2. Provide means for operator to reset error count for all controllers to zero.

3. Provide capability to select alarm indication for each controller.

H. Configuration/Setup: Provide means for operator to display and change system configuration. This shall include but not be limited to system time, day of the week, date of day light savings set forward setback, printer type and port addresses, modem port and speed, etc. Items shall be modified utilizing easy to understand terminology using simple mouse/cursor key movements.

I. Custom Report Generator:

1. Custom report generator shall allow the operator to create multiple custom reports utilizing system point information, text and outputs of other software modules such as trend logging, controller status, point values, etc.. Operation shall be similar to a word processing program allowing easy manipulation of report text, content, font and initiation parameters. Reports may be manually or automatically printed to system printer. Automatic printing initiation may be by assignment to a schedule (Weekly, Holiday or Event schedules), point Change Of State (COS), point alarm condition, or point value.

2. Reports shall fully support Windows DDE and OLE allowing information from other software programs (such as spreadsheet programs) to be part of the report.

J. Occupant Override Logging and Billing: Night cycle override of zone temperature control, lighting, etc., shall be automatically logged by field devices (Global Controllers) on a zone by zone basis. See section 2.2.G for description. Operator Terminal software shall allow zones to be grouped for totalization of all zones within the area over an adjustable time period. System shall include a billing program for creation of charges based on the billing rate and the totaled override usage from specified begin and end dates.

K. Terminal Hardware:

1. Provide Operator terminal at location instructed by Owner. Operator terminal shall include the following as a minimum:

a. PC compatible, utilizing ISA architecture

b. Intel processor Q8400 Core 2 Quad @2.66GHz, 1333FSB

c. 2GB RAM minimum

d. 500GB Hard Drive

e. DVD-R

f. Microsoft Windows 7 Ultimate 32-Bit

g. USB Optical Mouse

h. USB QWERTY Keyboard

L. Campus Local Area Network:

1. In addition to the LAN communication between the Operator Terminals and the Global Controllers (hereafter called a LOCAL system), the local system shall also be capable of connecting to other local systems or

Operators terminals via a Campus LAN. The Campus LAN shall be any of the ETHERNET type LANs available. Provide all ETHERNET hardware and Windows Network software necessary for a complete and operational system.

2. Any point in the interconnected system, comprised of all local systems connected together with the Campus LAN, shall be available for any and all functions of any one of the local systems. As an example, an electric meter input to one of the local systems shall be capable of being utilized in any of the other local systems demand limiting program(s).

2.3 GLOBAL CONTROLLER

A. General:

1. Global controller shall provide battery backed real time clock functions. It shall also provide system communications to programmable and application specific controllers as noted in section 2.3 in the field. Global controller shall interface with Operator terminal(s) for information display. Global controllers shall share information in a Peer-to-Peer manner utilizing a high speed LAN communication network. Global Controller shall be capable of 1 Meg baud LAN communication rates.

2. Global controller shall decide global strategies for system based on information from any points in the system regardless if the point is directly monitored by the controller. Program that implements these strategies shall be completely flexible and user definable. Any system utilizing factory pre-programmed global strategies that cannot be modified by field personnel on site or downloaded via remote communications are not acceptable. Changing global strategies via firmware changes is also unacceptable. Program executed speed shall be once per second as a minimum.

3. Programming shall be object oriented using control program blocks. Provide documentation in flow chart form for all programming as part of the final system As-Built documentation. Include samples of flow chart documentation in submittals. All flow charts shall be generated with CAD system and automatically downloaded to controller. No reentry of data base shall be necessary.

4. Provide means to view inputs and outputs to each program block in real time as program is executing. This function may be done via the Operators Terminal, field computer, or via modem.

5. Controller shall have a minimum of 1 Mb battery backed Static RAM, expandable to 2 Mb, along with 256 Kb of EPROM. Battery shall retain static RAM memory and clock functions for a minimum of 30 days. Battery shall be a field replaceable lithium type. Battery shall automatically re-charge on resumption of local power.

6. Communication to field devices shall be via four individual two wire communication trunks. Communication baud rate shall be at 156k baud. All field devices shall automatically search and detect the communication rate to match the Global controller. All field devices on the communication trunk shall be optically isolated. Ground referenced communications to field devices is prohibited. Routing of communication

trunk may be daisy chained, run in star patterns or any other configuration that makes wiring easiest.

7. Controller shall have at a minimum, four (4) additional communication ports in addition to the LAN port. Two of the ports shall be RS-232, one for communication to portable field computer and one for a modem for remote communications. The other two ports shall be RS-485 for connection to a permanent panel mounted display device (see 2.2 for description), and for future connection to other devices.

B. Remote Communications:

1. Provide all functions that will allow remote communications via internet to off-site locations.

2. Provide Windows 7 Ultimate compatible software for off-site computer which allows operator to view and change all information associated with system on color graphic displays if desired. Operator shall be able to change all parameters in this section from off-site location including all programming of global controllers and programmable terminal unit controllers.

3. Global Controller shall have capability to call out alarm conditions automatically if desired. Alarm message and site description may be sent to offsite computer or serial printer. If desired, controller may also send encoded message via text message or email. All Global controllers connected to the local LAN shall be capable of calling out alarm messages through one shared modem connected to one of the Global controllers on the local LAN.

4. Owner shall provide internet for remote communication function.

C. Schedules:

1. Schedules shall be arranged in a three tiered hierarchy as follows:

a. Highest level: Event Schedules

b. Middle level: Holiday Schedules

c. Lowest level: Weekly Schedules

2. Each Global Controller shall have at a minimum:

a. 100 Weekly time schedules (7 day)

b. 100 Holiday schedules (400 programmable days each)

c. 20 Event schedules (400 programmable days each) With 8 schedule entries per day.

3. Each schedule may be assigned to any point, controller, or program in the system.

4. Each schedule (Weekly, Holiday and Event) shall be capable of

performing an optimum start. Optimum start calculation shall be based on outside air temperature, zone air temperature deviation from zones daytime heating and cooling setpoints, and individual zone adaptive heating and cooling coefficients that are adjusted each day based on performance parameters of the individual zone. Each schedule may use identical or individual sensors in its calculations.

5. Holiday schedule shall be provided to allow operation of system based on different schedule on specified holidays. Display of Holiday schedule shall be via a monthly calendar format. Operator shall be able to scroll through months and years. Operator shall be capable of scheduling dates a minimum of 20 years into the future.

6. Event schedules shall be identical to Holiday schedule format and requirements.

7. Operator may define and setup all schedule information from system terminal, via portable computer on site or via remote communications. This includes all times, dates and optimum start parameters. These functions shall be password protected.

D. Logging Capabilities:

1. Each Global Controller shall log as a minimum 256 user selectable points with a minimum of 1440 samples per point. Sample time interval shall be from 1 to 1000 seconds. Sample initiation may be by any of the following conditions:

   a. Selectable begin and end date and time

   b. Point COS (Any system point)

   c. Point Alarm Status (Any system point)

   d. Schedule ON status (Weekly, Holiday or Event schedules)

2. Any point in the system whether it is real or calculated may be logged.

3. Logs may be viewed both on site or off-site via remote communication.

4. Global controller shall periodically upload trended data to Operator terminal for long term archiving if desired.

E. Alarm Generation:

1. Alarms may be generated for any condition of the system. This includes things such as analog point high/low alarm limits, digital point COS, communication failure to terminal unit controllers, etc. Controller shall have a minimum of 6 alarm types with 7 categories for each type.

2. Each alarm may be dialed out as noted in paragraph B. above.

3. Provide alarm log for viewing of alarms. Log may be viewed on site at the system terminal or off-site via remote communications.

F. Demand Limiting:

1. System shall monitor energy demand. Energy demand may be from any type of energy source such as electrical or gas. Provide a Demand Limiting routine which shall shed assigned points or zones in the system to prevent the demand from exceeding preset limits. Demand limiting routine shall be a priority shed type allowing automatic override of zone or point shed when assigned temperature sensor exceeds operator set limits. Routine shall be able to change between 4 sets of demand limit and restore setpoints based on time of day or operator command.

2. Zone shed method shall be by either preventing operation of heating and cooling, or by shifting the zones heating and cooling setpoints.

3. All parameters of the Demand Limiting routine shall be modifiable from the Operators Terminal or via remote communications.

G. Occupant Override Logging and Billing:

1. Night cycle override of zone temperature control, lighting, etc., shall be automatically logged on a zone by zone basis. Zones may be grouped into areas for totalization of all zones within the area over an adjustable time period. System shall include a billing program for creation of charges based on the billing rate and the totaled override usage from specified begin and end dates.

2. Provide Global Controller capacity to total override usage for a minimum of 100 areas with up to 256 zones per area and 30 overrides per zone. Global controller shall periodically upload the override information to the System terminal for long term archiving and billing generation.

H. Energy Logging:

1. Each global controller shall have ability to provide for a minimum of 10 Energy Logs. When required by specified sequence of operation, each log shall monitor an energy meter and record or calculate the following information for each Day, Month and Year:

a. Energy consumption

b. Demand peak value and time of peak

c. Outside air temperature minimum, maximum and average value

d. Heating and Cooling degree day calculation

2. Energy meter input may be from any type of energy source such as electric or gas. Input type shall be dry contact pulse.

I. Field Interface/Display Terminal: Provide a field interface and display terminal as located on the project plans. Field Terminal(s) shall connect to the Global controller via a two conductor RS-485 cable in a star or tee tap configuration allowing easy addition of terminals in the future. Field Terminals shall be capable of displaying and commanding any and all points in the system utilizing customizable menus and data displays. Field Terminal data displays shall be independent of Operator Terminal displays. Field Terminal operation shall not be

dependent on Operator terminal operation and shall be provided by a handheld device such as a smart phone or tablet.

J. Memory Modules: Global Controller data storage memory shall be modular, allowing additional memory to be added in the field (two modules minimum). Additional memory may be allocated by the operator to increase the storage capability of any or all routines requiring memory for storage of data. Modules shall be battery backed static RAM in Single In-line Modules (SIMM) or other easily insertable package.

2.4 TERMINAL UNIT CONTROLLERS

A. General:

1. Provide programmable and application specific Terminal Unit Controller as needed to comply with sequence of operation, point list and drawings. All Terminal Unit Controller units shall be completely stand-alone with no loss of control if communication with global controller is interrupted. All control parameters, DDC programs and local variables such as setpoint information shall be stored in EEPROM on board each Terminal Unit Controller allowing the operator to change information as desired. Controllers that utilize a battery to backup control parameters, etc., shall not be allowed.

2. All points on drawings, in sequence of operation and on point list shall be connected to and controlled by DDC units. No control shall be done by external devices such as thermostats or analog controls that are not part of the DDC system.

3. Programmable Terminal Unit Controllers shall be used in custom applications such as central plant, built up air handlers, fume hoods or when application specific controllers sequence of operation is not applicable.

4. Communication from Global controller to Terminal Unit Controllers shall be via two wire communication trunk as specified for Global Controllers above. Any type of Terminal Unit Controller shall communicate on the same communication trunk. System shall communicate to one Terminal Unit Controller regardless of whether other Terminal Unit Controllers on the same communication line are powered and connected. Ground referenced communications is prohibited.

B. Programmable Terminal Unit Controllers:

1. Each programmable Terminal Unit Controller shall be completely programmable from the system terminal, via field computer or via remote communications. Program execution rate shall be ten times per second minimum (once every 100 milliseconds).

2. This controller shall be programmed to perform custom strategies for system based on information from all points in the field. Program that implements these strategies shall be completely flexible and user definable. Any controllers utilizing factory programmed strategies that cannot be modified by field personnel on site, require factory assistance, or cannot be downloaded via remote communications are not acceptable. Changing strategies via firmware changes is also

unacceptable.

3. Programming shall be object oriented using program blocks familiar to control specialists for all program strategies. Provide documentation in flow chart form for all programming. Include samples of flow chart documentation in submittals. All flow charts shall be generated with CAD system and automatically downloaded to controller. No re-entry of data base shall be necessary. As-Built documentation of all software shall be provided to end user in flow chart form at completion of project.

4. Program and program parameters such as set points shall be stored in EEPROM. Battery backed RAM shall not be accepted for this level of controller.

5. All inputs shall be universal in that they accept analog and digital information. Inputs shall be capable of detecting a 0.1 second momentary closure. Analog inputs shall be capable of accepting thermistor inputs, 0 to 5 VDC, 0 to 10 VDC, or 4 to 20 mA inputs. No external hardware shall need to be added for Terminal Unit Controller to accept these different types of inputs. All inputs shall utilize a minimum of 10 bit analog to digital conversion.

6. Every digital output shall have local status indication. Outputs shall have minimum control resolution of 0.1 seconds On or Off.

7. Each of the analog outputs shall be independently switch selectable to output 0 to 10 VDC or 4 to 20 mA. Unit shall be programmable to output a sub range of voltage or current to match the device controlled. Analog outputs shall use 8 bit digital to analog conversion.

8. Terminal Unit Controller may be programmed to control what is displayed on zone sensor display. See section 2.4. Terminal Unit Controller may be programmed to show alpha numeric values on zone sensor display in response to program changes or button presses on the zone sensor.

9. Each Terminal Unit Controller shall provide 24 VDC at 250 mA as a source of power for current transducer sensors in the field.

C. Application Specific Terminal Unit Controllers:

1. Application Specific Terminal Unit Controllers shall be completely stand-alone controllers for unitary type controls such as VAV terminal boxes, heat pumps, AC units, unit ventilators, etc. All programs shall be resident in controller for complete stand-alone operation.

2. EEPROM technology shall be used for storage of program parameters such as set points, limits, etc., controllers utilizing a battery for backup of program parameters shall not be allowed.

3. All application specific Terminal Unit Controller units shall have capability to use Digital display zone sensor, or thermistor type zone sensor as listed in section 2.4.

2.5 TEMPERATURE SENSORS

A. General: All temperature sensors to be solid state electronic, factory calibrated to

within one-half degree F, totally interchangeable. Wall sensors to be housed in enclosure appropriate for application. Duct and well sensors to be electronically identical with housing appropriate for application. Provide appropriate wells for installation by others.

B. Zone Temperature Sensor:

1. Sensor shall contain push-button bypass switch, electronic sensor, setpoint bias lever, setting adjustable wheel and jack for connection to Digital Display zone sensor for troubleshooting. The operator shall program the time of on after hours override operation from 0.0, no override, to 9.9 hours in 0. hour increments. Push buttons are to remain inactive until zone is in the after hours mode.

2. Setpoint bias shall be via labeled bias lever. Maximum bias shall be plus or minus 3 degrees F.

2.6 OTHER CONTROL DEVICES

A. Valves: shall be straight or three-way pattern per existing conditions. Provide seat, disc, and body suitable for medium and pressure handled. Modulating valves shall have linear or equal percentage characterized plugs suitable for system operation. Water valves sized for 5 psi drop unless otherwise noted. Two-position valves line size, quick opening. Valves shall operate satisfactorily against system pressures and differentials. Butterfly valves allowed where currently existing and shall close bubble tight. All valves shall be sized and constructed for 100% tight shut off. Straight (2-way) double seat valves are not acceptable. Shop drawings shall include valve sizing schedule indicating required flow, required CV, proposed CV, and pressure drop with proposed CV and required flow, for each valve.

B. Dampers: shall be factory sizes nearest to duct size being used and shall have factory filler panels so damper assembly matches duct size. Bearings oil impregnated bronze. Provide parallel blades for positive or modulating mixing service and opposed blade for throttling service, or as specified in sequence. Maximum blade dimension 10 inches. Damper blades and damper frames galvanized. Provide blade edging and side seals for tight shutoff. Dampers shall be equal to Johnson D1200, D1300, or Ruskin CD35. Scribe end of damper drive shaft to indicate blade position.

C. Damper and valve actuators: Actuators to be pressure independent and sized to operate and shut valves and dampers properly against system pressures, differentials, velocities, and conditions. Damper actuators shall be sized for 80% of their published load rating including those with pilot positioners. Damper actuators shall be located to distribute operating force equally over full area of damper for uniform positioning of all blades. Quantity and size of actuators for each damper shall be listed on the shop drawings. Where damper operation and fan operation are interlocked, provide control to open damper sufficiently to prevent duct or equipment damage before fan is started. Where drawings indicate normal valve position for fail safe operation, valve actuator shall be spring return. Outside air and relief damper actuators shall also have spring return to closed position.

D. Variable frequency drives (VFD's): shall be solid state, with a Pulse Width Modulated (PWM) output waveform in a NEMA 1 enclosure, completely assembled and tested by the manufacturer. The VFD shall employ a full wave

rectifier (to prevent input line notching, DC line reactor, capacitors, and insulated gate bipolar transistors (IGBT's) as the output switching device. Drive efficiency shall be 97% or better at full speed and full load. Fundamental power factor shall be 0.98 at all speeds and loads. Drive shall be designed specifically for variable torque applications. Drive manufacturer shall have an existing local sales representative with expertise in HVAC systems and controls, and local service organization. Drive and all necessary controls, as herein specified shall be supplied by the drive manufacturer. Manufacturer shall have been engaged in the production of this type of equipment for a minimum of ten years.

1. Referenced Standards:

   a. Institute of Electrical and Electronic Engineers (IEEE), Standard 519-1992, IEEE Guide for Harmonic Content and Control.

   b. Underwriter's Laboratories, UL 508.

   c. National Electrical manufacturer's Association (NEMA), ISC 6, Enclosures for Industrial Controls and Systems.

2. All printed circuit boards shall be completely tested and burned-in before being assembled into the completed VFD. The VFD shall then be subject to a preliminary functional test, minimum eight hour burn-in, and computerized final test. The burn-in shall be at 104oF (40oC), at full rated load, or cycled load. Drive input power shall be continuously cycled for maximum stress and thermal variation.

3. All VFD's shall have the following standard features:

   a. All VFD's shall have the same digital display, keypad and customer connections, regardless of horsepower rating. Keypad to be used for local control, for setting all parameters, and for stepping through the displays and menus.

   b. VFD shall give user the option of either (1) displaying a fault, (2) running at a programmable preset speed, (3) hold the VFD speed based on the last reference received, or (4) cause a warning to be issued, if the input reference (4-20mA or 2-10V) is lost; AFT shall provide a programmable relay output for customer use to indicate loss of reference condition.

   c. VFD's shall utilize plain English digital display (code numbers and letters are not acceptable). Digital display shall be a 40-character (2 line x 20 characters/line) LCD display. LCD shall be backlit to provide easy viewing in any light condition. Contrast should be adjustable to optimize viewing at any angle. All set-up parameters, indications, faults, warnings and other information must be displayed in words to allow user to understand what is being displayed without use of a manual or cross-reference table.

   d. VFD's shall utilize pre-programmed application macros specifically designed to facilitate start-up. Application macros shall provide one command to reprogram all parameters and customer interfaces for a particular application to reduce programming time.

e. VFD shall have the ability to automatically restart after an overcurrent, overvoltage, undervoltage, or loss of input signal protective trip. Number of restart attempts, trial time, and time between reset attempts shall be programmable. If time between reset attempts is greater than zero, time remaining until reset occurs shall count down on the display to warn an operator that a restart will occur.

f. VFD shall be capable of starting into a rotating load (forward or reverse) and accelerate or decelerate to setpoint without safety tripping or component damage (flying start).

g. VFD shall be equipped with an automatic extended power loss ride-through circuit which will utilize inertia of the load to keep drive powered. Minimum power loss ride-through shall be one-cycle, based on full load an no inertia. Removing power from motor is not an acceptable method of increasing power loss ride-through.

h. Customer terminal strip shall be isolated from line and ground.

i. Prewired 3-position Hand-Off-Auto switch and speed potentiometer. When in "Hand", the VFD will be started, and the speed will be controlled from the speed potentiometer. When in "Off", the VFD will be stopped. When in "Auto", the VFD will start via an external contact closure, and its speed will be controlled via an external speed reference.

j. VFD shall employ three current limit circuits to provide trip free operation:

    1) Slow current regulation limit circuit shall be adjustable to 125% (minimum) of VFD's variable torque current rating. This adjustment shall be made via the keypad, and shall be displayed in actual amps, and not as percent of full load.

    2) Rapid current regulation limit shall be adjustable to 170% (minimum) of VFD's variable torque current rating.

    3) Current switch-off limit shall be fixed at 255% (minimum, instantaneous) of VFD's variable torque current rating.

k. Overload rating of VFD shall be 110% of its variable torque current rating for 1 minute every 10 minutes, and 140% of its variable torque current rating for 2 seconds every 15 seconds.

l. VFD shall have input line fuses standard in the drive enclosure.

m. VFD shall have a DC line reactor to reduce harmonics to the power line and to increase the fundamental power factor.

n. VFD shall be optimized for a 3 kHz carrier frequency to reduce motor noise and provide high system efficiency. Carrier frequency shall be adjustable by the start-up engineer.

o. VFD shall have a manual speed potentiometer in addition to using the keypad as a means of controlling speed manually.

4. All VFD's shall have the following adjustments:

a. Five (5) programmable critical frequency lockout ranges to prevent the VFD from continuously operating at an unstable speed.

b. PI setpoint controller shall be standard in the drive, allowing a pressure or flow signal to be connected to the VFD, using the microprocessor in the VFD for the closed loop control.

c. Two (2) programmable analog inputs shall accept a current or voltage signal for speed reference, or for reference and actual (feedback) signals for PI controller. Analog inputs shall include a filter, programmable from 0.01 to 10 seconds to remove any oscillation in the input signal. Minimum and maximum values (gain and offset) shall be adjustable within the range of 0-20 mA and 0-10 volts. Additionally, the reference must be able to be scaled so that maximum reference can represent a frequency less than 60 Hz, without lowering drive maximum frequency below 60 Hz.

d. Six (6) programmable digital inputs for maximum flexibility in interfacing with external devices. One digital input is to be utilized as a customer safety connection point for fire, freeze, and smoke interlocks (Enable). Upon remote, customer reset (reclosure of interlock), drive is to resume normal operation.

e. Two (2) programmable analog outputs proportional to frequency, motor speed, output voltage, output current, motor torque, motor power (kW), DC bus voltage, or active reference.

f. Three (3) programmable digital relay outputs. The relays shall be rated for maximum switching current 8 amps at 24 VDC and 0.4 amps at 250 VAC; Maximum voltage 300 VDC and 250 VAC; continuous current rating 2 amps RMS. Outputs must be true from C type contacts; open collector outputs are not acceptable.

g. Seven (7) programmable preset speeds.

h. Two independently adjustable accel and decel ramps. These ramp times shall be adjustable from 1 to 1800 seconds.

i. VFD shall have ramp or coast to a stop, as selected by the user.

5. The following operating information displays shall be standard on the VFD digital display. Display shall be in complete English words (alpha-numeric codes are not acceptable).

a. Output frequency

b. Motor speed (RPM, % or engineering units)

c. Motor current

d. Calculated motor torque

e. Calculated motor power

f. DC bus voltage

g. Output voltage

h. Heatsink temperature

i. Analog input values

j. Keypad reference values

k. Elapsed time meter

l. kWh meter

6. VFD shall have the following protection circuits. In the case of a protective trip, drive shall stop, and announce the fault condition in complete words (alpha-numeric codes are not acceptable).

   a. Overcurrent trip 315% instantaneous (225% RMS) of the VFD's variable torque current rating.

   b. Overvoltage trip 130% of the VFD's rated voltage

   c. Undervoltage trip 65% of the VFD's rated voltage

   d. Overtemperature +70oC (ACH 501); +85oC (ACH 502)

   e. Ground fault either running or at start

   f. Adaptable electronic motor overload (I2t). The electronic motor overload protection shall protect motor based on speed, load curve, and external fan parameter. Circuits which are not speed dependant are unacceptable. The electronic motor overload protection shall be UL listed for this function.

7. Speed command input shall e via:

   a. Keypad.

   b. Two analog inputs, each capable of accepting a 0-20 mA, 4-20 mA, 0-10V, 2-10V signal. Input shall be isolated from ground, and programmable via the keypad for different uses.

   c. Floating point input shall accept a three-wire input from a Dwyer Photohelic (or equivalent type) instrument.

8. Serial Communications:

   a. VFD shall have an RS-405 port as standard.

   b. VFD shall be able to communicate with PLC's, DCS's. and

DDC's.

c. Serial communication capabilities shall include, but not be limited to, run-stop control, speed set adjustment, proportional/integral PI controller adjustments, current limit, and accel/decel time adjustments. Drive shall have the capability of allowing DDC to monitor feedback such as output speed/frequency, current (in amps), % torque, % power, kilowatt hours, relay outputs, and diagnostic fault information.

9. Accessories to be furnished and mounted by drive manufacturer:

a. Customer interlock terminal strip - provide a separate terminal strip for connection of freeze, fire, smoke contacts, and external start command. All external interlocks and start/stop contacts shall remain fully functional whether the drive is in Hand, Auto or Bypass.

b. All wires to be individually numbered at both ends for ease of troubleshooting.

c. Door interlocked thermal magnetic circuit breaker which will disconnect all input power from the drive and all internally mounted options. The disconnect handle shall be thru-the-door type, and be padlockable in the "Off" position.

10. VFD's shall be UL listed or CSA approved.

11. Submittals shall include the following information:

a. Outline dimensions.

b. Weight.

c. Typical efficiency vs. speed graph for variable torque load.

d. Compliance to IEEE 519 - Harmonic analysis for particular jobsite including total voltage harmonic distortion and total current distortion.

1) VFD manufacturer shall provide calculations, specific to this installation, showing total harmonic voltage distortion is less than 5%. Input line filters shall be sized and provided as required by VFD manufacturer to ensure compliance with IEEE standard 519-1992, Guide for Harmonic Control and Reactive Compensation for Static Power Converters. Acceptance of this calculation must be completed prior to VFD installation.

2) Prior to installation, VFD manufacturer shall provide estimated total harmonic distortion (thd) caused by the VFD's. results shall be based on a computer aided circuit simulation of total actual system, with information obtained from power provider and user.

3) If voltage THD exceeds 5%, VFD manufacturer is to

recommend additional equipment required to reduce the voltage THD to an acceptable level.

12. Install drive in accordance with recommendations of the VFD manufacturer. Complete all wiring in accordance with the recommendations of the VFD manufacturer. Certified factory start-up shall be provided for each drive by a factory authorized service center. A certified start-up form shall be filled out for each drive with copies provided to Architect, Owner, and a coy kept on file at the manufacturer.

13. Warranty shall be 24 months from the date of certified start-up, not to exceed 30 months from the date of shipment. Warranty shall include all parts, labor, travel time, and expenses.

14. Manufacturer shall be ABB Industrial Systems, Inc., Danfoss, Trane, Yaskawa, Siemens or approved equal.

E. Electronic Air Flow Measuring Equipment:

1. Provide thermal anemometer using instrument grade self heated thermistors or platinum RTD sensors with solid state temperature sensors. Flow measurement drift shall not exceed Manufacturer's repeatability statement for the life of the equipment. Manufacturer shall provide ETL or other nationally recognized testing for accuracy and dust loading performance. Provide in outside air duct and inlets of supply fan and return fan of each VAV system to maintain minimum system outside air, and control return fan CFM as a function of variable supply air demand less known constant exhaust air quantity.

2. Flow station construction: Duct mounted probe with heated flow sensing thermistors and epoxy encapsulated chip thermistors inside of an aluminum 6061 tubular casing. Each thermistor sensor shall be mounted in a solid Noryl, EN265, engineering thermoplastic housing.

3. Electronics:

   a. Sensor probe: microprocessor based electronics mounted in an aluminum enclosure, for indoor installation. Single probes shall have a use adjustable offset and span.

   b. Signal averager: analog electronics mounted in an aluminum enclosure for indoor installation. Each unit shall have a user adjustable offset and span.

   c. Each probe and signal averager shall be powered by an isolated (secondary not grounded) 24 VAC transformer or a regulated 24 VDC power supply. Multiple probes and averagers powered from a single transformer must be wired in phase.

4. Performance:

   a. Electronics temperature range: 30 to 160 F

   b. Flow station temperature range: 30 to 160 F

   c. Flow station velocity range: 0 to 5,000 ft/min

d. Flow station pressure drop: less than 0.005 inwc @ 2000 ft/min

e. Flow station humidity range: 0 to 99% RH (non-condensing)

f. Output signals:

1) Velocity accuracy: + 10 ft/min < 500 ft/min, +2% reading > 500 ft/min

2) Temperature accuracy: typ. 0.18 F, max. 0.36 F

3) Repeatability: + 0.2% scale

4) Type: linear

5) Resolution 0.4% of scale

5. Manufacturer

a. Ebtron

b. Air Monitor Electro

2.7 SMOKE DETECTORS

A. Dual chamber ionization type with duct sampling tubes. UL approved with adjustable sensitivity. Arrange to stop associated fan on presence of smoke. Provide in return duct upstream of outside air connection and filters for all fan systems above 2000 CFM.

2.8 CARBON DIOXIDE SENSORS

A. General: Duct-mounted carbon dioxide sensor. Infrared type.

B. Range and Accuracy: 0 to 2,000 ppm plus or minus 100 ppm. Maximum drift plus or minus 100 ppm per year.

C. Output Signal: 4 to 20 milliamp linearized.

D. Calibration Interval: One year.

E. Ambient Operating Conditions: 32□F to 122□F.

3 EXECUTION

3.1 EXAMINATION

A. Prior to starting work, carefully inspect installed work of other trades and verify that such work is complete to the point where work of this Section may properly commence.

B. Notify the Owners Representative in writing of conditions detrimental to the proper and timely completion of the work.

C. Do not begin work until all unsatisfactory conditions are resolved.

3.2 GENERAL INSTALLATION

A. Install in accordance with manufacturer's instructions.

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

3.3 LOCATION AND INSTALLATION OF COMPONENTS

A. Locate and install components for easy accessibility; in general, mount 60 inches above floor with minimum 3'-0" clear access space in front of units. Obtain Owner Representative's approval on locations prior to installation.

B. All instruments, switches, transmitters, etc., shall be suitably wired and mounted to protect them from vibration and high temperatures.

C. Identify all equipment and panels. Provide permanently mounted tags to all panels.

D. Provide stainless steel or brass thermowells suitable for respective application and for installation under other sections; sized to suit pipe diameter without restricting flow.

3.4 INTERLOCKING AND CONTROL WIRING

A. Provide all interlock and control wiring. All wiring shall be installed in a neat and professional manner in accordance with all state and local electrical codes.

B. Provide wiring as required by functions as specified and as recommended by equipment manufacturers, to serve specified control functions.

C. Control wiring shall not be installed in power circuit raceways. Magnetic starters and disconnect switches shall not be used as junction boxes. Provide auxiliary junction boxes as required. Coordinate location and arrangement of all control equipment with the Owner's Representative prior to rough-in.

D. Provide auxiliary pilot duty relays on motor starters as required for control function.

E. Provide power for all control components from nearest electrical control panel or as indicated on the electrical drawings; coordinate with electrical contractor.

F. All control wiring in the mechanical, electrical, telephone and boiler rooms to be installed in raceways. All other wiring to be installed in a neat and inconspicuous manner per local code requirements.

G. Where Class 2 wires are in concealed and accessible locations; including ceiling return air plenums, approved cables outside of electrical raceway can be used provided that the following conditions are met:

1. Circuits meet NEC Class 2 (current-limited) requirements. (Low-voltage power circuits shall be sub-fused when required to meet Class 2 current-limit.)

2. All cables shall be UL listed for application (i.e., cables used in ceiling plenums shall be UL listed specifically for that purpose).

H. Do not install Class 2 wiring in conduits containing Class 1 wiring. Boxes and panels containing high voltage may not be used for low voltage wiring except for the purpose of interfacing the two via control relays and transformers.

I. Where Class 2 wiring is run exposed, wiring shall be run parallel along a surface or perpendicular to it, and bundled, using approved wire ties at no greater than 3 m [10 ft] intervals. Such bundled cable shall be fastened to the structure, using industry approved fasteners, at 1.5 m [5 ft] intervals or more often to achieve a neat and workmanlike result.

J. All wire-to-device connections shall be made at a terminal blocks or terminal strip. All wire-to wire connections shall be at a terminal block, or with a crimped connector. All wiring within enclosures shall be neatly bundled and anchored to permit access and prevent restriction to devices and terminals.

K. Maximum allowable voltage for control wiring shall be 120Vac. If only higher voltages are available for use, the BAS manufacturer shall provide step-down transformers to achieve the desired control voltages.

L. All control wiring shall be installed as continuous lengths, where possible. Any required splices shall be made only within an approved junction box or other approved protective device.

M. Install plenum wiring in sleeves where it passes through walls and floors. Maintain fire rating at all penetrations in accordance with Contract Documents and National and/or Local Codes.

N. Conduit and wire sizing shall be determined by the BAS manufacturer in order to maintain manufacturer’s recommendation and must meet National and Local Codes.

O. Control and status relays are to be located in pre-fabricated enclosures that meet the application. These relays may also be located within packaged equipment control panel enclosures as coordinated. These relays shall not be located within Class 1 starter enclosures.

P. Follow manufacturer's installation recommendations for all communication and network bus cabling. Network or communication cabling shall be run separately from all control power wiring.

Q. BAS manufacturer shall terminate all control and/or interlock wiring and shall maintain updated (as-built) wiring diagrams with terminations identified at the job site.

R. Flexible metal conduits and liquid-tight flexible metal conduits shall not exceed 3' in length and shall be supported at each end. Flexible metal conduit less than 1/2" electrical trade size shall not be used. In areas exposed to moisture, including chiller and boiler rooms, liquid-tight, flexible metal conduits shall be used.

3.5 DDC POINT SUMMARY

A. Provide all Data-base generation.

B. Displays: System displays shall show all points in the system. They shall be logically laid out for ease of use by the owner. Provide outside air temperature indication on all system displays associated with economizer cycles.

C. Run time Totalization: At a minimum, run time totalization shall be incorporated for each monitored supply fan, return fan, exhaust fan, hot water and chilled water pumps. Warning limits for each point shall be entered for alarm and or maintenance purposes.

D. Trend Log: All binary and analog points shall have the capability to be trended.

E. Alarm Points: All analog inputs (High/Low Limits) and selected digital input alarm points shall be prioritized and routed/auto-dial with alarm message per owner's requirements.

F. Database Save: Provide back-up database for all stand-alone DDC panels on floppy disk.

G. Provide all points required in above specification and in point schedule, included in this specification.

3.6 FIELD SERVICES

A. Prepare and start DDCS under provisions of this section.

B. Start-up and commission systems. Allow sufficient time for start-up and commissioning prior to placing control systems in permanent operation.

C. Provide the capability for off-site monitoring at Control Contractor's local or main office. At a minimum, off-site facility shall be capable of system diagnostics and software download. Owner shall provide phone line for this service.

D. Provide Owner's Representative with spare parts list. Identify equipment critical to maintaining the integrity of the operating system.

3.7 TRAINING

A. Provide application engineer to instruct owner in operation of systems and equipment.

B. Provide basic operator training for a minimum of 3 persons on data display, alarm and status descriptors, requesting data, execution of commands and request of logs.

C. Provide training above as required up to 40 hours as part of this contract.

3.8 DEMONSTRATION

A. Provide systems demonstration under provisions of Section 15010.

B. Demonstrate complete and operating system to Owner's Representative.

C. Provide certificate stating that control system has been tested and adjusted for proper operation.

4 SEQUENCE OF OPERATION

4.1 MIXING BOXES

A. Room sensor modulates unit dampers in sequence to control room temperature. On decrease in room temperature, modulate heating damper open. On rise in room temperature, modulate heating damper toward minimum air volume to maintain code required ventilation. On increase in room temperature, heating damper shall close and cooling damper shall open, starting at minimum air volume to maintain code required ventilation. On further increase in room temerpature, cooling damper shall modulate open further. Heating and cooling dampers shall not be open at the same time to prevent mixing of hot and cold air streams.

B. Space temperature, maximum CFM and minimum CFM for cooling and heating, desired and actual CFM, supply air discharge temperatures and all setpoints for above items and scheduling at each mixing box unit as applicable may be set and verified at operator terminal.

4.2 DUAL DUCT AIR HANDLING UNIT, SF-1/RF-1

A. Run AHU system during occupied schedules, override, warm-up/cool down cycle, or night low limit modes of operation.

B. When AHU system is off, supply and return fans off, outside air damper closed, return air damper full open, relief air damper closed.

C. When AHU system is on during occupied mode, start AHU return fan before supply fan. In sequence modulate heating valve to maintain 90^{o}F discharge supply temperature to hot duct, modulate outside - return - relief air dampers, and cooling coil valve to maintain 55^{o}F discharge supply air temperature to cold duct. Control outside - return - relief air dampers as required for free outside air economizer cooling to minimize mechanical cooling. CO2 sensor shall reduce ventilation amounts below design levels as allowed by number of people in areas served. Design ventilation amount is upper level of ventilation allowed (except as called for by economizer cooling cycle). Ventilation minimum is the least allowed by Oregon Mechanical Code to still maintain area required ventilation amounts. Electronic air flow station in outside air duct shall be used to verify control of dampers. When outside air temperature is greater than return air, discontinue economizer control and maintain minimum outside air. Limit discharge supply air temperature to a low limit of 50^{o}F.

D. Reset discharge supply air temperature to hot duct and cold duct as possilbe to just satisfy mixing boxes requiring the most heating and cooling for maximum energy savings.

E. A duct static pressure sensor in supply duct shall modulate supply fan speed with variable frequency motor drive to maintain a resettable pressure at pressure sensor location. Supply fan volume shall not be less than system minimum outside air CFM. Implement pressure reset control strategy to open mixing box dampers and reduce supply and return fan speeds to minimize energy use.

F. Modulate return fan speed with variable frequency motor drive to maintain preset building pressure at all times.

G. Freeze protection thermostat downstream of heating coil to stop supply fan, stop

return fan, close outside and exhaust dampers, open return damper, or start heating, whenever temperature of any one foot length of freezestat is 40°F or below.

H. Start heating water system if AHU or associated mixing boxes demand heat.

I. Provide ionization type duct smoke detector(s) as required in the IMC for automatic fan shut down, in supply and return air duct and stop AHU when smoke is detected. Also stop AHU when fire alarm system initiates an alarm condition.

J. During unoccupied schedules, stop AHU and reduce room temperature set point to a night low limit setting selected by Owner. If any space temperature served by AHU terminal units drops below the night low limit temperature, start heating system and run AHU only in a night low limit mode, providing heat only, with outside and relief dampers closed and return dampers full open until space temperature returns to the night low limit setting. When unoccupied mode changes to occupied, by time schedule or override, outside and relief dampers shall remain closed in a "warm up/cool down" cycle until space temperature reaches the occupied set point.

K. Manual override of the unoccupied operating mode and night set back temperature is accomplished at any room sensor. Override is for an adjustable, timed period of 1 hr, 2 hr, 3 hr, etc. as requested by Owner. During override operation AHU shall operate same as the occupied mode described above. Mixing box sensor set point temperatures shall be changed to occupied set points for only the terminal unit zones where override operation is initiated.

L. Return air temperature, supply air temperature (hot duct and cold duct) and supply air reset schedule, outside air temperature, mixed air temperature, filter cleanliness status, damper positions, damper minimum positions, outside air CFM, duct pressure, duct pressure reset schedule, building pressure, supply and return fan status and VFD frequency, CO2 ppm, smoke detectors, heating and cooling valve position and all setpoints for above items as applicable may be set and verified at operator terminal.

M. AHU shall have the ability to operate in night purge mode as required to lower space temperature prior to occupancy in morning.

4.3 MULTIZONE UNIT, MZ1

A. Run AHU system during occupied schedules, override, warm-up/cool down cycle, or night low limit modes of operation.

B. When AHU system is off, supply and return fans off, outside air damper closed, return air damper full open, relief air damper closed.

C. When AHU system is on during occupied mode, start AHU return fan before supply fan. In sequence modulate heating valve to maintain 90°F discharge supply temperature to hot duct, modulate outside - return - relief air dampers, and cooling coil valve to maintain 55°F discharge supply air temperature to cold duct. Control outside - return - relief air dampers as required for free outside air economizer cooling to minimize mechanical cooling. CO2 sensor shall reduce ventilation amounts below design levels as allowed by number of people in areas served. Design ventilation amount is upper level of ventilation allowed (except as called for by economizer cooling cycle). Ventilation minimum is the least allowed by Oregon Mechanical Code to still maintain area required ventilation amounts.

Electronic air flow station in outside air duct shall be used to verify control of dampers. When outside air temperature is greater than return air, discontinue economizer control and maintain minimum outside air. Limit discharge supply air temperature to a low limit of 50°F.

D. Reset discharge supply air temperature to hot duct and cold duct as possible to just satisfy zone requiring the most heating and cooling and for maximum energy savings.

E. Supply and return fans to be set at fixed speed.

G. Freeze protection thermostat downstream of heating coil to stop supply fan, stop return fan, close outside and exhaust dampers, open return damper, or start heating, whenever temperature of any one foot length of freezestat is 40°F or below.

H. Start heating water system if AHU or associated zone demands heat.

I. Provide ionization type duct smoke detector(s) as required in the IMC for automatic fan shut down, in supply and return air duct and stop AHU when smoke is detected. Also stop AHU when fire alarm system initiates an alarm condition.

J. During unoccupied schedules, stop AHU and reduce room temperature set point to a night low limit setting selected by Owner. If any space temperature served by AHU drops below the night low limit temperature, start heating system and run AHU only in a night low limit mode, providing heat only, with outside and relief dampers closed and return dampers full open until space temperature returns to the night low limit setting. When unoccupied mode changes to occupied, by time schedule or override, outside and relief dampers shall remain closed in a "warm up/cool down" cycle until space temperature reaches the occupied set point.

K. Manual override of the unoccupied operating mode and night set back temperature is accomplished at any room sensor. Override is for an adjustable, timed period of 1 hr, 2 hr, 3 hr, etc. as requested by Owner. During override operation AHU shall operate same as the occupied mode described above. Zone set point temperature shall be changed to occupied set point for only the zones where override operation is initiated.

L. Return air temperature, supply air temperature (hot duct and cold duct) and supply air reset schedule, outside air temperature, mixed air temperature, filter cleanliness status, damper positions, damper minimum positions, outside air CFM, building pressure, supply and return fan status, CO2 ppm, smoke detectors, heating and cooling valve position and all setpoints for above items as applicable may be set and verified at operator terminal.

M. MZU1 shall have the ability to operate in night purge mode as required to lower space temperature prior to occupancy in morning.

4.4 AIR HANDLING UNIT, CD-1

A. Run AHU system during occupied schedules, override, warm-up/cool down cycle, or night low limit modes of operation.

B. When AHU system is off, supply fan off, outside air damper closed, return air damper full open, relief air damper closed.

C. Condensing heat recovery coil is no longer connected to heat source. Face/bypass damper shall be set to bypass condensing heat recovery coil in all stages.

D. When AHU system is on during occupied mode, start AHU supply fan. In sequence modulate heating valve at heating coil, HC-2, to maintain 90°F discharge supply temperature, modulate outside - return - relief air dampers to provide minimum ventilation amount as called for by CO2 sensor. Upon drop in space temperature, modulate heating coil valve open. Upon rise in space temperature, modulate heating coil valve closed. Control outside - return - relief air dampers as required for free outside air economizer cooling. CO2 sensor shall reduce ventilation amounts below design levels as allowed by number of people in areas served. Design ventilation amount is upper level of ventilation allowed (except as called for by economizer cooling cycle). Ventilation minimum is the least allowed by Oregon Mechanical Code to still maintain area required ventilation amounts. Electronic air flow station in outside air duct shall be used to verify control of dampers. When outside air temperature is greater than return air, discontinue economizer control and maintain minimum outside air. Limit discharge supply air temperature to a low limit of 50°F.

E. Reset discharge supply air temperature as possible to just satisfy space heating requirements for maximum energy savings.

F. Freeze protection thermostat downstream of heating coil to stop supply fan, close outside and relief dampers, open return damper, or start heating, whenever temperature of any one foot length of freezestat is 40°F or below.

G. Start heating water system if AHU or associated zone demands heat.

H. Provide ionization type duct smoke detector(s) as required in the IMC for automatic fan shut down, in supply and return air duct and stop AHU when smoke is detected. Also stop AHU when fire alarm system initiates an alarm condition.

I. During unoccupied schedules, stop AHU and reduce room temperature set point to a night low limit setting selected by Owner. If space temperature served by AHU drops below the night low limit temperature, start heating system and run AHU only in a night low limit mode, providing heat only, with outside and relief dampers closed and return dampers full open until space temperature returns to the night low limit setting. When unoccupied mode changes to occupied, by time schedule or override, outside and relief dampers shall remain closed in a "warm up/cool down" cycle until space temperature reaches the occupied set point.

J. Manual override of the unoccupied operating mode and night set back temperature is accomplished at room sensor. Override is for an adjustable, timed period of 1 hr, 2 hr, 3 hr, etc. as requested by Owner. During override operation AHU shall operate same as the occupied mode described above. Zone set point temperature shall be changed to occupied set point.

K. Return air temperature, supply air temperature and supply air reset schedule, outside air temperature, mixed air temperature, filter cleanliness status, damper positions, damper minimum positions, outside air CFM, supply fan status, CO2 ppm, smoke detectors, heating valve position and all setpoints for above items as applicable may be set and verified at operator terminal.

L. AHU shall have the ability to operate in night purge mode as required to lower space temperature prior to occupancy in morning.

4.5 AIR HANDLING UNIT, CD-2

A. Run AHU system during occupied schedules, override, cool down cycle, or night low limit modes of operation. CD-2 is used for economizer cooling only.

B. When AHU system is off, supply fan off, outside air damper closed, return air damper full open, relief air damper closed.

C. Condensing heat recovery coil is no longer connected to heat source. Face/bypass damper shall be set to bypass condensing heat recovery coil in all stages.

D. When AHU system is on during occupied mode, start AHU supply fan only when economizer cooling is called for. Control outside - return - relief air dampers as required for free outside air economizer cooling. Electronic air flow station in outside air duct shall be used to verify control of dampers. When outside air temperature is greater than return air, discontinue economizer control. Limit discharge supply air temperature to a low limit of 50°F. When not in economizer cooling mode, outside air damper and relief dampers shall be closed, return damper shall be open and supply fan shall be off.

E. Provide ionization type duct smoke detector(s) as required in the IMC for automatic fan shut down, in supply and return air duct and stop AHU when smoke is detected. Also stop AHU when fire alarm system initiates an alarm condition.

F. During unoccupied schedules, stop AHU and raise room temperature set point to a night setting selected by Owner. If space temperature served by AHU rises above the night temperature, and outside air temperature is less than space temperature, start economizer cooling and run AHU only in night mode, providing economizer cooling only, with outside and relief dampers open and return dampers closed until space temperature returns to the night setting. When unoccupied mode changes to occupied, by time schedule or override, outside and relief dampers shall remain opened in economizer cooling mode until space temperature reaches the occupied set point.

G. Manual override of the unoccupied operating mode and night set back temperature is accomplished at room sensor. Override is for an adjustable, timed period of 1 hr, 2 hr, 3 hr, etc. as requested by Owner. During override operation AHU shall operate same as the occupied mode described above. Zone set point temperature shall be changed to occupied set point.

H. Return air temperature, supply air temperature, outside air temperature, mixed air temperature, filter cleanliness status, damper positions, outside air CFM, supply fan status, smoke detectors and all setpoints for above items as applicable may be set and verified at operator terminal.

I. AHU shall have the ability to operate in night purge mode as required to lower space temperature prior to occupancy in morning.

4.6 FAN COIL, AC-1

A. Run AHU system during occupied schedules, override, warm-up/cool down cycle, or night low limit modes of operation.

B. When AHU system is off, supply fan off, outside air damper closed, return air damper full open.

C. When AHU system is on during occupied mode, start AHU supply fan. In sequence modulate heating valve to maintain 90ºF discharge supply temperature or, modulate outside - return - relief air dampers, and cooling coil valve to maintain 55ºF discharge supply air temperature. Control outside - return air dampers as required for free outside air economizer cooling to minimize mechanical cooling. CO2 sensor shall reduce ventilation amounts below design levels as allowed by number of people in areas served. Design ventilation amount is upper level of ventilation allowed (except as called for by economizer cooling cycle). Ventilation minimum is the least allowed by Oregon Mechanical Code to still maintain area required ventilation amounts. Electronic air flow station in outside air duct shall be used to verify control of dampers. When outside air temperature is greater than return air, discontinue economizer control and maintain minimum outside air. Limit discharge supply air temperature to a low limit of 50ºF.

D. Reset discharge supply air temperature as possible to just satisfy zone requiring the most heating or cooling for maximum energy savings.

E. Freeze protection thermostat downstream of heating coil to stop supply fan, close outside air dampers, open return damper, or start heating, whenever temperature of any one foot length of freezestat is 40ºF or below.

H. Start heating water system if AHU or associated zone demands heat.

I. Provide ionization type duct smoke detector(s) as required in the IMC for automatic fan shut down, in supply and return air duct and stop AHU when smoke is detected. Also stop AHU when fire alarm system initiates an alarm condition.

J. During unoccupied schedules, stop AHU and reduce room temperature set point to a night low limit setting selected by Owner. If any space temperature served by AHU drops below the night low limit temperature, start heating system and run AHU only in a night low limit mode, providing heat only, with outside damper closed and return damper full open until space temperature returns to the night low limit setting. When unoccupied mode changes to occupied, by time schedule or override, outside dampers shall remain closed in a "warm up/cool down" cycle until space temperature reaches the occupied set point.

K. Manual override of the unoccupied operating mode and night set back temperature is accomplished at any room sensor. Override is for an adjustable, timed period of 1 hr, 2 hr, 3 hr, etc. as requested by Owner. During override operation AHU shall operate same as the occupied mode described above. Zone set point temperature shall be changed to occupied set point for only the zone where override operation is initiated.

L. Return air temperature, supply air temperature, supply air reset schedule, outside air temperature, mixed air temperature, filter cleanliness status, damper positions, damper minimum positions, outside air CFM, supply fan status, CO2 ppm, smoke detectors, heating and cooling valve position and all setpoints for above items as applicable may be set and verified at operator terminal.

M. AC-1 shall have the ability to operate in night purge mode as required to lower space temperature prior to occupancy in morning.

4.7 HEATING WATER SYSTEM

A. Run heating water system on call for heating from associated coils or equipment in occupied, override, or night low limit operating mode. Alternate boilers as appropriate. Manufacturer's proprietary controls shall be the primary source of control but the Owner shall be able to monitor and operate items as indicated below from the central DDC system.

B. When heating water system is off all associated pumps to be off.

C. When heating water system is on, start pumps as required to maintain heating water temperature set point for heating water supply to heating system. Alternate lead/lag of pumps as appropriate.

D. Boiler controls set to maintain the minimum hot water temperature supply to coils that will meet building load demands and maximize efficiency of boilers. System shall reset hot water supply temperature as allowed by demand and outside temperature.

E. Stop boilers if heating water temperature exceeds 210°F.

F. Heating water system shall be lockout above Owner determined outside air temperature.

F. Boiler start/stop, pump start/stop, boiler isolation valve position, hot water reset schedule, outside air temperature, outside air temperature lockout, lead/lag controls, hot water return and supply temperatures, boiler staging and all setpoints for above items as applicable may be set and verified at operator terminal.

4.8 CHILLED WATER SYSTEM

A. Run chiller water system on call for cooling from associated coils or equipment in occupied, override, or night low limit operating mode. Manufacturer's proprietary controls shall be the primary source of control but the Owner shall be able to monitor and operate items as indicated below from the central DDC system.

B. When chilled water system is off all associated pumps to be off.

C. When chilled water system is on, start pumps and cooling tower as required to maintain water temperature set point for chilled water supply to system.

D. Chiller controls set to maintain the maximum chilled water temperature supply to coils that will meet building load demands and maximize efficiency of chiller and cooling tower. System shall reset chilled water supply temperature as allowed by demand and outside temperature.

E. Chilled water system shall be lockout below Owner determined outside air temperature.

F. Chiller start/stop, pumps start/stop, cooling tower fan and pump start/stop, chilled water reset schedule, outside air temperature, outside air temperature lockout, chilled water return and supply temperatures, condensing water supply and return temperatures, cooling tower supply temperature, bypass valve position and all

setpoints for above items as applicable may be set and verified at operator terminal.

4.9 EXHAUST/SUPPLY FANS

A. Start/stop exhaust and supply fans based on time schedule or space temperature as indicated in Drawings.

B. Fan start/stop, space temperature, time schedules and associated setpoints as applicable may be set and verified at operator terminal.

4.10 WATER HEATERS

A. Start/stop hot water recirculation pump based on time schedule and hot water recirculation aquastat as appropriate.

B. Recirculation pump start/stop, time schedules, water temperature and associated setpoints as applicable may be set and verified at operator terminal.

4.11 AUXILIARY MONITORING

A. IT room temperature shall be monitored and alarms sent from operator terminal.

B. Conference room temperature setpoints, occupied/unoccupied mode shall be monitored and alarms sent from operator terminal.

END OF SECTION

1 GENERAL

1.01 WORK INCLUDED

A. After completion of the work of installation, test and regulate all components of the heating, air conditioning and ventilating systems to verify air and water flow rates shown.

B. Testing, adjustment, and balancing of air and water systems.

C. Measurement of final operating condition of mechanical systems.

1.02 REFERENCES

A. AABC - National Standards for Field Measurement and Instrumentation, Total System Balance.

B. ASHRAE – Measurements, Instruments and Testing, Adjusting and Balancing.

C. NEBB - Procedural Standards for Testing, Balancing and Adjusting of Environmental Systems.

1.03 QUALITY ASSURANCE

A. Agency shall be company specializing in the adjusting and balancing of systems specified in this Section with minimum five years documented experience.

B. Testing, adjusting and balancing shall be performed by a firm with 10 years of experience and certified for direct digital control systems.

1.04 SUBMITTALS

A. Submit name of adjusting and balancing agency for approval within 30 days after award of Contract.

B. Submit test reports as a submittal under provisions of Section 15010.

C. Prior to commencing work, submit draft reports indicating adjusting, balancing, and equipment data required.

D. Submit draft copies of report for review prior to final acceptance of Project. Provide final copies for Architect and for inclusion in operating and maintenance manuals.

E. Provide reports in soft cover, letter size, 3-ring binder manuals, complete with index page and indexing tabs, with cover identification at front and side. Include set of reduced drawings with air outlets and equipment identified to correspond with data sheets, and indicating thermostat locations.

2 PRODUCTS

2.01 EQUIPMENT

A. Provide all necessary personnel, equipment and services.

2.02 REPORT FORMS

A. Submit reports on forms.

B. Forms shall include the following information:

1. Title Page:

a. Company name.

b. Company address.

c. Company telephone number.

d. Project name.

e. Project location.

f. Project Architect.

g. Project Engineer.

h. Project Contractor.

i. Project altitude.

j. Outdoor conditions.

2. Instrument List:

a. Instrument.

b. Manufacturer.

c. Model.

d. Serial number.

e. Range.

f. Calibration date.

3. Air Handling Units, Make-up Air Unit, Supply Fans, Exhaust Fans and Fan Coil Units:

a. Location.

b. Manufacturer.

c. Model.

d. Supply air flow, specified and actual.

e. Return and/or outside air flows, specified and actual.

f. Total and external static pressure, specified and actual.

g. Inlet pressure.

h. Discharge pressure.

i. Fan RPM.

j. Cooling and heating coils inlet/outlet water and air temperature including flow rates.

4. Mixing Box:

a. Location.

b. Manufacturer.

c. Model.

d. Air flow, specified and actual (maximum and minimum).

e. Total static pressure (total external), specified and actual.

f. Inlet pressure.

5. Air Flow:

a. Identification/ location.

b. Design air flow.

c. Actual air flow.

d. Supply air temperature.

e. Return air temperature.

6. Chilled Water and Heating Water (all coils):

a. Identification/location.

b. Design water flow rate.

c. Actual water flow rate.

d. Entering temperature, specified and actual.

e. Leaving temperature, specified and actual.

f. Design and actual air flow rate.

7. Electric Motors and VFD's:

a. Manufacturer.

b. HP/BHP.

c. Phase, voltage, amperage; nameplate, and actual.

d. RPM.

e. Service factor.

f. Starter size, rating, heater elements.

8. V-Belt Drive:

a. Identification/location.

b. Required driven RPM.

c. Driven sheave, diameter and RPM.

d. Belt, size and quantity.

e. Motor sheave, diameter and RPM.

f. Center to center distance, maximum, minimum, and actual.

9. Pumps:

a. Identification/number.

b. Manufacturer.

c. Size/model.

d. Impeller.

e. Type of service system.

f. Design flow rate, pressure drop, BHP.

g. Actual flow rate, pressure drop, BHP.

h. Shut off, discharge and suction pressures.

10. Boilers:

a. Manufacturer.

b. Model.

c. Input firing rate, MBH.

d. Rated output, MBH.

e. Water flow, design and actual.

f. Water pressure drop.

g. Water temperature, supply and return.

11. Cooling Towers:

a. Tower identification/location.

b. Manufacturer.

c. Model.

d. Rated capacity.

e. Entering air WB temperature, specified and actual.

f. Leaving air WB, specified and actual.

g. Ambient air DB temperature.

h. Water temperature, entering and leaving.

i. Water flow rate.

12. Chiller

a. Ambient temperature.

b. Water flow.

c. Entering water temperature.

d. Leaving water temperature.

e. Head pressure.

f. Suction pressure.

g. Electrical data.

3 EXECUTION

3.01 EXAMINATION

A. Before commencing work, verify that systems are complete and operable. Ensure the following:

1. Equipment is operable and 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. Final filters are clean and in place. If required, install temporary media in addition to final filters.

5. Duct systems are clean of debris.

6. Correct fan rotation.

7. Fire and volume dampers are in place and open.

8. Coil fins have been cleaned and combed.

9. Access doors are closed and duct end caps are in place.

10. Air outlets are installed and connected.

11. Duct system leakage has been minimized.

B. Report any defects or deficiencies noted during performance of services to Architect.

C. Promptly report abnormal conditions in mechanical systems or conditions which prevent system balance.

D. If, for design reasons, system cannot be properly balanced, report as soon as observed.

E. Beginning of work means acceptance of existing conditions.

3.02 PREPARATION

A. Provide instruments required for testing, adjusting, and balancing operations. Make instruments available to Architect to facilitate spot checks during testing.

B. Provide additional balancing devices as required.

3.03 INSTALLATION TOLERANCES

A. Adjust air handling systems to plus or minus 5 percent for supply, return and exhaust systems from figures indicated.

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

C. At final inspection, recheck random selections of data recorded in report. Recheck points or areas as selected and witnessed by the Owner.

3.04 ADJUSTING

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

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

C. Leave systems in proper working order, replacing belt guards, closing access doors, closing doors to electrical switch boxes, and restoring thermostats to specified settings.

3.05 AIR SYSTEM PROCEDURE

A. Adjust air handling and distribution systems to provide required or design supply, return, and exhaust air quantities.

B. Make air quantity measurements in ducts by Pitot tube traverse of entire cross sectional area of duct.

C. Measure air quantities at air inlets and outlets.

D. Adjust distribution system to obtain uniform space temperatures free from objectionable drafts and noise.

E. Use volume control devices to regulate air quantities only to extent that adjustments do not create objectionable air motion or sound levels. Effect volume control by duct internal devices such as dampers and splitters.

F. Vary total system air quantities by adjustment of fan speeds. Provide drive changes required. Vary branch air quantities by damper regulation.

G. Provide system schematic with required and actual air quantities recorded at each outlet or inlet.

H. Measure static air pressure conditions on air supply units, including filter and coil pressure drops, and total pressure across the fan.

I. Adjust outside air automatic dampers, outside air, return air, and exhaust dampers for design conditions.

J. Measure temperature conditions across outside air, return air, and exhaust dampers to check leakage.

K. Where modulating dampers are provided, take measurements and balance at extreme conditions.

L. Measure building static pressure and adjust supply, return, and exhaust air systems to provide required relationship between each to maintain approximately 0.05 inches positive static pressure near the building entries.

3.06 WATER SYSTEM PROCEDURES

A. Adjust water systems to provide required or design quantities. Use calibrated orifices or other metered fittings and pressure gauges to determine flow rates for system balance.

B. Adjust systems to provide specified pressure drops and flows through heat transfer elements. Perform balancing by measurement of temperature differential.

C. Effect system balance with automatic control valves fully open.

D. Effect adjustment of water distribution systems by means of balancing valves, valves and fittings. Do not use service or shutoff valves for balancing.

3.07 DOMESTIC WATER

A. Test and adjust domestic water recirculation system to ensure hot water circulation in all mains.

3.08 VERIFICATION OF CONTRACTOR'S PERFORMANCE

A. Balancing data may be spot checked with instruments similar to that used by the balancing firm.

B. If there are discrepancies between balancing data and spot check data, readjust and rebalance the systems at no additional project cost.

END OF SECTION