

SECTION 201000**GENERAL MECHANICAL PROVISIONS****PART 1 GENERAL****1.01 CONTRACT CONDITIONS**

- A. Work of this Division is bound by the Provisions of Division 1 bound herewith, in addition to these Specifications and accompanying Drawings.

1.02 SECTION INCLUDES

- A. General requirements specifically applicable to Division 20, 21, 22 and 23 sections, which apply in addition to Division 1 - General Requirements.

1.03 DRAWINGS AND SPECIFICATIONS

- A. The Drawings and Specifications are complimentary, and what is called for by one shall be as binding as if called for by both.
- B. Use of the word "Provide" shall be equivalent to "Furnish and Install."
- C. Use of singular or plural in article, paragraph, and subparagraph headings does not indicate numbers of products required. Example: The heading "Chiller" does not necessarily mean there is only one chiller required.
- D. Abbreviations:
 - 1. ADA: Americans with Disabilities Act
 - 2. AASHTO: American Association of State Highway and Transportation Officials
 - 3. ASTM: American Society for Testing and Materials
 - 4. AWWA: American Water Works Association
 - 5. ANSI: American National Standards Institute
 - 6. NEMA: National Electrical Manufacturers' Association
 - 7. ASME: American Society of Mechanical Engineers
 - 8. UL: Underwriters' Laboratories
 - 9. IAPMO: International Association of Plumbing and Mechanical Officials
 - 10. Fed. Spec.: Federal Specifications
 - 11. MSS: Manufacturers' Standardization Society of the Valve and Fitting Industry
 - 12. WOG: Non-shock Water-Oil-Gas maximum working pressure rating
 - 13. NFPA: National Fire Prevention Association
 - 14. FM: Factory Mutual
 - 15. SMACNA: Sheet Metal and Air Conditioning Contractors' National Association
 - 16. ARI: Air Conditioning and Refrigeration Institute
 - 17. AMCA: Air Movement and Control Association
 - 18. TIMA: Thermal Insulation Manufacturers' Association
 - 19. ASHRAE: American Society of Heating, Refrigerating, and Air Conditioning Engineers
 - 20. AABC: Associated Air Balance Council
 - 21. NEBB: National Environmental Balancing Bureau
- E. For products specified by listing one or more manufacturers, followed by "Similar to" and one manufacturer's model number, the following requirements apply:
 - 1. Approval of each listed manufacturer is contingent upon that manufacturer having a product which meets the specification, fits the available space, and is comparable to the listed model.

2. Electrical requirements, duct connections, pipe connections, and space requirements indicated on Drawings are based on the listed model. Provide revisions required to accommodate the model actually furnished.
- F. For products specified by listing one or more manufacturers, followed by a model number for each manufacturer, the following requirements apply:
1. Provide one of the listed model numbers or an approved substitution.
 2. Electrical requirements, duct connections, pipe connections, and space requirements indicated on Drawings are based on one of the listed models, and may not be suitable for all models listed. Provide revisions required to accommodate the model actually furnished.

1.04 PERMITS, FEES, AND GOVERNING AGENCIES

- A. Obtain permits required by governing agencies. Owner will pay associated permit fees.
- B. Minimum requirements not otherwise stated herein shall meet governing codes and standards.
- C. Arrange and pay for inspections and tests required by applicable codes and ordinances.

1.05 SITE VISITATION AND FIELD MEASUREMENTS

- A. Examine site of proposed Work to verify conditions. Beginning of Work means acceptance of conditions.
- B. If conditions differ substantially from conditions indicated on Drawings, notify Architect before commencing Work.

1.06 SUBSTITUTIONS

- A. Substitution requests will not be considered unless they are submitted in writing, in accordance with Division 0 and Division 1.
- B. Substitution requests will not be considered unless they include the following:
 1. Model numbers of proposed substitutions.
 2. Options that are required to make the proposed substitution comply with Specifications.
 3. Summary of modifications of the Work that are required to accommodate the proposed substitution.

1.07 OWNER FURNISHED ITEMS

- A. Refer to Division 1.

1.08 ALTERNATES

- A. Refer to Division 1.

1.09 PROJECT MANAGEMENT AND COORDINATION

- A. Provide coordination for the Work of Divisions 20, 21, 22 and 23 in accordance with Division 1.
- B. Locations shown on Drawings are approximate and are not intended to fully coordinate the Work of all Sections. Plan exact locations based on field measurements of field conditions and the Work of other Sections.
- C. Drawings do not show all required duct and pipe offsets and fittings. Provide offsets and fittings as required to coordinate with the Work of other Sections and with field conditions.
- D. Locate equipment, piping, valves, dampers, etc. to provide adequate space for normal operating and maintenance activities.

1.10 CUTTING AND PATCHING

- A. Provide cutting and patching for the Work of Divisions 20, 21, 22 and 23 in accordance with Division 1.

1.11 SHOP DRAWINGS AND PRODUCT DATA

- A. Provide shop drawings and product data for the Work of Divisions 20, 21, 22 and 23 in accordance with Division 1. Refer to each Section for required shop drawings and product data submittals.
- B. Submittal Format: Electronic with hard-copy. At least one hard-copy of the information must be submitted with the electronic copies. (The hard-copy will be retained by the Engineer.)
- C. Submittal content shall conform with the following requirements:
 - 1. Each hard-copy Submittal package shall be formatted as follows:
 - a. Use three-ring loose leaf binders.
 - b. Provide index referencing specification section and page.
 - c. Tab individual sections.
 - 2. Each Electronic Submittal package shall be formatted as follows:
 - a. The full extent of the submitted data shall be presented in a single electronic file on a CD-ROM.
 - b. File Format Type: Adobe pdf, or universally readable equivalent.
 - c. Scanned information: Minimum 400 dpi.
 - d. Provide index referencing specification section and page.
 - e. Bookmark individual sections.
 - f. One file per CD-ROM.
 - 1) Format CD-ROM for use in PC compatible hardware
 - 2) Format CD-ROM so that additional files may be written to it (read-write).
- D. Contractor may provide one (1) early submittal for items with long lead times as determined by the Contractor. The submittal shall be clearly identified as "Long Lead Time Item Submittal".
- E. The remainder of the shop drawings and product data shall be submitted as a single Project Submittal, except:
 - 1. Control system shop drawings and product data may be provided as a single, separate submittal package prior to beginning of control work on site.
 - 2. Fire Sprinkler Shop Drawings and Product Data may be provided as a single, separate submittal package before or after the project submittal.
 - 3. Seismic Restraint Shop Drawings, and Product Data may be provided as a single, separate submittal package before or after the Project Submittal.
- F. The Project Submittal must be submitted no more than three (3) weeks after the Long Lead Time Item Submittal. If the Project Submittal is found to be incomplete, it will be rejected and returned. The Project Submittal shall then be completed by the Contractor and resubmitted in its entirety.
- G. Definitions of comments used in submittal review:
 - 1. "No Exception Taken" The meaning and intent of this statement is that the Engineer finds no objection (except those noted thereon or in correspondence) to inclusion of items or Work indicated in construction provided that it:
 - a. Complies with Contract Drawings and Specifications as to quantities, space requirements, and dimensions.
 - b. Does not interfere with other trades.
 - c. Is not the cause of union tradesmen disputes.

- d. Does not infringe on patent rights.
- e. Is not the cause of injury or damage to persons or property.
- f. Complies with OSHA regulations.
2. "Rejected" The meaning and intent of this statement is that the submitted material does not conform to plans and specifications. Resubmittal of a different product or shop drawing is required.
3. "Revise and Resubmit" This statement is used when the general product line is acceptable, but the submitted material varies in dimension, accessories, etc. from what is required. Resubmittal is required.
4. "Make Corrections Noted" This statement is used as an alternative to "Revise and Resubmit" when resubmittal is not required.
5. Said review does not relieve Contractor of any Contractual responsibilities.

1.12 TEMPORARY FACILITIES AND CONTROLS

- A. Refer to Division 1.
- B. Use of Project equipment for temporary service during construction is not acceptable.

1.13 SCHEDULING

- A. Schedule the Work of Divisions 20, 21, 22 and 23 in accordance with Division 1.
- B. Schedule Work at such a time, and in such a manner, to minimize interference and inconvenience to the Owner.
- C. Work that causes disruptions of existing services shall be coordinated with the Owner. Provide a minimum of 24 hour notice prior to any shutdown of existing services.

1.14 OPERATION AND MAINTENANCE MANUALS

- A. Provide operation and maintenance manuals for the Work of this Division in accordance with Division 1 and Section 202000.

1.15 VALVE AND NAMEPLATE DIRECTORIES

- A. Provide valve and nameplate directories as required herein, and in accordance with Sections 202000 and 206000.
- B. Framed Copies:
 1. Number Required: One.
 2. Location: As directed by Owner's representative.
 3. Type: Wood with glass cover.
- C. Service Copies:
 1. Number Required: Two.
 2. Type: Laminated plastic cover with chain loop.

1.16 MATERIAL AND EQUIPMENT

- A. Comply with Division 1.
- B. Similar products shall be of the same manufacturer.
- C. Comply with manufacturer's printed instructions, in addition to requirements of the Contract Documents, regarding storage, handling, installation, operation, and adjustment of materials and equipment.
- D. Protect ductwork, piping, outlets/inlets, equipment, and mechanical appurtenances from

damage. Provide temporary covers as necessary to prevent accumulation of dust and debris.

- E. Notify the Architect (or authorized representative) immediately of conflicts between manufacturer's instructions and Contract Documents. Resolve such conflicts before proceeding with the work.

1.17 CONTRACT CLOSEOUT

- A. Comply with Division 1.

1.18 FINAL CLEANING

- A. Provide cleaning for the Work of Divisions 20, 21, 22 and 23 in accordance with Division 1.

1.19 RECORD DOCUMENTS

- A. Provide Record Documents for the Work of this Division in accordance with Division 1.
- B. Record Drawings shall include:
 - 1. Contract Drawings
 - 2. Fire Suppression System Shop Drawings
 - 3. Seismic Restraint Shop Drawings

1.20 INSTRUCTION OF OPERATING PERSONNEL

- A. Provide instruction of Owner's operating personnel associated with the Work of Divisions 20, 21, 22 and 23 in accordance with Division 1.
- B. Instruct Owner's designated operating personnel in the operation and maintenance of all systems.
- C. Submit written certificate from Owner that Instruction of Operating Personnel has been performed.

1.21 WARRANTIES

- A. Provide and document warranties applicable to the Work of Divisions 20, 21, 22 and 23 in accordance with Division 1 and Section 202000.

1.22 SELECTIVE STRUCTURE DEMOLITION

- A. Provide demolition for the Work of this Division in accordance with Division 2.
- B. Where items are to be salvaged for relocation or retained by the Owner, removal shall cause no damage to these items. Move in accordance with manufacturer's instructions.

1.23 EXCAVATION AND BACKFILLING

- A. Provide trenching, excavation, and backfilling for the Work of Divisions 20, 21, 22 and 23 in accordance with Section 313233.

1.24 PAINTING

- A. Provide painting for the Work of Divisions 20, 21, 22 and 23 in accordance with Division 9.
- B. Provide cleaning and surface preparation for products specified in Divisions 20, 21, 22 and 23 that have finishes specified in Division 9.
- C. Paint the following items with one coat of primer and two coats of oil-based enamel:
 - 1. Uninsulated black steel pipe which is not concealed within walls or above ceilings.
 - 2. Steel supports, stands, and brackets which are not galvanized or factory painted.

3. Pipe rollers, hangers, and hanger rods which are not galvanized.
4. Additional items noted on Drawings or in Divisions 20, 21, 22 and 23.

D. Colors shall be approved by Architect.

PART 2 PRODUCTS - NOT USED

PART 3 EXECUTION - NOT USED

END OF SECTION

SECTION 202000**MECHANICAL OPERATION AND MAINTENANCE MANUALS****PART 1 GENERAL****1.01 SECTION INCLUDES**

- A. General and specific requirements for Operation and Maintenance Manuals applicable to Division 20, 21, 22 and 23 sections. Requirements apply in addition to Division 1 requirements. Contractor shall provide Operation and Maintenance Manual for the Work of this Division.

1.02 SHOP DRAWINGS AND PRODUCT DATA

- A. Submittals required for the following, in accordance with Section 201000:
 - 1. Table of Contents (TOC) for the Operation and Maintenance Manual. Provide one complete TOC with Project Submittal.

1.03 CONTRACT CLOSEOUT

- A. Submittals required for the following, in accordance with Section 201000:
 - 1. Operation and Maintenance Manual. Provide 3 complete sets.

PART 2 PRODUCTS**2.01 GENERAL**

- A. The requirements listed herein apply to one full set of the Operation and Maintenance Manual. Provide multiple copies of the set in accordance with requirements listed under Part 1 of this Section.
- B. Information provided in the Operation and Maintenance Manuals shall be customized for the specific equipment provided for, and as applied to, this Project.

2.02 PRESENTATION

- A. Format:
 - 1. Manufacturer's literature shall be pre-printed.
 - 2. Documents generated specifically for this project shall be machine printed on white paper, or typed.
 - 3. Hand written material is not acceptable unless specifically noted herein.
 - 4. Internally subdivide binder contents with permanent page dividers in accordance with the organizational format described herein. Tab titles shall, as a minimum, be legibly printed and inserted into reinforced laminated plastic tabs.
- B. Binding:
 - 1. In three-ring (D-side ring style) loose leaf plastic or cloth side binders. Paper report binders, or bend-tab thesis covers are not acceptable.
 - 2. 8-1/2 inch x 11 inch format.
 - 3. Ring size as necessary to contain the information for this project. Minimum ring size: 1 inch. Maximum ring size: 4 inch.
 - 4. Provide sheet lifters, front and back, in each notebook.
 - 5. Provide multiple binders where required to accommodate the data. Each binder maximum 80% full.

6. Label each binder with typed, permanently adhered, labels on the front cover and the spine.
Minimum Label information:
 - a. Project Name
 - b. Project Location
 - c. Project Owner
 - d. Project Engineer
 - e. Volume (notebook no.) of (number of notebooks in one set of O&M Manuals)
- C. Provide a plastic page cover for each occurrence of the following pages:
 1. Cover Sheet
 2. Table of Contents
 3. Nameplate Directory
 4. Valve Directory
 5. Service and Dealer Directory

2.03 ORGANIZATION AND CONTENT OF MANUAL

- A. Include in the front of EACH Notebook of the Operation and Maintenance Manual:
 1. Cover Sheet
 2. Table of Contents:
 - a. List the contents of the full manual.
 - b. List full extent of major and minor divisions (tabs).
- B. Include the following information in the Project Operation and Maintenance Manual:
 1. Directories, including:
 - a. Equipment and Nameplate Directory
 - b. Itemized Service and Maintenance Directory
 - c. Service and Dealer Directory
 - d. Warranties Directory
 - e. Valve Directory
 2. Material and Equipment Information (with Individual Tabs by Divisions 20, 21, 22 and 23 Section Number and Name), including:
 - a. Shop Drawings and Product Data
 - b. Manufacturer's Printed Operation and Maintenance Manuals
 - c. Service Contracts and Field Start-up Reports
 3. Cleaning, Certification, and Test Reports:
 - a. Domestic water system disinfections report and test results
 - b. Air and Water Balance Report
 4. System Information (with Individual Tabs by Divisions 20, 21, 22 and 23 Section Number and Name), including:
 - a. Operation instructions
 - b. Record drawings (reduced size set)
 - c. Controls operation and maintenance Information

2.04 DESCRIPTION OF MANUAL CONTENT

- A. Cover Sheet, listing:
 1. Project name and location
 2. Architect
 3. Engineer
 4. General Contractor
 5. Mechanical Contractor
 6. Electrical Contractor

- B. Table of Contents, listing:
1. Volume number.
 2. Section title
 3. Items included under each section (e.g., equipment name and number, parts list, service instructions, etc.)
- C. Directories (with Individual Directory Specific Tab):
1. "Equipment Nameplate Directory". This is a summary of the equipment included in the Project with a nameplate designation (code), such as "AHU-1", including:
 - a. Mechanical equipment type
 - b. Nameplate designation
 - c. Manufacturer's nameplate data
 - 1) Data as read from the nameplate for the actual equipment provided
 - d. Installed location
 - 1) List room name and number
 - e. Area served
 - f. Control switch normal position
 2. "Itemized Service and Maintenance Directory". Obtain information from the manufacturer. This is an itemized summary listing of service and inspection requirements. Itemize by Nameplate Designation (i.e.; AHU-1, CH-1, etc.). include:
 - a. Service and lubrication schedule:
 - 1) Filter, size, number of, performance, clean pressure drop, and recommended change-out.
 - 2) Bearing type, recommended lubricant, and frequency.
 - b. Inspection Requirements:
 - 1) Inspection type (e.g., belt wear, refrigerant charge, etc.), frequency, recommended actions.
 3. "Service and Dealer Directory". This is a summary of the equipment and material suppliers for the Project, including:
 - a. Company name for authorized service and parts
 - b. Physical address
 - c. Phone number, fax number, e-mail, and web site address (if available)
 - d. Summary listing of applicable equipment and materials
 4. "Warranties". In addition to the warranty statement, include:
 - a. Project name as shown on the Project Manual
 - b. The equipment (nameplate designation and description) and/or system to which the warranty applies
 - c. Effective date of the warranty
 - d. Expiration date of the warranty
 - e. Extent of the warranty
 - f. Company name, address, telephone number, and contact person for the issuer of the warranty
 5. "Valve Directory". This is a sequential, ascending, summary of the numbered valves in the Project, separated by system, including:
 - a. Valve number
 - b. Valve Type
 - c. Valve Size
 - d. Installed location
 - e. Valve function
 - f. Valve normal position

- D. Material and Equipment Information (under individual material or equipment specification specific tabs):
1. Shop Drawings and Product Data for items reviewed, approved, and provided for this Project
 2. Manufacturer's Printed Operation and Maintenance Manuals, including:
 - a. Manufacturer's parts list
 - b. Information for starting, adjusting, and maintaining each item in continuous operation for long periods of time
 - c. Dismantling and reassembling of the complete units and sub-assembly components with illustrations including "exploded" views showing and identifying each separate item
 - d. Identification of special tools and instrument requirements
 - e. Detailed explanation of function and control of each piece of equipment, component, or accessory
 - f. Precautions for operation of equipment and reason for each precaution
 - g. Troubleshooting guide
 3. Service Contracts and Field Start-up Reports:
 - a. Provide for boilers, chillers, etc.
 - b. Include list of inspection requirements to be completed prior to end of warranty.
- E. Cleaning, Certification, and Test Reports:
1. Backflow Prevention Devices Inspection and Testing. Coordinate with requirements listed in Section 224100.
 2. Piping Systems Cleaning, Disinfection, and Chemical Treatment Report. Coordinate with requirements listed in Section 225400.
 3. Written certification of combination fire/smoke damper testing. Coordinate with requirements listed in Section 209100.
 4. Air and Water Balance Report. Coordinate with requirements listed in Section 209100.
 - a. When an Air and Water Balance Report is provided in a separate notebook (three-ring binder), reference the notebook as a volume of the Project Operation and Maintenance Manual set. Label the notebook accordingly.
 5. Seismic restraint system installation report certifying that seismic restraints are installed in conformance with approved shop drawings and no additional restraints are necessary based on field conditions. Include the written authorization, from seismic restraint system Engineer, of the designated representative.
- F. System Information:
1. Operation Instructions. Under individual system specific tab. Provide complete, detailed guidance for the operation of each system (e.g., Hydronic System, etc.)
 - a. Information shall include:
 - 1) Start-up
 - 2) Routine and normal operation
 - 3) Adjustment and regulation
 - 4) Chemical treatment
 - 5) Testing
 - 6) Detection of malfunction
 - 7) Shut-down
 - 8) Cleaning
 - 9) Summer and winter operations
 - 10) Emergency operation

2. Record Drawings. Provide an 11 inch by 17 inch set (print-to-fit) bound in a separate pressboard report cover with reinforced top hinges. Label front of report cover in accordance with previously listed notebook labeling requirements.
3. Controls Operation and Maintenance Information. Coordinate with controls requirements listed in Division 23.
 - a. Where controls information is provided in separate notebook(s) (three-ring binder), reference the notebook(s) as volume(s) of the Project Operation and Maintenance Manual set. Label the notebook(s) accordingly.

PART 3 EXECUTION

3.01 GENERAL

- A. Information provided in the Operation and Maintenance Manuals shall be specific to actual equipment, materials, and systems provided under the Work of this project.
- B. Pre-printed Parts lists, service instructions, equipment data manuals, etc., shall be marked to indicate the model number of the corresponding item provided under the Work of this project.
 1. Use an arrow stamp to designate the pre-printed model numbers for Products applicable to this Project. Arrow shall be of a reproducible color (i.e.; red or black).
 2. Where the corresponding model number is not shown on a pre-printed sheet, hand write the model number, and associated data, in ink using legible block style lettering.

END OF SECTION

SECTION 204100**VIBRATION ISOLATION****PART 1 GENERAL****1.01 RELATED SECTIONS**

- A. Section 201000 - General Mechanical Provisions
- B. Section 202000 - Mechanical Operation and Maintenance Manuals
- C. Section 204200 - Seismic Restraints

1.02 SCOPE OF WORK

- A. Provide vibration isolation for piping and ductwork as specified herein.
- B. Provide vibration isolation for equipment as specified herein.
- C. Vibration Isolator Selection:
 - 1. Determine vibration isolator sizes and locations including anchor bolt design.
 - 2. Verify that the type of isolators and deflections shown in the vibration isolation schedule are correct for the application.
- D. Provide shop drawings and installation instructions for vibration isolators.
- E. At completion of installation, perform final inspection of project and provide report certifying vibration isolators are installed as shown in shop drawings and in accordance with manufacturer's recommendations.

1.03 SHOP DRAWINGS, PRODUCT DATA, OPERATION & MAINTENANCE DATA

- A. Submit the following in accordance with Section 201000 (reference isolated equipment as numbered in Contract Documents). Operation & Maintenance information required as indicated in Section 202000:
 - 1. Isolator type as numbered in Contract Documents.
 - 2. Manufacturer's isolator model numbers.
 - 3. Drawings of individual isolators selected for each support point, details of mounting brackets for isolators, location for all equipment mounting bolts, and size and locations of concrete piers supporting the isolators.
 - 4. Detailed calculations showing the weight distribution for each equipment support point (as calculated, not averaged), calculations showing the loads at each isolator, anticipated expansion, calculations showing the loads at restraints, spring deflections, initial and final loads on the building structure. Calculations are to be included for all connections to the structure, considering localized effects on the structural elements.
- B. At project completion, submit three (3) copies of report certifying that vibration isolators are installed as shown on shop drawings and in accordance with manufacturer's recommendations.

1.04 DEFINITIONS AND ABBREVIATIONS

- A. Equipment: Includes (but not limited to) pumps, fans, air handling units, water heaters, heat exchangers, tanks, air separators, terminal units, etc. Equipment referred to by type is typical. Equipment not specifically listed here is still subject to the requirements listed in this specification.
- B. Equipment Weight: Installed operating weight of equipment as reported by equipment manufacturer.

- C. Floor-Mounted Equipment: Equipment located on and attached to floor.
- D. Integral Isolation: Isolators furnished as an integral part of the equipment.
- E. Piping Component Weight: Calculated installed (operating) weight of component.

1.05 PROJECT DESIGN CRITERIA

- A. Systems and components shall be designed and installed in accordance with the vibration Isolator manufacturer's instructions.
- B. Isolators for a single piece of equipment shall have equal deflections when loaded with the equipment.
- C. A minimum of four isolators shall be used to support each piece of equipment.
- D. See Seismic Design Criteria of Section 204200 for application of seismically restrained isolators.

PART 2 PRODUCTS

2.01 SEISMICALLY RESTRAINED VIBRATION ISOLATORS

- A. Type SRS-1 (Seismic Restrained Spring):
 - 1. Free standing and laterally stable and complete with a neoprene cup or 1/4 inch neoprene acoustical friction pads between the spring and the support.
 - 2. Mountings with leveling bolts.
 - 3. Spring diameters no less than 80 percent of the compressed height of the spring at rated load.
 - 4. Springs to have a minimum additional travel to solid equal to 50 percent of the rated deflection.
 - 5. A steel housing to resist motion due to earthquake loads in all directions. Minimum 0.50 G rating.
 - 6. Minimum clearance of 1/4 inch to be maintained between the restraining bolts and a molded neoprene bushing so as not to interfere with the spring action.
 - 7. The housing shall be out of contact during normal operations.
 - 8. Manufacturers: Mason Industries, Kinetics, Korfund, Amber Booth, or approved. Similar to Mason Industries type SSLFH or SLR.

2.02 NON-SEISMIC VIBRATION ISOLATORS

- A. Type N-1 (Neoprene waffle pad):
 - 1. One or two layers equal to 3/4 inch minimum thick neoprene ribbed or waffled pad.
 - 2. Bonded to galvanized steel load distribution plate.
 - 3. For anchoring applications: Provide neoprene grommets and washers to prevent anchor bolt from short circuiting isolation.
 - 4. Manufacturer: Mason Industries, Kinetics, Korfund, Amber Booth, or approved. Similar to Mason Industries Super "W".
- B. Type SH-1 (Spring Hanger):
 - 1. Steel frame containing a steel spring in a neoprene cup.
 - 2. Neoprene cup to be molded with an integral rod isolation bushing that passes through the hanger box.
 - 3. Spring diameters and hanger box lower hole sizes to be large enough to permit the hanger rod to swing through a 30 degree arc before contacting the hole and short circuiting the spring.

4. Springs to have a minimum additional travel to solid equal to 50 percent of the rated deflection.
5. Manufacturers: Mason Industries, Kinetics, Korfund, Amber Booth, or approved. Similar to Mason Industries type 30/HS.

2.03 BASES

- A. Type IB-1 (Inertia Base):
 1. Inertia steel base furnished by Isolator manufacturer.
 2. Concrete filled base sized to support equipment without overhanging structural members that form perimeter framing. Use T-shape where necessary to conserve weight and size.
 3. Concrete shall be 3,000 psig concrete to ASTM C94 standards.
 4. Minimum concrete reinforcing to be 1/2 inch bars or angles welded in place on six inch centers both ways.
 5. Cutout in center may be provided with structural member interior section to adjust base weight if necessary.
 6. If the depth of base is not shown in schedule, the depth of base shall not be less than six inches for equipment up to 40 HP and not less than ten inches for equipment over 40 HP.
 7. Furnish with preset embedded anchor bolts and pipe sleeves for fan and motor slide rail or other equipment attachment.
 8. Size base to support suction elbow of end suction pumps and suction and discharge elbow of horizontal split case pumps.
 9. Bases shall have a minimum clearance of one inch between top of floor and underside of base. Provide height-saving brackets where required.
 10. Structural steel members to be primed with corrosion resistant paint before shipment.
 11. Manufacturers: Mason Industries, Kinetics, Korfund, Amber Booth, or approved. Similar to Mason Industries type BMK or K.

PART 3 EXECUTION

3.01 GENERAL

- A. Vibration isolators shall be installed in strict accordance with the manufacturer's written instructions and certified submittal data.
- B. Coordinate selection of supports with equipment support points to provide isolation without creating excessive stresses at equipment connections or in piping.
- C. Review equipment manufacturer's literature to ensure that procedures for setting and adjusting all isolation devices are in accordance with the recommendations.
- D. Conflicts with other trades that result in rigid contact with the equipment or piping due to inadequate space or other conditions shall be corrected.
- E. Provide supplementary support steel for equipment, piping, and ductwork required for the work of this Section.

3.02 EQUIPMENT VIBRATION ISOLATORS

- A. Coordinate size of housekeeping pads and concrete piers to ensure adequate space for required bases, isolators, and attachment thereto.
- B. Anchor isolator to structural system in accordance with details on Drawings and isolator manufacturer's instructions.

3.03 BASES

- A. Provide directional seismic snubbers to prevent excessive motion during starting and for earthquake bracing. Snubbers shall be installed after equipment is in operation to allow proper placement and alignment and to insure the bumpers are not engaged during normal system operation.
- B. Motor-driven equipment shall be mounted with motors on a common base of sufficient rigidity to maintain permanent alignment.

PART 4 APPLICATION TO SYSTEMS

4.01 EQUIPMENT

- A. Fans, Suspended, (FCU-1, & EF-1):
 - 1. Supporting Structure: Overhead structure.
 - 2. Isolator Type: SH-1.
 - 3. Isolator Deflection (ins.): 2.0 inches, or as recommended by manufacturer for equipment support from existing wood framed structure.
 - 4. Seismic Restraint Type: In accordance with Section 204200.
 - 5. Anchorage: Anchor isolators and restraints to supporting structure.
- B. Base Mounted pumps (CHWP-1):
 - 1. Supporting Structure: Concrete slab.
 - 2. Base: By pump manufacturer.
 - 3. Isolator Type: IB-1
 - 4. Isolator Deflection: (ins.): 1.0 inch.
 - 5. Anchorage: Seismically anchor to slab.
- C. In-Line Pumps, HWP-1 & HWP-2:
 - 1. Supporting Structure: Floor and support stand.
 - 2. Isolator Type: N-1
 - 3. Isolator Deflection: 0.20 inch minimum.
 - 4. Install with grommets at attachment bolts to prevent short circuiting through isolation.
 - 5. Seismic Restraint: In accordance with Section 20 42 00.
 - 6. Anchorage: Anchor isolators and restraints to supporting structure.
- D. Condensing Units (CU-1):
 - 1. Supporting Structure: See Drawings.
 - 2. Isolator/Restraint Type: SRS-1.
 - 3. Isolator Deflection (ins.): 2.0 inch.
 - 4. Anchorage: Anchor isolators to concrete mounting base.

END OF SECTION

SECTION 204200**SEISMIC RESTRAINTS****PART 1 GENERAL****1.01 RELATED SECTIONS**

- A. Section 201000 - General Mechanical Provisions
- B. Section 202000 - Mechanical Operation and Maintenance Manuals
- C. Section 204100 - Vibration Isolation

1.02 SCOPE OF WORK

- A. Provide seismic restraints in accordance with ASCE Standard 7-05 requirements for piping, ductwork, and mechanical equipment.
- B. Provide engineering for seismic restraint system, assemblies, and components.
- C. Provide shop drawings and installation instructions for seismic restraint system.
- D. Provide final inspection and report for installed restraint system acceptance.

1.03 DEFINITIONS AND STANDARDS

- A. Referenced Standards:
 - 1. ASCE Standard 7-05: American Society of Civil Engineers / Structural Engineering Institute, Standard 7-05, Minimum Design Loads for Buildings and Other Structures
- B. Design Criteria:
 - 1. Occupancy Category: ASCE 7-05 Occupancy Category designation, Table 1-1
 - 2. Site Classification: ASCE 7-05 Site Classification designation, Table 20.3-1
 - 3. Peak Spectral Response Acceleration (SS): ASCE 7-05 Figure 22-1 - Maximum Considered Earthquake Ground Motion of 0.2s spectral response acceleration, Site Class B
 - 4. Design Spectral Response Acceleration (SDS): ASCE 7-05, Eqs. 11.4-1 and 11.4-3
 - 5. Seismic Design Category: ASCE 7-05 Seismic Design Category designation, Tables 11.6-1 and 11.6-2.
 - 6. Component Importance Factor (IP): ASCE 7-05, Section 13.1.3
- C. Custom Engineered Assembly: Anchorage and seismic restraint assembly, comprised of standard or proprietary components, designed and applied to system by the Seismic Engineer.
- D. Pre-Engineered Assembly: Previously designed anchorage and seismic restraint assembly selected and applied to system by the Seismic Restraint System Engineer.
- E. Seismic Restraint System Engineer: Registered Professional Engineer currently licensed in Oregon as a structural, civil, or mechanical engineer. Responsible for designing, applying, and inspecting pre-engineered seismic restraint assemblies and components in accordance with applicable codes and component manufacturer's published recommendations.
- F. Seismic Engineer: Professional engineer currently licensed in Oregon as a structural, civil, or mechanical engineer. Responsible for designing, applying, and inspecting custom seismic restraint components in accordance with applicable codes.

G. Equipment:

1. Includes (but not limited to) pumps, fans, air handling units, heat exchangers, etc. Equipment referred to by type is typical. Equipment not specifically listed here is still subject to the requirements listed herein.
2. Weight: Installed operating weight of equipment as reported by equipment manufacturer.
3. Integral Isolation: Isolators which are furnished as an integral part of the equipment.
4. Roof-Mounted: Equipment located above and attached to roof.
5. Floor-Mounted: Equipment located on and attached to floor.

H. Ductwork and Piping:

1. Duct Run: A length of duct without change in direction.
2. Piping Run: A length of pipe without change in direction.
3. Component Weight: Calculated installed (operating) weight of component.
4. Longitudinal Bracing: Restraints applied to limit motion parallel to the centerline of the pipe or duct.
5. Transverse Bracing: Restraints applied to limit motion perpendicular to the centerline of the pipe or duct.

1.04 PROJECT DESIGN CRITERIA

- A. Restraint system, assemblies, and components shall be designed and installed to resist lateral loads in accordance with the current adopted State of Oregon Structural Specialty Code.
- B. Seismic Design Criteria:
 1. Occupancy Category: III.
 2. Site Classification: D.
 3. Peak Spectral Response Acceleration (SS): 0.565.
 4. Design Spectral Response Acceleration (SDS): 0.51.
 5. Seismic Design Category: D.
 6. Maximum Allowable Lateral Loads and Anchorage Requirements: See Structural Drawings.
 7. Component Importance Factors (IP): 1.0, unless otherwise noted below:
 - a. IP = 1.5:
 - 1) Piping Systems: Fire Protection Systems.

1.05 SYSTEM ENGINEERING AND QUALITY ASSURANCE

- A. Seismic restraint system shall be engineered to comply with criteria stated and referenced herein.
- B. Seismic restraints and related engineering for HVAC, plumbing, and piping systems to be provided by a single vendor.
- C. Application of Pre-engineered Assemblies by Seismic Restraint System Engineer:
 1. Application of Custom Engineered and/or Pre-Engineered Assemblies, as applicable to this project, and as follows:
 - a. Application of restraints for floor or roof-mounted equipment.
 - b. Application of restraints for curb mounted equipment including unit-to-curb and curb-to-structure attachments.
 - c. Application of seismic restraint assemblies for vibration isolated and suspended equipment.
 - d. Application of seismic restraint assemblies for piping and ductwork.
 2. Submittal packages shall bear the stamp of only the responsible Seismic Restraint System Engineer.

3. Approved Pre-engineered Assembly and Application Services: Mason Industries, Kinetics, or an independent professional engineer meeting qualifications listed herein as Seismic Restraint System Engineer.
- D. Custom Engineered Assemblies:
 1. System engineering shall include design and Application of Custom Engineered Assemblies, as applicable to this project, and as follows:
 - a. Design and Application of restraints for floor or roof-mounted equipment.
 - b. Design and Application of restraints for curb mounted equipment including unit-to-curb and curb-to-structure attachments.
 - c. Design and Application of seismic restraint assemblies for vibration isolated and suspended equipment.
 - d. Design and Application of seismic restraint assemblies for piping and ductwork.
 2. Engineering shall be performed by, or under the direct supervision of, a Seismic Engineer meeting the qualifications listed herein. Submittal packages shall bear the signed seal of only the Seismic Engineer.
- E. Lateral loads and anchorage requirements at attachment to building structural system to be coordinated with project Structural Engineer.

1.06 SHOP DRAWINGS, PRODUCT DATA, OPERATION & MAINTENANCE DATA

- A. Pre-submittal:
 1. Included within project Mechanical Submittals, submit attached letter outlining how the seismic requirements for this project will be met (i.e., Pre-engineered Assemblies, Custom Assemblies). In the letter state what companies will be providing the services and the qualifications of the responsible individuals.
- B. Shop drawings shall be submitted as one complete package inclusive of all mechanical systems and equipment.
- C. Submit the following in accordance with Section 201000 (Reference isolated equipment as numbered in Contract Documents):
 1. Seismic Restraint Location Plan: Full or half size copies of ductwork and piping plans from the Contract Documents, showing locations and type of seismic restraint assemblies to be used.
 - a. Drawings shall consist of mechanically reproduced copies of the Contract Documents, or custom drafted specifically for the Work of this Project and bear only the seal of the Seismic Restraint System Engineer or Seismic Engineer. All other seals shall be eradicated from drawings prior to submittal.
 - b. Provide separate drawings for ductwork and piping systems.
 - c. Each drawing shall be printed on a single sheet. Drawings pieced together from multiple copies are not acceptable.
 2. Seismic Restraint Assembly Installation Details: Pre-Engineered or Custom Engineered assembly details showing required components, dimensions, and method of connection to supporting structure.
 3. Calculations For System Application: Calculations shall indicate maximum forces anticipated at each restraint assembly, method of determining forces, and selection of restraint assemblies.
 - a. For Pre-Engineered Assemblies, include documentation of design conditions, maximum load capacity of assembly, and maximum forces at anchorage points.
 - b. For Custom Engineered Assemblies, submit calculations identifying maximum load capacity of assembly, maximum forces on each component, sizing/selection of each component, and maximum forces at anchorage points.

- D. The entire submittal package comprised of drawings, details, and calculations for mechanical ductwork, piping, and equipment shall be stamped and signed in accordance with the requirements listed under 1.05 SYSTEM ENGINEERING AND QUALITY ASSURANCE in this specification section.
- E. At seismic restraint system installation completion, submit three (3) copies of report from seismic restraint system Engineer, or the Engineer's representative, certifying that seismic restraints are installed in conformance with approved shop drawings and no additional restraints are necessary based on field conditions. Include written authorization, from Seismic Restraint System Engineer, of the designated representative.
- F. Prior to Contract Closeout submit Operation and Maintenance information required as indicated in Section 202000.

PART 2 PRODUCTS

2.01 PRE-ENGINEERED ASSEMBLIES

- A. Anchorage and seismic restraint assemblies, comprised of standard or proprietary components, capable of application to restraint system and supporting structure.
- B. Acceptable Proprietary Manufacturers: Mason Industries, Kinetics, Tolco, B-Line, or approved.

PART 3 EXECUTION

3.01 GENERAL

- A. Seismic restraint system shall be installed in strict accordance with the manufacturer's written instructions and certified submittal data.
- B. Conflicts with other trades that result in rigid contact with the equipment or piping due to inadequate space or other conditions shall be coordinated with the Seismic Restraint Engineer and corrected.
- C. Attach restraints and anchors to a common structural element plane and within a common structural system.
- D. For vibration isolated suspended equipment, piping, and ducts, install flexible cable restraints slightly slack to avoid vibration short circuiting.
- E. For non-isolated suspended equipment, piping, and ducts, install solid braces or taut flexible cable restraints.
- F. Provide supplementary support steel for equipment, piping, and ductwork required for the work of this Section.

3.02 EQUIPMENT SEISMIC RESTRAINT

- A. Coordinate size of housekeeping pads and/or concrete piers to ensure adequate space for required bases, isolators, restraints, and attachment thereto.

3.03 DUCTWORK AND PIPING SEISMIC RESTRAINT

- A. Provide minimum of two transverse supports and one longitudinal support on each pipe or duct run. Transverse bracing shall be installed at each turn and at each end of a run with a minimum of one brace at each end. Where a pipe or duct run is shorter than the minimum interval between braces, provide braces at each end.
- B. Where restraints are attached to clevis style pipe hangers, the cross bolt must be reinforced.

3.04 EQUIPMENT WITH VIBRATION ISOLATION SUPPORTS

- A. Anchor isolator to structural system in accordance with details on Drawings and isolator manufacturer's instructions.

3.05 PIPING WITH VIBRATION ISOLATION SUPPORTS

- A. Seismic restraints for vibration isolated piping shall be installed to restrict excessive lateral, vertical, and longitudinal motion without providing support or rigid contact between piping and structure during normal operation.

END OF SECTION

SECTION 20 42 00 - SEISMIC RESTRAINT SYSTEM ENGINEERING PRE-SUBMITTAL

PROJECT: _____
(Project Title)

The Undersigned states the following:

- Seismic restraints for the work of Divisions 22 and 23 for this project will be provided as required in Section 204200.
- Application of Pre-Engineered Restraint Assemblies will be provided by Seismic Restraint System Engineer meeting qualifications of Section 204200.

Seismic Restraint System Engineer: _____

Firm Name: _____

Authorized Representative: _____
(Name of representative authorized to act on Engineer's behalf)

- Design for Custom Engineered Restraint Assemblies will be provided by Seismic Engineer meeting qualifications of Section 204200.

Seismic Engineer: _____

Firm Name: _____

Authorized Representative: _____
(Name of representative authorized to act on Engineer's behalf)

- Upon completion of seismic restraint system installation the Engineers listed above, or the designated representative listed, will inspect and certify that seismic restraints are installed in conformance with approved shop drawings and, based on actual field conditions, no additional restraints are necessary to comply with applicable codes.

Submitted by: _____ Signature: _____

Firm: _____

Address: _____

Telephone: _____ E-mail: _____

Date: _____

SECTION 205100

MOTORS

PART 1 GENERAL

1.01 RELATED SECTIONS

- A. Section 201000 - General Mechanical Provisions
- B. Section 202000 - Mechanical Operation and Maintenance Manuals

1.02 REFERENCES

- A. AFBMA 9 - Load Ratings and Fatigue Life for Ball Bearings
- B. AFBMA 11 - Load Ratings and Fatigue Life for Roller Bearings
- C. IEEE 112 (NEMA MG1-12-53a) - Test Procedure for Polyphase Induction Motors and Generators
- D. NEMA MG 1 - Motors and Generators
- E. NFPA 70 - National Electrical Code

1.03 SHOP DRAWINGS, PRODUCT DATA, OPERATION & MAINTENANCE DATA

- A. Submittals required for the products listed in the Product Table, in accordance with Section 201000. Operation & Maintenance Information required as indicated in the Product Table in accordance with Section 202000.
- B. Operation & Maintenance Information requirements indicated by number designation as follows. Refer to Section 202000 for a description of each type of information.
 - 1. Shop Drawings (submittal data)
 - 2. Product Data (submittal data)
 - 3. Manufacturer's Operation Manuals
 - 4. Manufacturer's Service and Lubrication Requirements
 - 5. Service Contracts and Field Start-up Reports
 - 6. Cleaning, Certification, and Test Reports
 - 7. System Information
 - 8. Warranties

PRODUCT TABLE	Operation & Maintenance Information							
	1	2	3	4	5	6	7	8
Wiring diagrams with electrical characteristics and connection requirements.		X						
Performance specifications (NEMA Nominal Efficiency).		X						
Construction features.		X						
Indicate test results verifying nominal efficiency and power factor for 3-phase motors 3/4 hp and larger.		X				X		
Indicate setting, mechanical connections, lubrication, and wiring instructions.		X		X				

1.04 QUALIFICATIONS

- A. Manufacturer: Company specializing in manufacture of electric motors for specified use, and their accessories, with minimum three years documented product development, testing, and manufacturing experience.

1.05 REGULATORY REQUIREMENTS

- A. Conform to National Electrical Code (NFPA 70), requirements.
- B. Products Requiring Electrical Connection: Listed and classified by Underwriters' Laboratories, Inc., as suitable for the purpose specified and indicated.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Baldor, Siemens, Century, Reliance, Gould, US Motors, General Electric, Magnetec, Lincoln, or approved.

2.02 GENERAL CONSTRUCTION AND REQUIREMENTS

- A. Motors one horsepower and less: Equipment manufacturer's standard need not conform to these specifications.
- B. Electrical Service:
 - 1. As noted on Electrical and Mechanical drawings.
 - 2. Refer to Division 26 for required electrical characteristics.
- C. Type:
 - 1. Open drip-proof except where specifically noted otherwise.
 - 2. Motors: Design for continuous operation in 40 degrees C environment.
 - 3. Design for temperature rise in accordance with NEMA MG 1 limits for insulation class, service factor, and motor enclosure type.
 - 4. Motors 1 hp and larger: Premium Efficient Type.
- D. Visible Nameplate: Indicating motor horsepower, voltage, phase, cycles, RPM, full load amps, locked rotor amps, frame size, manufacturer's name and model number, service factor, power factor, and efficiency.
- E. Wiring Terminations:
 - 1. Provide terminal lugs to match branch circuit conductor quantities, sizes, and materials indicated. Enclose terminal lugs in terminal box sized to NFPA 70, threaded for conduit.
 - 2. For fractional horsepower motors where connection is made directly, provide threaded conduit connection in end frame.

2.03 THREE PHASE POWER - SQUIRREL CAGE MOTORS

- A. Starting Torque: Between 1 and 1-1/2 times full load torque.
- B. Starting Current: 6 times full load current.
- C. Power Output, Locked Rotor Torque, Breakdown or Pull Out Torque: NEMA Design B characteristics.
- D. Design, Construction, Testing, and Performance: Conform to NEMA MG 1 for Design B motors.

- E. Insulation System:
 1. NEMA Class B or better for constant speed applications.
 2. NEMA Class F or better for variable speed applications.
- F. Testing Procedure: In accordance with IEEE 112. Load test motors to determine free from electrical or mechanical defects in compliance with performance data.
- G. Motor Frames: NEMA Standard T-Frames of steel, aluminum, or cast iron with end brackets of cast iron or aluminum with steel inserts.
- H. Thermistor System (Motor Frame Sizes 254T and Larger): Three PTC thermistors imbedded in motor windings and epoxy encapsulated solid state control relay for wiring into motor starter; refer to Division 26.
- I. Bearings: Grease lubricated anti-friction ball bearings with housings equipped with plugged provision for relubrication, rated for minimum AFBMA 9, L-10 life of 20,000 hours. Calculate bearing load with NEMA minimum V-belt pulley with belt center line at end of NEMA standard shaft extension. Stamp bearing sizes on nameplate.
- J. Sound Power Levels: To NEMA MG 1.
- K. Nominal Efficiency: As scheduled at full load and rated voltage when tested in accordance with IEEE 112.

PART 3 EXECUTION

3.01 APPLICATION

- A. Motors with variable frequency drives: Refer to Section 205200 Variable Frequency Drives.

3.02 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Install securely on firm foundation. Mount ball bearing motors with shaft in any position.
- C. Check line voltage and phase and ensure agreement with nameplate.

3.03 NEMA OPEN MOTOR SERVICE FACTOR SCHEDULE

<u>HP</u>	<u>3600 RPM</u>	<u>1800 RPM</u>	<u>1200 RPM</u>	<u>900 RPM</u>
1	1.25	1.15	1.15	1.15
1.5-150	1.15	1.15	1.15	1.15

3.04 PERFORMANCE SCHEDULES

- A. Exemptions:
 1. Single-phase motors.
 2. Three phase motors less than 1 hp.
 3. Motors part of equipment which have an energy efficiency rating that would be voided by providing a non-standard motor.
 4. Motors part of equipment which are listed by a specified or required testing agency that would be voided by providing a non-standard motor.
- B. Three phase - premium efficient, open drip-proof:
 1. Per NEMA MG 1-2006.
- C. Three phase - premium efficient, totally enclosed, fan cooled:
 1. Per NEMA MG 1-2006.

END OF SECTION

SECTION 205200**VARIABLE FREQUENCY DRIVES****PART 1 GENERAL****1.01 RELATED SECTIONS**

- A. Section 201000 - General Mechanical Provisions
- B. Section 202000 - Mechanical Operation and Maintenance Manuals
- C. Section 205100 - Motors
- D. Section 230900 - Controls
- E. Section 231000 - Controls Sequence of Operations

1.02 SHOP DRAWINGS, PRODUCT DATA, OPERATION & MAINTENANCE DATA

- A. Submittals required for the products listed in the Product Table, in accordance with Section 201000. Operation & Maintenance Information required as indicated in the Product Table in accordance with Section 202000.
- B. Operation & Maintenance Information requirements indicated by number designation as follows. Refer to Section 202000 for a description of each type of information.
 - 1. Shop Drawings (submittal data)
 - 2. Product Data (submittal data)
 - 3. Manufacturer's Operation Manuals
 - 4. Manufacturer's Service and Lubrication Requirements
 - 5. Service Contracts and Field Start-up Reports
 - 6. Cleaning, Certification, and Test Reports
 - 7. System Information
 - 8. Warranties

PRODUCT TABLE	Operation & Maintenance Information							
	1	2	3	4	5	6	7	8
Variable Frequency Drives	X	X	X	X	X	X		X

PART 2 PRODUCTS**2.01 VARIABLE FREQUENCY DRIVES**

- A. Manufacturer: ABB, Allen Bradley, Yaskawa, Danfoss Graham, or approved.
- B. Voltage Rating: 208 volts (as scheduled), three phase, 60 hertz.
- C. Motors with variable frequency drives:
 - 1. Air Handlers:
 - a. AHU-1 supply and return fans
 - b. AHU-2 supply and return fans
 - c. AHU-3 supply and return fans
 - d. AHU-4 supply and return fans

2. Pumps:
 - a. CHWP-1
 - b. HWP-1
 - c. HWP-2
- D. VFD shall be furnished with door mounted operator controls consisting of Hand/Off/Auto switch, start/stop (reset switch, speed selection and 40 character LCD alphanumeric display. In automatic mode, VFD will follow an external signal and respond to remote start-stop contact wired to terminal strip. While in auto mode the VFD shall attempt up to ten restarts after a power dip, drive fault or external fault.
- E. 40 character LCD alphanumeric display.
 1. Frequency
 - a.
 2. Speed (RPM, %, or user programmable)
 3. Motor current
 4. Torque (calculated)
 5. Motor power (calculated)
 6. DC buss voltage
 7. Output voltage
 8. Heatsink temperature
 9. Elapsed time meter
 10. kWh meter
 11. Fault Text
- F. Controllers: Provide controllers for motorized equipment as indicated in schedules on Mechanical Drawings.
- G. Two Stage Current Limit:
 1. 175% at start-up
 2. 50% to 150% motor load current
- H. Power factor: 95% minimum.
- I. Fault withstand capability: 18,000 symmetrical amperes.
- J. Instantaneous overcurrent trip: Non-adjustable, 180% of controller continuous rated current.
- K. Enclosure: Wall mounted NEMA 1 and MCC as scheduled. Refer to Electrical drawings.
- L. The adjustable frequency controller shall convert three-phase 60 Hertz utility power to adjustable voltage and frequency, three-phase, A-C power for stepless motor control from 10% to 110% of base speed.
- M. The VFD shall be a voltage source type with a Pulse Width Modulated (PWM) output utilizing power transistor semiconductors.
- N. The VFD together with options and modifications shall mount within standard NEMA 1 enclosure suitable for continuous operation at a maximum ambient temperature of 40 degrees C. High voltage components within enclosure shall be isolated with steel covers. The complete unit shall be UL approved and labeled.
- O. VFD shall be capable of starting into a rotating load without delay. Protective circuits shall cause instantaneous trip should any of the following faults occur:
 1. 115% of VFD maximum current rating is exceeded.
 2. Output phase to phase to phase to ground (ground fault) short circuit condition.

3. High input line voltage.
 4. Loss of input phase.
 5. External fault. This protective circuit shall permit, by means of the terminal strip, wiring of remote NC safety contacts such as high static, pressure, fire alarm duct detector, etc., to shut down the drive.
- P. Provide with by-pass switch/starters. Means shall be provided for isolating the VFD from line voltage conductors and by-pass mode conductors. Safety interlocks and limit controls shall remain in effect during by-pass mode. Refer to Section 230900.
- Q. The following adjustments shall be available in the controller and retained in non-volatile memory:
1. Maximum frequency (15 to 400 Hz) factory set at 60 Hz.
 2. Minimum frequency (3 to 60 Hz) factory set at 6 Hz.
 3. Acceleration (.1 to 360 second) factory set at 20 sec.
 4. Deceleration (.1 to 360 seconds) factory set at 20 sec.
 5. Volts/Hertz ratio factory set for 460 V at 60 Hz.
 6. Voltage offset or boost factory set at 100% torque.
 7. Current limit (50% to 115% sine wave current rating) factory set at 11% current.
- R. The VFD shall have:
1. 0(4)-20 MA.
 2. 0(2)-10 VDC.
 3. RS-485 communications.
 4. Frequency pulse isolated or non-isolated signals as speed reference (increase/decrease speed control).
 5. Ethernet communication protocol with BAS controls specified in Section 230900.
- S. The VFD shall have a programmable electronic overload designed to protect the A-C motor, operated on VFD output, from extended overload operation.
- T. The VFD shall provide true ground fault protection in all modes, starting and running, without any component failure, and a D-C bus contactor shall be used to provide this protection.
- U. The VFD shall have three critical frequency avoidance bands to skip frequencies, which may cause mechanical damage.
- V. The VFD shall have a digital display with the following display:
1. Instantaneous output current, voltage, and frequency.
 2. First fault indication of over temperature, motor overload, high D-C bus voltage, high motor current line to line and line to ground, function loss, low D-C bus voltage.
- W. The VFD shall have an internal input line reactor and/or isolation transformer to minimize nuisance trips, line noise, and electrical line problems. VFD operation shall result in less than 10% total harmonic distortion on the electrical distribution system.
- X. The VFD shall be compatible with squirrel cage fan motors.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install motor control equipment in accordance with manufacturer's instructions.
- B. Select and install heater elements motor starters to match installed motor characteristics.

- C. Motor Data: Provide neatly typed label inside each motor starter enclosure door identifying motor served, nameplate horsepower, full load amperes, code letter, service factor, and voltage/phase rating.

3.02 VARIABLE FREQUENCY DRIVE START UP SERVICE

- A. Start-up service including physical inspection of drive and connected wiring and final adjustments to meet specified performance requirements shall be provided by a factory trained service engineer employed by the manufacturer.

3.03 APPLICATION

- A. Provide variable frequency drives for equipment as scheduled on Drawings and as required for the required sequence of operations as listed in Section 230900.

END OF SECTION

SECTION 206000

MECHANICAL IDENTIFICATION

PART 1 GENERAL

1.01 RELATED SECTIONS

- A. Section 201000 - General Mechanical Provisions

1.02 SHOP DRAWINGS, PRODUCT DATA, OPERATION & MAINTENANCE DATA

- A. Submittals required for the products listed in the Product Table, in accordance with Section 201000. Operation & Maintenance Information required as indicated in the Product Table in accordance with Section 202000.
- B. Operation & Maintenance Information requirements indicated by number designation as follows. Refer to Section 202000 for a description of each type of information.
 - 1. Shop Drawings (submittal data)
 - 2. Product Data (submittal data)
 - 3. Manufacturer's Operation Manuals
 - 4. Manufacturer's Service and Lubrication Requirements
 - 5. Service Contracts and Field Start-up Reports
 - 6. Cleaning, Certification, and Test Reports
 - 7. System Information
 - 8. Warranties

PRODUCT TABLE	Operation & Maintenance Information							
	1	2	3	4	5	6	7	8
Pipe Labels		X						
Valve Tags		X						
Control and Equipment Nameplates		X						
Ceiling Tacks		X						
Damper Locator Labels	X	X						
Pipe Union Labels	X	X						

1.03 REFERENCES

- A. ANSI A13.1 (American National Standards Institute) - Scheme for the Identification of Piping Systems, latest edition.

PART 2 PRODUCTS

2.01 PIPE LABELS

- A. Pipe Labels:
 - 1. Type: Preformed plastic or adhesive-backed vinyl, with factory printed legend on colored background.
 - 2. Letter Size: Conform to ANSI A13.1 1981.
 - 3. Background Color: Conform to ANSI A13.1 1981.
 - 4. Flow Direction Arrow: At each pipe label.
 - 5. Legend Wording: Match the pipe description shown in Symbols List on Drawings.
 - 6. Manufacturer: Seton, Brady, MSI, or approved.

2.02 VALVE TAGS

- A. Valve Tags:
 - 1. Type: Brass or aluminum disc, 1-1/2 inch diameter, with stamped legend.
 - 2. Letter Size:
 - a. System Type: 1/4 inch.
 - b. Valve Number: 1/2 inch.
 - 3. Legend Wording:
 - a. System Type: Match pipe abbreviation shown in Symbols List on Drawings.
 - b. Valve Number: Sequential numbers by system designation. Coordinate with Owner to determine the starting number for each system type.
 - 4. Manufacturer: Seton, Hanson, MSI, or approved.

2.03 CONTROL AND EQUIPMENT NAMEPLATES

- A. Nameplates:
 - 1. Type: Laminated plastic, with engraved white letters on black background.
 - 2. Letter Size: 1/2 inch tall.

2.04 CEILING TACKS

- A. Description: Steel with 3/4 inch (19 mm) diameter color-coded head.
- B. Color code as follows:
 - 1. HVAC equipment: Yellow
 - 2. Fire dampers/smoke dampers: Red
 - 3. Plumbing valves: Green
 - 4. Heating/cooling valves: Blue
- C. Manufacturer: Seton, Hanson, MSI, or approved.

2.05 MISCELLANEOUS LABELS

- A. Damper Locator Labels:
 - 1. Material: White vinyl, self-adhesive, permanent.
 - 2. Red lettering, minimum 1/2 inch tall.
 - 3. Labels at combination fire/smoke dampers read "FIRE AND SMOKE DAMPER ACCESS".
 - 4. Manufacturer: Seton, Brady, MSI, or approved.
- B. Pipe Union Labels
 - 1. Material: White vinyl, self-adhesive, permanent.
 - 2. Red lettering, minimum 1/2 inch tall.
 - 3. Labels at unions and die-electric unions read "UNION".
 - 4. Manufacturer: Seton, Brady, MSI, or approved.

PART 3 EXECUTION

3.01 PIPE LABELS

- A. Provide labels for piping.
- B. Labels shall be oriented to be visible from the normal access side of the pipe.
- C. Locate pipe labels as follows:
 - 1. Within 3 feet of each valve.
 - 2. Within 3 feet of each equipment connection.
 - 3. Within 3 feet of each wall, floor, or ceiling penetration.

4. Within 3 feet of each branch.
 5. At intervals along the pipe, not to exceed 20 feet on center.
- D. Prior to label installation, clean pipe or insulation surfaces according to label manufacturer's recommendations.

3.02 VALVE TAGS

- A. Provide tags for valves, except as follows:
1. Tags not required for:
 - a. Stop valves at plumbing fixtures
 - b. Relief valves
 - c. Check valves
 - d. Pressure reducing valves
 - e. Balancing valves
 - f. Automatic flow control valves
 - g. Equipment isolation valves within 5 feet of equipment served
- B. Secure tag to valve with corrosion-resistant metal chain, S-hook, or meter seal.

3.03 CONTROL AND EQUIPMENT NAMEPLATES

- A. Provide nameplates for mechanical equipment -- including air handling units, fans, pumps, terminal units, reheat coils, furnaces, unit heaters, chillers, boilers, heat exchangers, storage tanks, expansion tanks, radiant piping manifolds, etc. Wording to match equipment designations on Drawings
- B. Provide nameplates for variable frequency drives. Wording to indicate equipment served, followed by the letters "VFD". For instance, label for a VFD serving an air handling unit supply fan would read: AHU-XX SF VFD
- C. Provide nameplates for control panels and major control components.
- D. Attach nameplates with rivets or screws; adhesive only fastening not permitted. Provide weather-proof sealant for outdoor applications where screws penetrate casing.
- E. At room thermostats and temperature sensors, write the name of the unit served on the inside of cover in permanent ink.

3.04 CEILING TACKS

- A. Provide ceiling tacks to locate equipment, valves, or dampers above T-bar type panel ceilings. Locate in corner of panel closest to equipment.

3.05 PIPE UNION LABELS

- A. Provide label for each union and die-electric union concealed inside pipe insulation. Orient label parallel with pipe run and position to be visible from the normal access side of the pipe.
- B. Prior to label installation, clean surfaces in accordance with label manufacturer's instructions.

END OF SECTION

SECTION 211000**FIRE PROTECTION****PART 1 GENERAL****1.01 RELATED SECTIONS**

- A. Section 201000 - General Mechanical Provisions
- B. Section 202000 - Mechanical Operation and Maintenance Manuals
- C. Section 204200 - Seismic Restraints
- D. Section 221100 - Piping
- E. Section 224100 - Plumbing Specialties

1.02 SCOPE OF WORK

- A. Provide complete design and engineering, shop drawings, and installation of a complete fire protection system for full coverage of the entire building. The fire protection system shall fully comply with the following requirements:
 - 1. Latest adopted edition of NFPA 13 - Installation of Sprinkler Systems
 - 2. Latest adopted edition of NFPA 24 - Private Fire Service Mains
 - 3. State of Oregon Fire Marshall's Office.
 - 4. Fire Protection Systems Design, Installation & Maintenance Guide, by M.C. Thrapp, June 2007.
- B. Coverage shall also include, but not be limited to, the following:
 - 1. Exterior overhangs and canopies in accordance with construction, storage and exiting requirements.
 - 2. Elevator shafts and elevator equipment rooms
 - 3. Mechanical rooms and penthouses
 - 4. Storage racks where applicable
 - 5. Concealed spaces with combustible construction.

1.03 DESCRIPTION OF SYSTEMS

- A. Wet pipe sprinkler system.
- B. Where a wet pipe sprinkler system serves areas subject to freezing conditions or ambient temperatures less than 40 deg. F, provide dry heads.
- C. Dry pipe sprinkler system.
- D. Provide seismic restraints in accordance with NFPA 13, the Oregon Structural Specialty Code, and The Project Design Criteria in Section 204200.
- E. Provide seismic separation assemblies in accordance with NFPA 13 where piping crosses building seismic separation joints. Refer to architectural and structural drawings for amount of relative building movement.

1.04 SYSTEM ENGINEERING AND QUALITY ASSURANCE

- A. Fire Protection engineering and design shall be performed by, or under the direct supervision of, a currently licensed Oregon Professional Engineer. Submittal packages (drawings, calculations) shall bear the signed seal of the supervising engineer.

- B. The Fire Protection System engineer/designer:
 - 1. Shall be familiar with and comply with documented standards and ordinances required by the local authority having jurisdiction.
 - 2. Shall be responsible for verifying design and field conditions prior to submitting shop drawings for preliminary approval. Field conditions include, but are not limited to, areas subject to freezing or ambient temperatures less than 40 deg. F, available ceiling space, and obstructions such as structural elements.
- C. Piping shall be concealed above new ceilings except as noted on Drawings. Where no ceilings occur, pipe routing is subject to review and approval by Architect at time of preliminary system drawings.

1.05 SHOP DRAWINGS, PRODUCT DATA, OPERATION & MAINTENANCE DATA

- A. Submittals required for the products listed in the Product Table, in accordance with Section 201000. Operation & Maintenance Information required as indicated in the Product Table in accordance with Section 202000.
- B. Operation & Maintenance Information requirements indicated by number designation as follows. Refer to Section 202000 for a description of each type of information.
 - 1. Shop Drawings (submittal data)
 - 2. Product Data (submittal data)
 - 3. Manufacturer's Operation Manuals
 - 4. Manufacturer's Service and Lubrication Requirements
 - 5. Service Contracts and Field Start-up Reports
 - 6. Cleaning, Certification, and Test Reports
 - 7. System Information
 - 8. Warranties

PRODUCT TABLE	Operation & Maintenance Information							
	1	2	3	4	5	6	7	8
Pipe, fittings, hangers, and joining systems.		X						
Sprinkler Heads. Indicate head response type and listed coverage area.		X						
Valves		X	X					
Specialties		X	X					
Automatic Supervisory Air Supply		X	X	X				X
Hydraulic Calculations for Pipe Sizing: (1) For calculated pipe sizes, submit hydraulic calculation worksheets. (2) Worksheets shall include a list of all abbreviations used. (3) Worksheets shall include hydrant flow and test data with location, date, and testing agency. (4) Worksheets shall include information listed in NFPA 13 and NFPA 14.	X							

- C. Submit Shop Drawings as follows:
 - 1. Submit system drawings to Architect for preliminary review and comments.
 - 2. If comments are received, make noted changes and resubmit to Architect for review.
 - 3. Following Architect final review, submit final drawings to the local/state Fire Marshal for approval.
 - 4. After receiving approval from the local/state Fire Marshal, submit the drawings with Fire Marshal's approval stamp to the Architect.

5. Provide Architect a copy of transmittal letter documenting submittal to Owner's insurance carrier.

1.06 TRENCHING, BACKFILLING, AND COMPACTION

- A. Provide trenching, backfilling, and compaction for the Work of this Section.
- B. Trenching, backfilling, and compaction shall comply with requirements referenced in Section 201000, Section 221100, and the requirements specified in this Section.

PART 2 PRODUCTS

2.01 GENERAL

- A. Products shall be UL listed and FM approved for the purpose and system specified.

2.02 PIPE AND FITTINGS

- A. Sprinkler Systems:
 1. Pipe and fittings shall conform to NFPA 13.
 2. Pipe and fittings for preaction and dry pipe systems shall be hot dipped galvanized in accordance with ASTM-A-123.
 3. Proprietary pipe, listed and installed in accordance with NFPA 13, shall be limited to the following products:
 - a. Allied Dyna-Flo / Super Flo
 - b. Allied Dyna-Thread / Super-40.

2.03 SPRINKLER HEADS

- A. General:
 1. FM approval not required for enamel coated heads where noted.
 2. Provide required head response type and coverage area for spaces as indicated in Fire Protection System Plan on Drawings
 3. Provide proper temperature rating in accordance with NFPA 13.
 4. Provide quick-response type heads where permitted by Code.
- B. Manufacturer: Tyco Fire Products, Viking, Standard, Reliable, or approved.
- C. Upright:
 1. Finish:
 - a. Concealed: Standard brass.
 - b. Exposed: Standard chrome.
 2. Application: Exposed piping and concealed spaces.
- D. Wet Pendant:
 1. Finish:
 - a. Concealed: Standard brass.
 - b. Exposed: Standard chrome .
 2. Application: Exposed piping and concealed spaces.
- E. Semi-Recessed Wet Pendant:
 1. Finish: Polished chrome head and escutcheon.
 2. Application: Acoustical tile ceiling areas.
- F. Horizontal Sidewall:
 1. Deflector: Directional discharge designed for horizontal sidewall operation.
 2. Finish: Standard chrome.

- G. Dry Pendant:
 - 1. Finish:
 - a. Exposed: Standard Chrome.
 - b. Concealed: Standard brass.
 - 2. Water Seal: Located at upper (connecting) end to prevent vertical pipe from filling.
 - 3. Application: Areas subject to freezing or sensitive to water damage.
- H. Recessed Dry Pendant:
 - 1. Finish: Standard chromehead and Standard chrome cup.
 - 2. Water Seal: Located at upper (connecting) end to prevent vertical pipe from filling. Pipe length as required.
 - 3. Application: Areas subject to freezing or sensitive to water damage.
- I. Covered Wet Pendant (custom color):
 - 1. Description: Concealed deflector with removable cover, rated at temperature lower than the sprinkler temperature.
 - 2. Cover: Custom color to match adjacent ceiling, as approved by Architect.
 - 3. Application: Historic Ceiling Area, Conference Room 133. Coordinate head locations and color with Architect.
 - 4. Manufacturer and Model: Viking "Mirage" or approved.
- J. Protective Cages:
 - 1. Zinc plated steel wire sprinkler wire manufactured for use with the specific sprinkler head by the same manufacturer.
- K. Sprinkler Head Escutcheons:
 - 1. Matched escutcheon listed for use with the specific sprinkler head and manufactured by the same manufacturer.

2.04 VALVES

- A. OS & Y Gate Valves, 2-1/2 inch and larger:
 - 1. Iron body
 - 2. Bronze fitted
 - 3. Outside screw and yoke
 - 4. Rising stem
- B. Gate Valves, 2 inch and smaller:
 - 1. Bronze construction
 - 2. Threaded ends
- C. Supervised Butterfly Valve:
 - 1. Ductile iron body
 - 2. Ductile iron disc
 - 3. Grooved end or lug body
 - 4. Slow close, gear operator
 - 5. Position indicating flag
 - 6. Supervisory switch
- D. Check Valve:
 - 1. Iron or bronze body
 - 2. Bronze fitted
 - 3. Swing check design
 - 4. Composition seat

- E. Ball Drip:
 - 1. Brass body
 - 2. Threaded inlet and outlet
 - 3. Automatic operation
- F. Dry Pipe Valve Assembly
 - 1. Cast or ductile iron body
 - 2. Drip Funnel
 - 3. Accelerator Connection
 - 4. Taps for water motor and electric alarm
 - 5. Water Supply and System Air Pressure Gages
 - 6. Auto Drain and Main Drain Valves
 - 7. Alarm Test Valve
 - 8. Manufacturer: Tyco Fire Products, Viking, Reliable, or approved. Similar to Tyco Fire Products DVP-1.
- G. Double Check Detector Valve Assembly:
 - 1. Components: Two check valves, two OS & Y gate valves, and test cocks. Factory assembled and tested.
 - 2. Provide without detector meter and watertight plugs or caps on test cocks for installation by local utility.
 - 3. Approvals: UL listed, FM approved for fire service. Listed by Oregon State Health Division as an approved backflow prevention device.
 - 4. Manufacturer: Ames, Conbraco, Febco, Kennedy, Rainbird, Watts, or Wilkins. Similar to Watts 709.

2.05 SPECIALTIES

- A. Flow Switch:
 - 1. Construction:
 - a. Saddle: Suitable for mounting on vertical or horizontal pipe.
 - b. Vane: Polyethylene, sensitive to flow from one sprinkler.
 - c. Housing: Metal with connection for conduit and tamperproof screws.
 - d. Timer: 0 to 90 seconds adjustable to prevent false alarms due to surge.
 - e. Contacts: Two sets, one set normally open, one set normally closed.
 - 2. Manufacturer: Potter, or approved. Similar to Potter Model VSR-F.
- B. Supervisory Switch:
 - 1. Construction:
 - a. Switch: Single pole, double throw.
 - b. Housing: Weatherproof, metal, threaded conduit connection with tamperproof screws.
 - c. Bracket: Suitable for mounting on outside screw and yoke valve without interfering with hand wheel operation or suitable for mounting on a post indicator valve.
 - 2. Manufacturer: Potter, or approved. Similar to Potter OSYSU-A2.
- C. Pressure Alarm Switch:
 - 1. Construction:
 - a. Base: Weatherproof, threaded conduit connection, pipe threaded connection (explosion proof).
 - b. Operator: Bellows or diaphragm to sense system pressure.
 - c. Switches: Two single pole, double throw switches. Field adjust to provide trouble signal at 6 psig below line pressure and alarm signal at 15 psig below line pressure.
 - 2. UL listed, FM approved.
 - 3. Manufacturers: Potter, or approved. Similar to Potter PS40-2A.

- D. Low Pressure Alarm Switch:
 - 1. Base: Weatherproof, threaded conduit connection, pipe thread connection.
 - 2. Operator: Bellows or diaphragm to sense air system pressure.
 - 3. Switches: Two single pole, double throw switches. Factory set to activate at 5 psig.
 - 4. Approvals: FM approved, UL listed.
 - 5. Manufacturers: Potter, or approved. Similar to Potter PS10-2A
- E. Fire Department Connection, Sidewalk Type:
 - 1. Double clapper, 2-way, 90 degree siamese inlet.
 - 2. Rough brass.
 - 3. Inlets: Two 2½-inches.
 - 4. Outlet: 4 inches.
 - 5. Brass caps with chains.
 - 6. UL listed.
 - 7. Threads: Meet local fire department standard.
 - 8. Branding:
 - a. Sprinkler systems: "Auto Spkr"
 - b. Standpipe systems: "Standpipe"
 - 9. Manufacturer: Elkhart, Standard, Allenco, Croker or approved. Similar to Standard No. 133.

2.06 AUTOMATIC SUPERVISORY AIR SUPPLY

- A. Automatic Supervisory Air Supply:
 - 1. Description: Riser or tank mounted reciprocating oil-less air compressor.
 - 2. Control:
 - a. Riser Mounted Compressors: Fully automatic, factory assembled, factory set, integral pressure switch or factory recommended Air Maintenance Device with shutoff valve, bypass valve, strainer, pressure switch and pressure gage connection.
 - b. Tank Mounted Compressors: Provide factory recommended Air Maintenance Device with shutoff valve, bypass valve, strainer, regulator and pressure gage connection.
 - 3. Capacity: Nominal 10 psig, discharge volume suitable for system volume.
 - 4. Electrical: 120V AC.

2.07 PIPE SUPPORTS

- A. Ring Hangers for Pipe Sizes 3 inch and smaller:
 - 1. Type: Carbon steel band, adjustable, with knurled swivel nut.
 - 2. Finish:
 - a. Indoors: Zinc plated.
 - b. Outdoors or Wet Areas: Hot dip galvanized.
 - 3. Approvals: UL and FM.
 - 4. For uninsulated copper piping: Equivalent to model specified, with addition of copper plating, neoprene coating, or PVC coating.
 - 5. Manufacturer:
 - a. Anvil Fig. 69.
 - b. B-Line Fig. B 3170.
 - c. Super Strut C-727.
 - d. PHD Model 151.
 - e. Erico/Michigan Model 100.
 - f. Tolco Fig. 2, Fig. 200 for sizes 2" and smaller.

- B. Clevis Hangers for Pipe Sizes 4 inch and larger:
 - 1. Type: Adjustable clevis.
 - 2. Material: Carbon Steel.
 - 3. Finish:
 - a. Indoors: Zinc plated.
 - b. Outdoors or Wet Areas: Hot dip galvanized.
 - 4. Approvals: UL and FM.
 - 5. Manufacturers:
 - a. Anvil Fig. 260.
 - b. B-Line Fig. B 3100.
 - c. Super Strut C-710.
 - d. PHD Model 450.
 - e. Erico/Michigan Model 400.
 - f. Tolco Fig. 1.
- C. Hanger Rods:
 - 1. Materials: Carbon Steel.
 - 2. Finish:
 - a. Indoors: Zinc plated.
 - b. Outdoors or Wet Areas: Hot dip galvanized.
 - c. Diameter: Meet or exceed NFPA requirements.
- D. Riser Clamps:
 - 1. Type: 2 bolt.
 - 2. Materials: Carbon Steel.
 - 3. Finish:
 - a. Indoors: Zinc plated.
 - b. Outdoors or Wet Areas: Hot dip galvanized.
 - 4. Manufacturers:
 - a. Anvil Fig. 261.
 - b. B-Line Fig. B 3373.
 - c. Super Strut C-720.
 - d. PHD Model 550.
 - e. Erico/Michigan Model 510.
 - f. Tolco Fig. 6.
- E. Wall supports & Trapeze Assemblies:
 - 1. Description: Field fabricate of manufactured channel components.
 - 2. Pipe Supports: U-bolt, U-strap, or roller type components in accordance with those specified herein and compatible with manufactured channel system.
 - 3. Trapeze Size: As published by manufacturer for span and total weight supported. Provide sizing criteria with product data submittal.
 - 4. Manufacturer: Unistrut, Super-Strut, B-Line, Erico/Michigan, or approved.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install pipe plumb, parallel, and true to building structural system. Where possible, use full 20 ft. lengths.
- B. Install hangers at branch line connections to cross mains and as required by NFPA 13.

- C. For new sprinkler systems, provide metal box suitable for wall hanging containing six spare heads of each type used and a head wrench.
- D. Provide supervisory switch for each OS & Y gate valve.
- E. Mount flow switches no closer than twelve inches from any fitting. Verify, adjust, and modify as needed to compensate for nuisance trips due to flow and / or pressure fluctuations.
- F. For buildings five floors and greater, provide pressure reducing type standpipe hose valves for fourth floor and below.
- G. Coordinate piping and head locations with structure, ductwork, plumbing, lighting, and other electrical work.
- H. Coordinate sprinkler head locations with architectural reflected ceiling plans. Center heads both ways in ceiling tile.
- I. Provide protective cages on the following heads:
 - 1. Sprinklers in mechanical equipment areas.

3.02 INSPECTION AND TESTS

- A. Arrange and pay for inspection and tests required by the authorities and agencies to obtain complete and final acceptance of system.
- B. Piping: Rough-in hydrostatically tested and witnessed by the Fire Marshal or his assigned deputy.
- C. Inspections:
 - 1. At completion of work and again before end of years guarantee
 - 2. Operate control valves
 - 3. Lubricate operating stems
 - 4. Lubricate fire department connections
 - 5. Repair any leaks
- D. Provide certificate in duplicate of Fire Marshal's acceptance.

END OF SECTION

SECTION 221100**PIPING****PART 1 GENERAL****1.01 RELATED SECTIONS**

- A. Section 201000 - General Mechanical Provisions
- B. Section 202000 - Mechanical Operation and Maintenance Manuals
- C. Section 211000 - Fire Protection
- D. Products and Execution defined in this Section shall be commissioned. Refer to Sections 200510 and 019113 for scope of work and responsibilities related to commissioning.

1.02 TRENCHING, BACKFILLING, AND COMPACTION

- A. Provide trenching, backfilling, and compaction for the Work of this Section.
- B. Trenching, backfilling, and compaction shall comply with requirements referenced in Section 201000, in addition to requirements specified in this Section.

1.03 SHOP DRAWINGS, PRODUCT DATA, OPERATION & MAINTENANCE DATA

- A. Submittals required for the products listed in the Product Table, in accordance with Section 201000. Operation & Maintenance Information required as indicated in the Product Table in accordance with Section 202000.
- B. Operation & Maintenance Information requirements indicated by number designation as follows. Refer to Section 202000 for a description of each type of information.
 - 1. Shop Drawings (submittal data)
 - 2. Product Data (submittal data)
 - 3. Manufacturer's Operation Manuals
 - 4. Manufacturer's Service and Lubrication Requirements
 - 5. Service Contracts and Field Start-up Reports
 - 6. Cleaning, Certification, and Test Reports
 - 7. System Information
 - 8. Warranties

PRODUCT TABLE	Operation & Maintenance Information							
	1	2	3	4	5	6	7	8
Grooved-end Fittings		X						
Piping Specialties		X						
Flexible Pipe Connections		X						
Pipe Supports		X						

1.04 QUALITY ASSURANCE

- A. Qualification of Welders:
 - 1. Welders performing the Work of this Section shall have been certified within the last five years. Upon request, the Contractor shall provide the Owner with the names of welders employed in the Work, together with certification that each of these welders has passed qualification tests as prescribed by the National Certified Pipe Welding Bureau, or by other approved agency.

2. Welders installing piping connected to a boiler shall be qualified based on the Contractor's welding procedures and shall be boiler maker or steam fitter certified. In addition, at least one of the following is required:
 - a. National Board "R" stamp certificate.
 - b. "O" stamp certificate.
 - c. ASME Code shop with appropriate stamp.

1.05 DEFINITIONS

- A. Indoors: Inside building insulation envelope.
- B. Outdoors or Wet Areas: Outside building insulation envelope.

PART 2 PRODUCTS

2.01 PLUMBING PIPING

- A. Domestic Water (CW, HW, HWR):
 1. Pipe: Type L copper, hard drawn, ASTM B-88.
 2. Fittings: Wrought copper, ANSI B-16.22.
 3. Joints:
 - a. 2-1/2 inch diameter & smaller: Lead-free 95-5 tin-antimony solder or silver/copper-alloy brazed.
 - b. 3 inch diameter & larger: Silver/copper-alloy brazed.
- B. Sanitary Waste and Vent (W, V), buried, to minimum 5 feet outside building wall unless otherwise shown on Drawings:
 1. Pipe: Cast iron, no-hub, CISPI 301.
 2. Fittings: Cast iron, no-hub, CISPI 301.
 3. Joints: Neoprene gaskets and stainless steel clamp-shield assemblies, CISPI 310 or listed by IAPMO.
- C. Sanitary Waste and Vent (W, V), above ground:
 1. Pipe: Cast iron, no-hub, CISPI 301.
 2. Fittings: Cast iron, no-hub, CISPI 301.
 3. Joints (All areas, unless noted otherwise): Neoprene gaskets and stainless steel clamp-shield assemblies, CISPI 310 or listed by IAPMO.
- D. Storm Drain (SD), above ground:
 1. Pipe: Cast iron, no-hub, CISPI 301.
 2. Fittings: Cast iron, no-hub, CISPI 301.
 3. Joints (All areas, unless noted otherwise): Neoprene gaskets and stainless steel clamp-shield assemblies, CISPI 310 or listed by IAPMO.
- E. Overflow Drain (OFD):
 1. Pipe: Cast iron, no-hub, CISPI 301.
 2. Fittings: Cast iron, no-hub, CISPI 301.
 3. Joints (All areas, unless noted otherwise): Neoprene gaskets and stainless steel clamp-shield assemblies, CISPI 310 or listed by IAPMO.
- F. Temperature & Pressure Relief Valve Discharge:
 1. Pipe: Type M copper, hard drawn, ASTM B-88.
 2. Fittings: Wrought copper, ANSI B-16.22.
 3. Joints: Lead-free 95-5 tin-antimony solder, or approved.

- G. Water Heater Drain Pan Piping:
 - 1. Pipe: Type M copper, hard drawn, ASTM B-88.
 - 2. Fittings: Wrought copper, ANSI B-16.22.
 - 3. Joints: Lead-free 95-5 tin-antimony solder, or approved.
- H. Cooling Coil Condensate Drain (CD) within building:
 - 1. Pipe: Type M copper, hard drawn, ASTM B-88.
 - 2. Fittings: Wrought copper, ANSI B-16.22.
 - 3. Joints: Lead-free 95-5 tin-antimony solder, or approved.
- I. Cooling Coil Condensate Drain (CD) outside building:
 - 1. Option #1:
 - a. Pipe: Schedule 40 PVC, ASTM D-1785, Type 1.
 - b. Fittings: Schedule 40 PVC, ASTM D-2466.
 - c. Joints: Solvent cemented, in accordance with ASTM D-2855, using ASTM D-2564 solvent cement and ASTM F-656 primer.
 - d. Paint: One coat outdoor latex.
 - 2. Option #2:
 - a. Pipe: Type M copper, hard drawn, ASTM B-88.
 - b. Fittings: Wrought copper, ANSI B-16.22.
 - c. Joints: Lead-free 95-5 tin-antimony solder, or approved.
- J. Indirect Drain Piping (D):
 - 1. Pipe: DWV copper tube, ASTM B-306.
 - 2. Fittings: Cast bronze solder joint drainage fittings, ANSI B16.23.
 - 3. Joints: Lead-free 95-5 tin-antimony solder, or approved.

2.02 HYDRONIC PIPING

- A. Chilled Water (CHS, CHR), 2-1/2 inch diameter and smaller:
 - 1. Option #1:
 - a. Pipe: Schedule 40 black steel, ASTM A-53, Grade B.
 - b. Fittings: Malleable iron, class 150, ANSI B-16.3.
 - c. Joints: Screwed.
 - 2. Option #2:
 - a. Pipe: Schedule 40 black steel, ASTM A-53, Grade B.
 - b. Fittings: Grooved-end.
 - c. Joints: Grooved-end pipe with rigid couplings.
 - 3. Gaskets: Standard style, EPDM, supplied by joint system manufacturer.
 - 4. Lubricant: Petroleum free silicone based, approved by joint system manufacturer.
 - a. Manufacturer: Grinnell, Anvil, Victaulic, Shurjoint, or approved.
 - 5. Option #3:
 - a. Pipe: Type L copper, hard drawn, ASTM B-88.
 - b. Fittings: Wrought copper, ANSI B-16.22.
 - c. Joints: Lead free 95-5 tin-antimony solder or approved.
- B. Chilled Water (CHS, CHR), 3 inch diameter and larger:
 - 1. Option #1:
 - a. Pipe: Schedule 40 black steel, ASTM A-53, Grade B.
 - b. Weld Fittings: Black steel, schedule 40, ASTM A-234, ANSI B-16.9.
 - c. Flanged Fittings: Cast iron, class 125, ANSI B-16.1.
 - d. Flanges: Forged steel, welding neck, 150 pound, ANSI B-16.5.
 - e. Joints: Welded or flanged.

2. Option #2:
 - a. Pipe: Schedule 40 black steel, ASTM A-53, Grade B.
 - b. Fittings: Grooved-end.
 - c. Joints: Grooved-end pipe with rigid couplings
 - d. Gaskets: Standard style, EPDM, supplied by joint system manufacturer.
 - e. Lubricant: Petroleum free silicone based, approved by joint system manufacturer.
 - f. Manufacturer: Grinnell, Anvil, Victaulic, Shurjoint, or approved.
- C. Heating Water (HS, HR), 2-1/2 inch diameter and smaller:
 1. Option #1:
 - a. Pipe: Schedule 40 black steel, ASTM A-53, Grade B.
 - b. Fittings: Malleable iron, class 150, ANSI B-16.3.
 - c. Joints: Screwed.
 2. Option #2:
 - a. Pipe: Type L copper, hard drawn, ASTM B-88.
 - b. Fittings: Wrought copper, ANSI B-16.22.
 - c. Joints: Lead free 95-5 tin-antimony solder or approved.

2.03 STEAM AND CONDENSATE PIPING

- A. Steam (LPS), 2-1/2 inch diameter and smaller:
 1. Pipe: Schedule 40 black steel, ASTM A-53, Grade B.
 2. Fittings: Malleable iron, class 150, ANSI B-16.3.
 3. Joints: Screwed.
- B. Steam (LPS), 3 inch diameter and larger:
 1. Pipe: Schedule 40 black steel, ASTM A-53, Grade B.
 2. Weld Fittings: Black steel, schedule 40, ASTM A-234, ANSI B-16.9.
 3. Flanged Fittings: Cast iron, class 125, ANSI B-16.1.
 4. Flanges: Forged steel, welding neck, 150 pound, ANSI B-16.5.
 5. Flange Bolts: Grade 2.
 6. Joints: Welded or flanged.
- C. Condensate (LPC, PC), 2-1/2 inch diameter and smaller:
 1. Pipe: Schedule 80 black steel, ASTM A-53, Grade B.
 2. Fittings: Malleable iron, class 150, ANSI B-16.3.
 3. Joints: Screwed.
- D. Atmospheric Tank Vent (ATV), 2-1/2 inch diameter and smaller:
 1. Pipe: Schedule 80 black steel, ASTM A-53, Grade B.
 2. Fittings: Malleable iron, class 150, ANSI B-16.3.
 3. Joints: Screwed.

2.04 FIRE SPRINKLER PIPING

- A. Fire Sprinkler Pipe (F), above ground: Refer to Section 211000.
- B. Fire Sprinkler Pipe (F), buried, to minimum 5 feet outside building wall unless otherwise shown on Drawings:
 1. Pipe: Ductile iron, ANSI A21.51 (AWWA C151), with cement lining per ANSI A21.4 (AWWA C104).
 2. Minimum Thickness Class:
 - a. 4 inch: Class 51
 - b. 6 inch and larger: Class 50.

3. Fittings: Gray iron or ductile iron, mechanical joint, ANSI A21.10 (AWWA C110), cement lined per ANSI A21.4.
 4. Joints: Mechanical joint, with gaskets in accordance with ANSI A21.11 (AWWA C111).
 5. Joint Restraints:
 - a. Description: UL and FM approved, ductile iron mechanical joint follower gland, with restraining wedges secured to pipe by torque-limiting twist-off nuts.
 - b. Manufacturer: EBBA Iron Sales "Megalug" Series 1100 or approved.
- C. Fire Sprinkler Pipe (F), buried, 5 feet or more outside of building wall unless otherwise shown on Drawings:
1. Pipe: Class 200 (DR14) PVC, AWWA C900, NSF approved, UL and FM approved for fire protection systems.
 2. Fittings: Gray iron or ductile iron, ANSI A21.10 (AWWA C111), cement lined per ANSI A21.4.
 3. Joints: Push-on or mechanical joint, with approved gaskets.
 4. Joint Restraints: Concrete thrust blocks, in accordance with pipe manufacturer's recommendations and details on Drawings.

2.05 REFRIGERANT PIPING

- A. Refrigerant (RS, RL):
1. Pipe: Type ACR copper, hard drawn, ASTM B280, factory dehydrated, degreased, and plugged at each end to maintain cleanliness during storage, marked "ACR" in blue.
 2. Fittings: Wrought copper, ANSI B-16.22.
 3. Joints: Silver/copper-alloy brazed.
- B. Insulated Pipe Shields for use at Pipe Supports for Refrigerant Piping:
1. General: Closed cell insulation assembly with internal load-bearing segments and integral jacket.
 2. Material:
 - a. Insulation: Closed cell elastomeric foam.
 - b. Load-bearing segments: CFC-free PUR/PIP.
 - c. Jacket: Aluminum.
 3. Manufacturer and Model: Cooper B-Line "Armafix" or similar.

2.06 PIPING SPECIALTIES

- A. Flange Gaskets:
1. Type: Full faced or flat ring, to suit flange facings.
 2. Conform to: ASTM F-104.
 3. Min. Thickness: 1/16 inch.
 4. Manufacturer: Garlock Style 3200 or approved.
- B. Escutcheons:
1. Construction:
 - a. 2" diameter opening and smaller: Cast brass, nickel-plated with set screw.
 - b. Over 2" diameter opening: Chrome plated stamped steel.
 2. Size: Sufficient to cover sleeves and openings.
- C. Strainers:
1. Body:
 - a. At steel pipe, iron or steel.
 - b. At copper pipe, bronze or brass.

2. Rated Working Pressure:
 - a. High pressure steam: 250 psig minimum.
 - b. All others: 125 psig minimum.
 3. Pattern: Self-cleaning Y with blow-off connection.
 4. Basket:
 - a. 2-1/2 inch and larger: 0.045 inch perforated, type 304 stainless steel.
 - b. 2 inch and smaller: 20 mesh monel.
 5. Manufacturer: Fabrotech, Sarco, Hoffman, Keckley, Mueller, Armstrong, Hayward, Wheatley, Streamflow, Victaulic, or approved.
- D. Unions for steel pipe:
1. Body: Iron
 2. Seat: Brass.
 3. Rated Working Pressure:
 - a. Domestic Water: 125 psi minimum.
 - b. Hydronic: 250 psi minimum at 210 degrees F.
 4. Connection: Screwed or flanged to match pipe.
- E. Unions for copper pipe:
1. Body: Bronze.
 2. Seat: Brass.
 3. Rated Working Pressure:
 - a. Domestic Water: 125 psi minimum.
 - b. Hydronic: 250 psi minimum at 210 degrees F.
 4. Connection: Screwed, brazed, or flanged to match pipe.
- F. Unions for connecting copper pipe to steel pipe, 2-1/2 inch and smaller:
1. Description: Red brass body and seat.
 2. Rated Working Pressure: 250 psig minimum at 210 degrees F.
 3. Connection: Screwed or brazed, to match pipe.
- G. Isolation Flanged Connections for connecting copper pipe to steel pipe, 3 inch and larger pipe:
1. Description: Isolation flanged connection.
 2. Rated Working Pressure: 250 psig minimum at 210 degrees F.
 3. Connection: Flanged, to match pipe size.
 4. Manufacturer: Epco, CTS, or approved.
- H. Transition Couplings:
1. Transition Couplings in Traffic-Rated Areas:
 - a. Description: Compression style coupling, adaptable to dissimilar piping materials with different outside diameters.
 - b. Material: Ductile iron per ASTM A536, Grade 65-45-12 with shopcoat finish.
 - c. Gaskets: Virgin SBR per ASTM D 2000 MBA 710, compounded for water and sewer service.
 - d. Fasteners: Track-head bolts, heavy hex nuts, UNC 5/8" rolled thread, high strength, low alloy, corrosion resistant per AWWA C111.
 - e. Manufacturer: Romac, Smith-Blair or approved. Similar to Romac Style 501.
 2. Transition Couplings in Non-Traffic Areas:
 - a. Description: Rubber sleeve with full stainless steel jacket and clamping bands, adaptable to dissimilar piping materials with different outside diameters.
 - b. Material: Marine grade, 300 Series stainless steel jacket conforming to ASTM A240.
 - c. Sleeve: Rubber conforming to ASTM C425 and ASTM C1173.
 - d. Clamping Bands: Dual, worm drive, 300 series stainless steel.

- e. Manufacturer: Mission or approved. Similar to Mission MR Series Flex-Seal.
- I. Flashing at Vents Through Roof:
 - 1. Type: 24 gauge galvanized steel with neoprene seal around vent pipe.

2.07 PIPE SUPPORTS

- A. Ring Hangers for Pipe Sizes 3 inch and smaller:
 - 1. Type: Carbon steel band, adjustable, with knurled swivel nut.
 - 2. Finish:
 - a. Indoors: Zinc plated.
 - b. Outdoors or Wet Areas: Hot dip galvanized.
 - 3. Approvals: UL and FM.
 - 4. For uninsulated copper piping: Equivalent to model specified, with addition of copper plating, neoprene coating, or PVC coating.
 - 5. Manufacturer:
 - a. Anvil Fig. 70
 - b. B-Line Fig. B 3170
 - c. Super Strut C-727
 - d. PHD Model 151
 - e. Erico/Michigan Model 100
- B. Hanger Rods:
 - 1. Material: Carbon steel.
 - 2. Finish:
 - a. Indoors: Zinc plated.
 - b. Outdoors or Wet Areas: Hot dip galvanized.
- C. Insulated Pipe Shields for Use at Pipe Supports:
 - 1. Type: Preformed pipe insulation with an insulation shield.
 - 2. Insulation (Pipe sizes 1-1/4 inch through 3 inch):
 - a. Type: Rigid, polyisocyanurate foam, preformed to fit pipe size.
 - b. Conductivity ("k"): Not to exceed 0.19 at 75 degrees F mean temperature.
 - c. Thickness: To match adjacent pipe insulation. See Section 221410.
 - d. Length: To match insulation shield.
 - e. Manufacturer: Dow "Trymer 2000".
 - 3. Insulation (Pipe sizes 4 inch and larger):
 - a. Type: Rigid, hydrous calcium silicate, premolded to fit pipe size.
 - b. Density: 14 pounds per cubic foot.
 - c. Conductivity ("k"): Not to exceed 0.36 at 75 degrees F mean temperature.
 - d. Temperature Rating: 1200 degrees F.
 - e. Manufacturer:
 - 1) Manville "Thermo-12"
 - 2) Owens Corning "Kaylo 10"
 - 4. Insulation Jacket:
 - a. Type: .016 inch thick aluminum, preformed to fit pipe.
 - b. Finish: Stucco embossed pattern.
 - c. Moisture Barrier: Kraft or polyethylene.
 - 5. Insulation Shield:
 - a. Type: Galvanized steel, 2 overlapping pieces, full 360 degree.
 - b. Minimum Thickness:
 - 1) Pipe Sizes 1-1/4 to 2 inch: 24 gauge
 - 2) Pipe Sizes 2-1/2 to 3 inch: 20 gauge

- c. Minimum Length: 12 inch.
 6. Manufacturer: E.J. Bartells, ISSI Product Inc., Pipe Shields Inc., Erico/Michigan, or field fabricated with components specified herein.
- D. Riser Clamps:
1. Type: 2 bolt.
 2. Material: Carbon steel.
 3. Finish:
 - a. Indoors: Zinc plated.
 - b. Outdoors or Wet Areas: Hot dip galvanized.
 4. For uninsulated copper piping: Equivalent to model specified, with addition of copper plating, neoprene coating, or PVC coating.
 5. Manufacturer:
 - a. Anvil Fig. 261
 - b. B-Line Fig. B 3373
 - c. Super Strut C-720
 - d. PHD 550
 - e. Erico/Michigan Model 510
- E. Wall Supports & Trapeze Assemblies:
1. Description: Field fabricate of manufactured channel components.
 2. Pipe Supports: U-bolt, U-strap, or roller type components in accordance with those specified herein and compatible with manufactured channel system.
 3. Trapeze Size: As published by manufacturer for span and total weight supported. Provide sizing criteria with product data submittal.
 4. Manufacturer: Unistrut, Super-Strut, B-Line, Erico/Michigan, or approved.

2.08 SLEEVES

- A. Sleeves:
1. Material: Galvanized steel.
 2. Minimum Gauge: 20 gauge minimum.
 3. Minimum Size: 1/2 Inch larger than diameter of pipe, including insulation.
- B. Mechanical Seals:
1. Type: Interlocking rubber links assembled with bolts, to fill annular space around pipe for a waterproof seal.
 2. Manufacturer: Thunderline, Metraflex, or approved. Similar to Thunderline Corp. "Link-Seal".

2.09 EXCAVATION AND BACKFILL

- A. Bedding and Backfill Material:
1. Unclassified or Native Material: Existing material.
 2. Crushed Rock: 3/4 inch minus; conforming to the latest Oregon State Highway Specification for base rock.
 3. Pea Gravel: Washed, naturally rounded aggregate with particle size not less than 1/8 inch nor more than 3/4 inch in diameter.
 4. Sand: Washed concrete sand or washed fill sand if available.

PART 3 EXECUTION

3.01 GENERAL

- A. Install products in accordance with manufacturer's recommendations.

- B. Install piping plumb and parallel true to building structural system.
- C. Where possible, use full 20 foot lengths.
- D. Install branch piping to allow for expansion with offsets and swing joints as necessary to prevent undue strain.
- E. Do not use bushings and close nipples.
- F. Do not penetrate structural members.
- G. Screwed joints shall have less than two percent of threads showing.
- H. Ream pipes to full inside diameter prior to making up joints.
- I. Comply with applicable IAPMO Installation Standard for each particular piping material.
- J. Make branches and elbows with fittings specified herein. "Pulled tees", saddle taps, and field fabricated fittings are not acceptable.
- K. Welded Pipe Joints:
 - 1. Conform to American National Standard Code for Pressure Piping, ANSI B31, latest edition, including addenda.
 - 2. Branches, elbows, offsets shall be made only with welding fittings specified herein. "Cut-in" or metered tees are not permitted.
 - 3. Saddle-type fittings (e.g., "Weldolet") are permitted only when making 2 inch and smaller branches off of 4 inch and larger mains.
- L. Grooved-end Pipe Joints:
 - 1. Lubricate gaskets prior to installing couplings.
- M. Testing of Piping Systems:
 - 1. Advise Architect or authorized representative when testing will be performed.
 - 2. Test before concealing pipe joints and welds.
 - 3. Before testing, isolate all equipment or components which are not rated for test pressures.
 - 4. Record temperature at start and finish of test. Pressure readings at finish of test shall be adjusted to account for temperature change of medium during the test.
 - 5. Test pressures shall be as specified herein for each type of piping system.
 - 6. Comply with testing requirements of authorities having jurisdiction, in addition to requirements specified herein.
 - 7. Piping systems shall hold test pressure for a minimum of one hour with no leakage.

3.02 PLUMBING PIPING

- A. Domestic Water Piping:
 - 1. Slope toward low points of system and provide ball valves with caps for drainage.
 - 2. Test Pressure: Fill system with water and pressurize to 125 psig.
 - 3. Joints nominally 1" diameter or smaller not permitted below grade.
- B. Drain and Waste Piping:
 - 1. Slope 1/4 inch per foot, minimum, unless otherwise noted on Drawings.
 - 2. Test Pressure: Fill system with water to highest point.
 - 3. At pipes crossing building seismic joints, install four 6-inch long sections of pipe with no-hub couplings.
- C. Vent Piping:
 - 1. Vents through roof shall be plumb, with weatherproof flashing.
 - 2. Slope 1/2 inch per 10 feet, down toward fixture served.

3. Test Pressure: Fill system with water to highest point.
4. At pipes crossing building seismic joints, install four 6-inch long sections of pipe with no-hub couplings.

3.03 HYDRONIC PIPING

- A. Conform to applicable portions of ANSI/ASME B31.9 Building Services Piping.
- B. Make connections between steel and copper pipe in accessible locations, using red brass unions or isolation flanged connections, as determined by pipe size.
- C. Install piping level, using eccentric reducers as required to have an even plane on top for venting air.
- D. Provide manual air vents at system high points and where shown on Drawings.
- E. At low points of systems, provide ball valves with caps for drainage.
- F. Test Pressure: Fill system with water and pressurize to 150 psig.

3.04 STEAM AND CONDENSATE PIPING

- A. Conform to applicable portions of ANSI/ASME B31.1 Power Piping, and ANSI/ASME B31.9 Building Services Piping.
- B. Slope steam pipe down in direction of flow 1/4 inch per 10 feet.
- C. Slope condensate pipe (except pumped) down in direction of flow, 1 inch per 10 feet.
- D. Steam pipe runout to one piece of equipment shall slope back to main, 1 inch per 10 feet. Length of runout not to exceed 10 feet.
- E. Branches and runouts shall connect to top of serving pipe.
- F. Provide drip trap assembly at each rise in steam pipe and where indicated on Drawings.
- G. Test Pressure: Fill system with water and pressurize to 150 psig.

3.05 BURIED FIRE SPRINKLER PIPING

- A. For pipe to minimum 5 feet outside building wall, provide mechanical joint restraint at each joint and fitting. Piping system shall be fully-restrained without the need for thrust blocks.
- B. For pipe 5 feet or more outside building wall, provide thrust blocks and/or mechanical joint restraints at valves, tees, and changes in direction.
- C. Test in accordance with NFPA 24, pipe manufacturer's recommendations, and Fire Marshal's requirements.

3.06 REFRIGERANT PIPING

- A. Slope suction lines toward compressor 1 inch per 10 feet. Provide traps at vertical rises against flow in suction lines.
- B. Circulate dry nitrogen through pipe during brazing operation to eliminate formation of copper oxide.
- C. Pressure test with dry nitrogen at 300 psig for 12 hours.
- D. Evacuate piping system to achieve 27 inches Hg. vacuum, then break vacuum with dry nitrogen.

- E. Repeat evacuation process for a total of three purges, then charge with refrigerant after the last purge.
- F. Comply with ASHRAE 15 for refrigerant charging procedures.

3.07 PIPING SPECIALTIES

- A. Escutcheons:
 - 1. Install on exposed pipe through walls, floors, or ceilings.
 - 2. Secure escutcheon to pipe and wall.
 - 3. Escutcheons not required in mechanical rooms.
- B. Strainers:
 - 1. Install ahead of automatic valves, steam traps and where shown on Drawings.
 - 2. Strainer shall be same size as pipe.
 - 3. For water and condensate piping, install strainer with "Y" pointing down.
 - 4. For steam piping, install strainer with "Y" horizontal, to allow condensate to drain.
 - 5. Provide clearance for basket removal.
- C. Unions for steel pipe:
 - 1. Provide unions as follows:
 - a. Where indicated on Drawings.
 - b. At each automatic control valve.
 - c. As required for removal of pumps, steam traps, and equipment with piping connections.
- D. Unions for copper pipe:
 - 1. Provide unions as follows:
 - a. Where indicated on Drawings.
 - b. At each automatic control valve.
 - c. As required for removal of pumps, steam traps, and equipment with piping connections.
- E. Unions for connecting copper pipe to steel pipe, 2-1/2 inch and smaller:
 - 1. Provide unions as follows:
 - a. Where indicated on Drawings.
 - b. At connection points between copper and steel pipe.
 - c. Not required at heating and cooling coil connections.
 - d. Install in accessible locations.
- F. Isolation Flanged Connections for connecting copper pipe to steel pipe, 3 inch and larger pipe size:
 - 1. Provide isolation flanged connections as follows:
 - a. Where indicated on Drawings.
 - b. At connection points between copper and steel pipe.
 - c. Not required at heating and cooling coil connections.
 - d. Install in accessible locations.
- G. Transition Couplings:
 - 1. Provide transition couplings as follows:
 - a. Where indicated on Drawings.
 - b. For Sanitary Waste and Storm Drain, at connection points between piping materials nominally 5 feet outside building wall or as otherwise shown on Drawings.

3.08 PIPE SUPPORTS

A. General:

1. Refer to Section 221410 to determine pipe insulation requirements.
2. Supports for the following shall bear directly on the pipe:
 - a. Uninsulated pipe.
 - b. 1 inch and smaller domestic hot water and heating water pipe.
3. Size hangers to fit outside of pipe insulation, except where hangers shall bear directly on the pipe.
4. Provide pipe support shoe welded to pipe at each roller hanger.
5. Comply with applicable IAPMO Installation Standard for particular piping material.

B. Insulated Pipe Shields:

1. Provide insulated pipe shield at each support, except as follows:
 - a. Pipe sizes 1 inch and smaller.
 - b. Where supports are permitted to bear directly on the pipe.
 - c. Where support shoes are required.
2. Secure insulation with 16 gauge stainless steel wire, stainless steel bands, or nylon tape as recommended by insulation manufacturer.
3. Cover pipe insulation with aluminum jacket and preformed fitting covers.
4. For cold pipe installations, seal seams and joints in jacket with vapor barrier mastic or tape, to provide a continuous positive vapor barrier.

C. Steel Pipe, Horizontal:

1. Support within 2 feet of each direction change.
2. Maximum spacing of supports:

<u>Pipe Size</u>	<u>Rod Diameter</u>	<u>Maximum Spacing</u>
1 inch and smaller	3/8 inch	7 feet 0 inches
1-1/4 inch - 2 inch	3/8 inch	10 feet 0 inches
2-1/2 inch - 3-1/2 inch	1/2 inch	10 feet 0 inches
4 inch	5/8 inch	12 feet 0 inches
5 inch and larger	3/4 inch	12 feet 0 inches

D. Copper Pipe, Horizontal:

1. Support within 2 feet of each direction change.
2. Maximum spacing of supports:

<u>Pipe Size</u>	<u>Rod Diameter</u>	<u>Maximum Spacing</u>
1-1/2 inch and smaller	3/8 inch	6 feet 0 inches
2 inch and larger	3/8 inch	10 feet 0 inches

E. Cast Iron Pipe, Horizontal:

1. For joints less than 4 feet o.c.: Support at every other joint.
2. For joints 4 feet or greater o.c.: Support at every joint.
3. Support at every horizontal branch.
4. Maximum spacing of supports: 10 feet o.c.

F. PVC and ABS DWV Pipe, Horizontal:

1. Support at every change of direction or elevation.
2. Support ends of mains.
3. Maximum spacing of supports: 4 feet o.c.

G. Vertical Pipe Supports:

1. Provide riser clamp at each floor.

2. Provide wall supports, in addition to riser clamps, as follows:
 - a. For plastic pipe where spacing between riser clamps is greater than 6 feet.
 - b. For copper pipe where spacing between riser clamps is greater than 10 feet.
 - c. For cast iron and steel pipe where spacing between riser clamps is greater than 12 feet.
 3. For PEX pipe, provide sleeves or grommets to protect pipe at metal studs or other penetrations where wear might occur.
- H. Steel Pipes Through Floors in Finished Rooms:
1. Place slip-on steel flange on pipe above floor penetration.
 2. Tack weld flange in four places, 1 inch long.
 3. Anchor flange to floor, using bolts and lead anchor inserts.
- I. Copper Pipes Through Floors in Finished Rooms:
1. Place slip-on cast bronze flange on pipe above floor penetration.
 2. Braze flange to copper pipe.
 3. Anchor flange to floor, using bolts and lead anchor inserts.

3.09 SLEEVES AND SEALS

- A. Install sleeves and seals at pipe penetrations through walls and floors. Insulation shall be continuous through penetrations. Coordinate with pipe insulation requirements in Section 221410.
- B. Provide mechanical seal between pipe and sleeve at basement wall penetrations and as noted on Drawings.
- C. Caulk between pipe and sleeve at penetrations of walls and floors which are not fire-rated.

3.10 EXCAVATION AND BACKFILL

- A. General:
1. Determine location of existing underground utilities and services, uncover by hand digging.
 2. Completely de-water trenches and excavations before pipe is laid or concrete is placed.
 3. When necessary to prevent caving, excavation in sand, gravel or other unstable materials provide shoring and bracing. Shoring shall remain in place until testing, inspection and backfill for 12 inches above pipe are complete.
 4. Remove from site excavated materials not suitable for backfill.
 5. Delay backfill of trenches until all tests are performed and until after inspection and approval by governing authority.
 6. Record Drawings: During progress of underground work, maintain an accurate record of all installation depths and changes in direction for future accurate location. Record daily work progress prior to any backfill.
 7. Repair any damage to existing streets, sidewalks, concrete, piping, etc., at Contractor's expense.
- B. Excavation:
1. Unless otherwise shown, piping shall have the following minimum cover:
 - a. Water - 36 inches
 - b. Gas - 18 inches
 - c. Waste, Storm Drain - 24 inches
 2. Width: To provide working space, but in no case less than 18 inches plus the inside diameter of the pipe to be placed therein.

3. Grade Bottom of Trenches: Carried to lines and grades as shown or as required and established with instruments with proper allowances for pipe thickness and gravel bedding. Any amount of trench excavated below grade shall be corrected with approved materials thoroughly compacted.
- C. Bedding:
1. Buried pipes shall be laid on minimum 4 inches of compacted crushed rock bedding.
 2. Bedding shall extend from bottom of pipe to undisturbed earth, be evenly graded to support pipe at proper slope, and compacted to 95% density of AASHTO T-180/ASTM D-1557.
- D. Backfilling:
1. Under concrete slabs (inside or outside building), paved areas, streets, or sidewalks, backfill shall be pea gravel or crushed rock. Fill material shall extend from bedding material to the bottom of surfacing material, filling voids around pipe. Fill in maximum 8 inch lifts and compact to 95% density of AASHTO T-180/ASTM D-1557.
 2. For areas outside building, except as specified above, pipe shall be covered with minimum 12 inches of pea gravel or crushed rock and remainder of trench filled with thoroughly compacted native material.
 3. Should any backfilled ditch show settlement at any time through one year warranty period, Contractor shall bring ditch back to grade with compacted fill and repair any damage to concrete or paved areas caused by settlement.

END OF SECTION

SECTION 221300**VALVES****PART 1 GENERAL****1.01 RELATED SECTIONS**

- A. Section 201000 - General Mechanical Provisions
- B. Section 202000 - Mechanical Operation and Maintenance Manuals
- C. Products and Execution defined in this Section shall be commissioned. Refer to Sections 200510 and 019113 for scope of work and responsibilities related to commissioning.

1.02 SHOP DRAWINGS, PRODUCT DATA, OPERATION & MAINTENANCE DATA

- A. Submittals required for the products listed in the Product Table, in accordance with Section 201000. Operation & Maintenance Information required as indicated in the Product Table in accordance with Section 202000.
- B. Operation & Maintenance Information requirements indicated by number designation as follows. Refer to Section 202000 for a description of each type of information.
 - 1. Shop Drawings (submittal data)
 - 2. Product Data (submittal data)
 - 3. Manufacturer's Operation Manuals
 - 4. Manufacturer's Service and Lubrication Requirements
 - 5. Service Contracts and Field Start-up Reports
 - 6. Cleaning, Certification, and Test Reports
 - 7. System Information
 - 8. Warranties

PRODUCT TABLE	Operation & Maintenance Information							
	1	2	3	4	5	6	7	8
Gate Valves		X						
Butterfly Valves		X						
Ball Valves		X						
Check Valves		X						
Drain Valves		X						

PART 2 PRODUCTS**2.01 GATE VALVES**

- A. Gate Valves, Size 2-1/2 Inch and Smaller:
 - 1. Body: Bronze.
 - 2. Class: 125.
 - 3. Rated Working Pressure: Minimum of 125 psig steam; 200 psig WOG.
 - 4. Handle: Wheel.
 - 5. Connections: Threaded or soldered, to match pipe.
 - 6. Stem: Non-rising bronze or stainless steel.
 - 7. Wedge: Solid bronze.
 - 8. Stuffing Box: Repackable under pressure.
 - 9. Comply With: MSS SP-80.

10. Manufacturer: Crane, Nibco, Powell, Milwaukie, Kennedy, Grinnell, Walworth, Fairbanks, Jenkins, Lunkenheimer, Stockham, Hammond, or approved. Similar to Nibco T113.

2.02 BUTTERFLY VALVES

A. Butterfly Valves:

1. Type: Resilient-seated.
2. Body: Steel, cast iron, or nodular iron, with tapped lugs to permit isolation and removal of downstream piping.
3. Neck: Clearance for up to 2 inches of insulation.
4. Rated Working Pressure: 150 psig minimum.
5. Handle: Lever with disc position indicator and mechanical stops.
6. Stem: Stainless steel.
7. Disc: Bronze.
8. Seat/Liner: Ethylene propylene dien monomer (EPDM).
9. Manufacturer: Crane, Grinnell, Nibco, Hammond, Milwaukee, Demco, Powell, Keystone, Victaulic, Norris, or approved. Similar to Hammond Series 6200.

2.03 BALL VALVES

A. Ball Valves:

1. Type: Full port, 2-piece body.
2. Body: Bronze.
3. Rated Working Pressure: Minimum of 150 psig steam; 400 psig WOG.
4. Handle:
 - a. Uninsulated Pipe: Standard lever handle.
 - b. Insulated Pipe: Extended lever handle.
5. Ends: Threaded or soldered.
6. Stem and Ball: Stainless steel, or chrome-plated bronze or brass.
7. Seat and Seals: Teflon, TFE, or Buna-N.
8. Manufacturer: Crane, Worcester, Apollo, Watts, Hammond, Grinnell, Milwaukee, WKM, Nibco, Jomar, or approved. Similar to Hammond Model 8301A (threaded) or 8311A (soldered).

B. Ball Valves, 3 piece option:

1. Type: Full port, 3-piece body, bolted, swings out for maintenance.
2. Body: Bronze.
3. Rated Working Pressure: Minimum of 150 psig steam; 400 psig WOG.
4. Handle:
 - a. Uninsulated Pipe: Standard lever handle.
 - b. Insulated Pipe: Extended lever handle.
5. Ends: Threaded or soldered.
6. Stem and Ball: Stainless steel, or chrome-plated bronze or brass.
7. Seat and Seals: Teflon, TFE, or Buna-N.
8. Manufacturer: Crane, Watts, Apollo, Worcester, Hammond, Grinnell, Milwaukee, WKM, Nibco, Jomar, or approved. Similar to Hammond 8604 (threaded) or 8614 (soldered).

2.04 DRAIN VALVES

A. Drain Valves:

1. Type: 3/4 inch bronze ball valve, as previously specified, with 3/4 inch male hose thread adapter screwed into valve body, brass cap screwed onto hose thread adapter, and cap retainer chain.

2.05 CHECK VALVES

- A. Check Valve, Size 2-1/2 Inch and Smaller:
 - 1. Type: Y-pattern, swing, renewable seat and disc.
 - 2. Body: Bronze.
 - 3. Disc: Bronze.
 - 4. Class: 125 or 150.
 - 5. Rated Working Pressure: Minimum of 125 psig steam; 200 psig WOG.
 - 6. Ends: Threaded or soldered to match piping.
 - 7. Comply with: MSS SP-80.
 - 8. Manufacturer: Crane, Nibco, Powell, Milwaukie, Kennedy, Grinnell, Walworth, Fairbanks, Jenkins, Lunkenheimer, Stockham, Hammond, or approved. Similar to Hammond IB 940 (threaded) or Hammond IB 945 (solder).

- B. Check Valve, Size 3 Inch and Larger:
 - 1. Type: Swing, renewable seat and disc.
 - 2. Body: Iron.
 - 3. Class: 125.
 - 4. Rated Working Pressure: Minimum of 125 psig steam; 200 psig WOG.
 - 5. Ends: Flanged.
 - 6. Trim: Bronze.
 - 7. Disc: Iron.
 - 8. Bonnet: Bolted bonnet.
 - 9. Manufacturer: Crane, Nibco, Powell, Milwaukie, Kennedy, Grinnell, Walworth, Fairbanks, Jenkins, Lunkenheimer, Stockham, Hammond, or approved. Similar to Hammond IR 1124.

- C. Non-Slam Check Valve, Size 2-1/2" and Smaller:
 - 1. Type: Spring loaded disc.
 - 2. Class: 125 or 150.
 - 3. Body: Bronze.
 - 4. Disc: Bronze, renewable.
 - 5. Seat: Bronze, renewable.
 - 6. Rated Working Pressure: Minimum of 125 psig steam; 200 psig WOG.
 - 7. Spring: Stainless steel.
 - 8. Ends: Threaded or soldered to match piping.
 - 9. Comply with MSS SP-80.
 - 10. Model: Watts, Nibco, Mueller, or approved. Similar to Watts Series 600.

- D. Non-Slam Check Valve, Size 3 Inch and Larger:
 - 1. Type: Globe body and spring loaded disc.
 - 2. Body: Cast iron.
 - 3. Rated Working Pressure: Minimum of 150 psig WOG.
 - 4. Plug: Bronze.
 - 5. Spring: Stainless steel.
 - 6. Ends: Flanged.
 - 7. Model: Metraflex, McAlear, Mueller, or approved. Similar to Mueller 105M-AP.

PART 3 EXECUTION

3.01 GENERAL

- A. Valves shall be full line size, except where noted otherwise.
- B. Install valves in locations which are accessible without damage to finished walls and ceilings.

- C. Where possible, position valve operator towards access opening.

END OF SECTION

SECTION 221410**PIPING INSULATION****PART 1 GENERAL****1.01 RELATED SECTIONS**

- A. Section 201000 - General Mechanical Provisions
- B. Section 202000 - Mechanical Operation and Maintenance Manuals
- C. Section 221100 - Piping: Pipe Supports, Insulated Pipe Shields
- D. Products and Execution defined in this Section shall be commissioned. Refer to Sections 200510 and 019113 for scope of work and responsibilities related to commissioning.

1.02 QUALITY ASSURANCE

- A. Products shall have flame spread and smoke developed ratings based on test procedures in accordance with NFPA-255 and UL-723. Ratings shall be indicated on the product or on the shipping cartons.
- B. Unless otherwise specified herein, products shall have flame spread ratings not to exceed 25 and smoke developed ratings not to exceed 50.
- C. Products shall comply with the requirements of Oregon Revised Statute (ORS) 453.005 (7) (e), effective January 1, 2011. The referenced statute of limits the use of three types of brominated fire retardant chemicals, which are defined as hazardous substances.

1.03 SHOP DRAWINGS, PRODUCT DATA, OPERATION & MAINTENANCE DATA

- A. Submittals required for the products listed in the Product Table, in accordance with Section 201000. Operation & Maintenance Information required as indicated in the Product Table in accordance with Section 202000.
- B. Operation & Maintenance Information required for the products listed in the Product Table, indicated by number designation as follows. Refer to Section 202000 for a description of each type of information.
 - 1. Shop Drawings (submittal data)
 - 2. Product Data (submittal data), including documentation of ORS 453.005 (7) (e) compliance.
 - 3. Manufacturer's Operation Manuals
 - 4. Manufacturer's Service and Lubrication Requirements
 - 5. Service Contracts and Field Start-up Reports
 - 6. Cleaning, Certification, and Test Reports
 - 7. System Information
 - 8. Warranties

PRODUCT TABLE	Operation & Maintenance Information							
	1	2	3	4	5	6	7	8
Pipe Insulation		X						
Jackets and Fitting Covers		X						
HVAC Insulation Pads		X						
Accessories		X						

PART 2 PRODUCTS

2.01 PIPE INSULATION

- A. Preformed Fiberglass (FG):
 - 1. General: Preformed to fit pipe size, with factory applied vapor barrier facing.
 - 2. Conductivity ("k"): Not to exceed 0.24 at 75 degrees F mean temperature.
 - 3. Vapor Barrier Facing:
 - a. General: Factory applied, glass fiber reinforced, white kraft and aluminum foil laminate.
 - b. Permeability: Not to exceed 0.02 perms.
 - c. Closure System: Self-sealing pressure sensitive lap.
 - 4. Manufacturer:
 - a. Owens Corning "ASJ/SSL-II"
 - b. Knauf "Pipe Insulation, ASJ-SSL"
 - c. Certain Teed "Snap On, 500 deg., ASJ-SSL"
 - d. Manville "Micro-Lok AP-T, Micro-Flex CTS"
- B. Calcium Silicate (CS):
 - 1. Type: Rigid, hydrous calcium silicate, premolded to fit pipe size.
 - 2. Density: 14 pounds per cubic foot.
 - 3. Conductivity ("k"): Not to exceed 0.36 at 75 degrees F mean temperature.
 - 4. Temperature Rating: 1200 degrees F.
 - 5. Manufacturer:
 - a. Manville "Thermo-12"
 - b. Owens Corning "Kaylo 10"
- C. Elastomeric Foam (EF):
 - 1. Type: Flexible, closed cell elastomeric foam, unslit tubing.
 - 2. Joining System: Field applied contact cement at ends.
 - 3. Conductivity ("k"): Not to exceed 0.27 at 75 degrees F mean temperature.
 - 4. Manufacturer: Armstrong "AP Armaflex," with Armstrong "WB Armaflex Finish" weather resistant coating where required in Part 3.
- D. Polymer Foam (PF):
 - 1. Type: Flexible, flexible engineered polymer foam, pre-slit tubing.
 - 2. Joining System: Pre-slit, pre-glued, with peel-off release liner.
 - 3. Conductivity ("k"): Not to exceed 0.24 at 75 degrees F mean temperature.
 - 4. Manufacturer: Nomaco K-Flex "Imcolock", Thermacell or approved.
- E. Foam Insulation (RF):
 - 1. Type: Rigid polyisocyanurate foam, preformed to fit pipe size, with vapor barrier facing:
 - 2. Density: 2 lb./cubic ft.
 - 3. Conductivity ("k"): Not to exceed 0.19 at 75 degrees F mean temperature.
 - 4. Vapor Barrier Facing:
 - a. General: Factory applied, glass fiber reinforced, white kraft and aluminum foil laminate.
 - b. Permeability: Not to exceed 0.02 perms.
 - c. Closure System: Self-sealing pressure sensitive lap.
 - 5. Manufacturer: Dow "Trymer 2000."
- F. Fiberglass Fitting Inserts:
 - 1. Type: Precut fiberglass blanket for use with fitting covers.
 - 2. Conductivity ("k"): Not to exceed 0.28 at 75 degrees F mean temp.

3. Manufacturer: Same as fiberglass pipe insulation.

2.02 JACKETS AND FITTING COVERS

- A. Polyvinyl Chloride Jackets and Fitting Covers (PVC):
 1. Type: White PVC, preformed to fit pipe and fittings, UV-resistant.
 2. Shapes: Elbows, tees, valves, reducers, flanges, and end caps; in various sizes including Zest-on Flanged Gate Valve Fitting Covers or similar style cover sized to provide complete coverage of balancing valves and flow control valves.
 3. Thickness:
 - a. Indoors: Minimum 20 mils (.020 inches, 0.75 mm).
 - b. Outdoors: Minimum 30 mils (.030 inches, 0.75 mm).
 4. Manufacturer:
 - a. Johns Manville "Zeston 2000"
 - b. Certain-Teed "Snap Form"
 - c. Ceel-Co "Ceel-Tite 300"
 - d. Knauf "PVC Fitting Covers"
- B. Aluminum Jacket and Fitting Covers (AL):
 1. Type: .016 inch thick aluminum, preformed to fit pipe and fittings.
 2. Finish: Stucco embossed pattern.
 3. Shapes: Elbows, tees, valves, reducers, flanges, and end caps; in various sizes.
 4. Moisture Barrier: Kraft or polyethylene.

2.03 INSULATION PADS

- A. Type: Removable pad, tailored to fit the size and type of valve or fitting to be insulated.
- B. Temperature Rating: 500 degrees F.
- C. Cover:
 1. Material: Non-combustible, Teflon-treated or silicone-treated fiberglass cloth. Minimum 12 ounces per square yard.
 2. Manufacturer: Zetex, Alpha, or approved.
- D. Fill:
 1. Material: 1 inch thick glass fiber or ceramic fiber mat.
 2. Manufacturer: Thermal Ceramics, Manville, Lewco, Alpha, or approved.
- E. Fasteners: Hooks and stainless steel lacing or fiberglass straps with stainless steel buckles.

2.04 ACCESSORIES

- A. Insulating Cement: Comply with ANSI/ASTM C195.
- B. Finishing Cement: Comply with ASTM C449.
- C. Mastic, Coatings, Tapes, and Adhesives: Comply with Manufacturer's installation instructions for each type of insulation.

PART 3 EXECUTION

3.01 DEFINITIONS

- A. Above Ground:
 1. Includes:
 - a. Items inside buildings, except direct-buried below slab-on-grade floors.
 - b. Items inside tunnels and buried pipe chases.

- B. Subject to Damage:
 - 1. Includes:
 - a. Items less than 6 feet above floor in mechanical rooms.
 - b. Items in tunnels within a 7'-6" horizontal distance of access points above.
 - 2. Does not include:
 - a. Items where removable insulation pads are required.
- C. Exposed in Finished Spaces:
 - 1. Includes:
 - a. Items inside buildings.
 - 2. Does not include:
 - a. Items concealed by permanent ceilings, floors, or walls.
 - b. Items in tunnels.
 - c. Items in mechanical rooms
- D. Hot Pipe: Piping, fittings, equipment, or accessories handling media at design temperatures above 105 degrees F.
- E. Cold Pipe: Piping, fittings, equipment, or accessories handling rain water, potable cold water, and media at design temperature of 60 degrees F or below.

3.02 GENERAL

- A. Install products in accordance with Manufacturer's instructions.
- B. Install products in accordance with MICA (Midwest Insulation Contractors Association) - National Commercial & Industrial Insulation Standards.
- C. Insulate new pipe, fittings, valves, and specialties for each piping system included under APPLICATION TO PIPING SYSTEMS.
- D. Insulate pipe, fittings, valves, and specialties where existing insulation is removed to facilitate the remodel work.
- E. Insulate pipe, fittings, valves, and specialties where insulation was previously removed under separate abatement contracts.
- F. Where insulated piping is to be removed, report any portions which appear to be existing friable insulation to Architect. Repair and removal of asbestos are not part of this work.
- G. Verify piping has been tested and approved before installing insulation.
- H. Clean and dry piping before installing insulation.
- I. On exposed piping, locate insulation seams in least visible location.
- J. Insulation shall be continuous through walls, floors, ceilings, sleeves, and other penetrations. Where penetrations through non-structural framing members would require openings larger than allowed by the Oregon Structural Specialty Code or Oregon Mechanical Specialty Code (Section 302), fill maximum allowable size annulus with polyurethane expanding foam sealer. Trim foam sealer flush with framing member, butt insulation tight to foam, and seal vapor barrier to framing member.
- K. Label insulation that covers unions. Refer to Section 206000 for labeling requirements.
- L. Fill joints, cracks, seams, and depressions with canvas and finishing cement to form smooth surfaces.

3.03 TEMPERATURE-SPECIFIC REQUIREMENTS

- A. Cold Pipe Installation Requirements:
1. Seal seams and joints in vapor barrier facings, fitting covers, and insulation jackets with vapor barrier mastic or tape, to provide a continuous positive vapor barrier.
 2. At interruptions in insulation, seal ends of insulation to provide a continuous vapor barrier. For insulation with vapor barrier, seal with canvas or fiberglass cloth sealed with vapor barrier mastic. For insulation with PVC or aluminum jacket, seal ends with reducer endcaps, same material as jacket, tight to pipe surface and seal to pipe surface with vapor barrier mastic.
 3. For Cold Pipe do not insulate the following:
 - a. Exposed supplies at plumbing fixtures
 - b. Pressure reducing valves
 - c. Reduced pressure backflow preventers located in mechanical rooms
 - d. Water hammer arresters
 - e. Trap primer valves
 - f. Vacuum breakers
 - g. Pressure relief valves
 - h. Strainer access covers
 - i. Control valve actuators
 - j. Test plugs
 - k. Air vents
- B. Hot Pipe Installation Requirements:
1. In addition to tape system, staple insulation vapor barrier laps with outward clinch monel staples, 4 inches on center.
 2. In addition to tape, secure fitting covers with serrated stainless steel tacks.
 3. At interruptions in insulation, seal ends of insulation to cover exposed insulation. For insulation with vapor barrier, seal with canvas or fiberglass cloth sealed with mastic. For insulation with PVC or aluminum jacket, seal ends with reducer endcaps, same material as jacket, tight to pipe surface and seal to pipe surface with mastic.
 4. For Hot Pipe, do not insulate the following:
 - a. Water hammer arresters
 - b. Vacuum breakers
 - c. Pressure relief valves
 - d. Strainer access covers
 - e. Steam traps 1 inch or smaller
 - f. Control valves 1 inch or smaller
 - g. Control valve actuators
 - h. Test plugs
 - i. Air vents
 - j. Flow control valves 1 inch or smaller
 - k. Balancing valves 1 inch or smaller

3.04 INSULATION AT PIPE SUPPORTS

- A. Refer to Section 221100 for insulated pipe shields at pipe supports. At insulated pipe shields, lap insulation vapor barrier over cover of pipe shield and seal with factory approved vapor barrier tape. Seal longitudinal seams of pipe shield cover with vapor barrier tape or mastic. For piping where PVC or aluminum jacket is required, jacket shall be continuous over insulated pipe shields.

- B. Refer to Section 221100 for pipe support shoes at pipe supports. At pipe support shoes, fully insulate pipe around support shoe. Fill support shoe cavity with unfaced fiberglass insulation. For piping where PVC or aluminum jacket is required, jacket shall be continuous over support shoes.
- C. For heating water and domestic hot water pipes on ring hangers and clevis hangers where supports bear directly on the pipe per Section 221100, insulation shall cover the hanger, with cutout at the top of hanger. Fill hanger cutout with unfaced fiberglass insulation and seal vapor barrier with pressure sensitive tape to match vapor barrier facing.
- D. For heating water and domestic hot water pipes on channel strut where supports bear directly on the pipe per Section 221100, insulation shall be butted or trimmed tight to the side of the channel strut.

3.05 FIBERGLASS PIPE INSULATION (FG)

- A. General:
 - 1. Secure longitudinal laps in insulation vapor barrier with factory applied pressure sensitive tape system and outward clenching staples.
 - 2. Secure butt joints in insulation vapor barrier with pressure sensitive tape to match vapor barrier.
 - 3. Insulate fittings and valves (unless noted otherwise) with fiberglass fitting inserts and PVC Fitting Covers.

3.06 CALCIUM SILICATE PIPE INSULATION (CS)

- A. Secure insulation with 16 gauge stainless steel wire or with stainless steel bands, 12 inches maximum on center.
- B. Insulate fittings and valves (unless noted otherwise) with blocks or mitered segments of pipe insulation, secured with 16 gauge stainless steel wire. Fill voids with insulating cement, trowel smooth, and finish with canvas embedded in lagging adhesive.

3.07 CLOSED CELL ELASTOMERIC FOAM PIPE INSULATION (EF)

- A. Slip tubular insulation over pipe before making joints.
- B. Do not slit insulation lengthwise.
- C. Seal butt joints with contact adhesive approved by insulation manufacturer.
- D. Insulate fittings with oversize pipe insulation or miter-cut pieces of pipe insulation joined with contact adhesive to provide a continuous positive vapor barrier.
- E. On outdoor installations and installations where painting is required by Section 201000 provide two coats of insulation manufacturer's weather-resistant finish.

3.08 ENGINEERED POLYMER FOAM PIPE INSULATION (PF)

- A. Seal pre-glued longitudinal seams with factory approved seam roller.
- B. Seal butt joints with manufacturer approved contact adhesive or fuse seal system.
- C. Insulate fittings with oversize pipe insulation or miter-cut pieces of pipe insulation, joined with manufacturer approved contact adhesive or fuse seal system, to provide a continuous positive vapor barrier.
- D. For piping through studs with plastic or nylon stud inserts cut insulation 1/4" longer than stud space for tight fit.

3.09 JACKETS AND FITTING COVERS

A. General:

1. Provide Fitting covers as follows:
 - a. On piping where type FG insulation is required provide fitting covers at pipe fittings, valves, and piping accessories.
 - b. On steam and steam condensate piping provide fitting covers at pipe fittings, valves, and piping accessories.
 - c. Insulated piping in areas "Subject to Damage."
 - d. Insulated piping located outside building above ground.
 - e. Valves where adjacent piping has jackets.
 - f. Balancing Valves and Flow Control Valves, where adjacent piping has jackets.
2. Provide Jackets as follows:
 - a. Insulated piping Exposed in Finished Spaces.
 - b. Insulated piping in areas "Subject to Damage."
 - c. Insulated piping located outside building above ground.
 - d. On steam and steam condensate piping.
 - e. On piping where type CG insulation is required.
3. Where jackets and fitting covers are required, use the following types:
 - a. For Type FG insulation indoors: PVC (except where noted otherwise).
 - b. CW piping 4" and over: AL.
 - c. Outdoors above ground: AL.
 - d. Fitting covers shall be same material as jackets, except at Contractor's option Type EF insulation may be used as fitting covers on type FG insulation at flanged connections and grooved couplings.

B. Installation:

1. General:
 - a. Overlap seams 2 inches minimum and as indicated herein.
 - b. Seal per manufacturer's recommendations.
2. Polyvinyl Chloride Jackets and Fitting Covers (PVC):
 - a. Fitting Covers:
 - 1) Lap PVC fitting covers over adjacent vapor barrier facing with end of overlap pointed downward.
 - 2) On indoor installations secure PVC fitting covers with fitting cover manufacturer's pressure sensitive tape and secure ends of tapes using outward-clenching staples.
 - 3) On outdoor installations seal fitting covers with cover manufacturer's solvent welding adhesive.
 - b. Piping Jackets:
 - 1) Lap PVC jackets over fitting covers with longitudinal seams of jackets on lower third of piping, and end of overlap pointed downward.
 - 2) On indoor installations secure PVC fitting covers with fitting cover manufacturer's pressure sensitive tape and secure ends of tapes using outward-clenching staples.
 - 3) On outdoor installations seal fitting jacket seams and seal jackets to fitting covers using cover manufacturer's solvent welding adhesive.
3. Aluminum Jackets and Fitting Covers (AL):
 - a. Install aluminum fitting covers with overlap facing down.
 - b. Lap jackets over fitting covers with longitudinal seams of jackets on lower third of piping, and end of overlap facing downward.

- c. Secure jackets with aluminum bands or #8 x 1/2 inch galvanized sheet metal screws 6 inches maximum on center.
- d. At breaks in insulation, cover exposed ends with aluminum endcaps.
- e. Seal seams and joints with silicone sealer, to provide a continuous waterproof jacket.

3.10 INSULATION PADS

- A. Secure pads with stainless steel laces or with fiberglass straps, according to manufacturer's instructions.
- B. Pads shall overlap adjacent pipe insulation by 2 inches minimum.

3.11 APPLICATION TO PIPING SYSTEMS

- A. Domestic Cold Water (CW):
 1. Above Ground:
 - a. Type: FG. Or, at Contractor's option provide type PF.
 - b. Thickness: One inch. At Contractor's option, 1/2 inch thickness for branch lines up to 12 feet long for concealed piping serving individual fixtures.
 2. Embedded in concrete:
 - a. Type: PF.
 - b. Thickness: One half inch.
 3. In CMU walls:
 - a. Type: PF.
 - b. Thickness: One inch.
 4. Subject to Damage:
 - a. Type: CS.
 - b. Thickness: One and one half inches or same as insulation on adjacent piping, whichever is thicker.
- B. Domestic Hot Water (HW, HWR):
 1. Above Ground (except specific locations noted herein):
 - a. Type: FG. Or, at Contractor's option provide type PF.
 - b. Thickness:
 - 1) For pipe sizes 3/4" through 2": One inch. At Contractor's option, 1/2 inch thickness for branch lines up to 12 feet long for concealed piping serving individual fixtures.
 - 2) For pipe sizes 2-1/2" and larger: One and one half inches.
 2. In CMU walls:
 - a. Type: PF.
 - b. Thickness: One inch.
 3. Subject to Damage:
 - a. Type: CS.
 - b. Thickness:
 - 1) For pipe sizes 3/4" through 2": One and one half inches.
 - 2) For pipe sizes 2-1/2" and larger: Two inches.
 4. Buried:
 - a. Type: At Contractor's option, PF or EF.
 - b. Thickness:
 - 1) For pipe sizes 3/4" through 2": One inch.
 - 2) For pipe sizes 2-1/2" and larger: One and one half inches.

- C. Storm Drain, Overflow Drain (SD, OFD):
 - 1. Above Ground, Inside Building (except specific locations noted herein):
 - a. Type: FG.
 - b. Thickness: One inch.
 - 2. Subject to Damage:
 - a. Type: CS.
 - b. Thickness: One and one half inches.
- D. Chilled Water (CHS, CHR):
 - 1. Above Ground, Inside Building (except specific locations noted herein):
 - a. Type: FG.
 - b. Thickness: One inch. At Contractor's option, 1/2 inch thickness for branch lines up to 12 feet long for concealed piping serving individual terminal cooling coils.
- E. Heating Water (HS, HR):
 - 1. Above Ground, Inside Building (except specific locations noted herein):
 - a. Type: FG. Insulate Expansion Joints and Alignment Guides with Insulation Pads, installed to be removable. At Contractors' option, insulate valves with Insulation Pads, installed to be removable.
 - b. Thickness: One and one half inches, except one inch thickness for branch lines 2" size and smaller up to 12 feet long for concealed piping serving individual terminal devices.
- F. Cooling Coil Condensate Traps (CD):
 - 1. Type: PF.
 - 2. Thickness: Three quarter inches.
- G. Refrigerant Suction (RS) Refrigerant Liquid (RL):
 - 1. Inside Building, Above Ground:
 - a. Type: EF.
 - b. Thickness:
 - 1) For pipe sizes 1-1/8" OD and smaller: One-half inch.
 - 2) For pipe sizes 1-3/8" OD and larger: One inch.
 - 2. Outside Building, Above Ground:
 - a. Type: EF.
 - 1) Thickness: For pipe sizes 1-1/8" OD and smaller: One-half inch.
 - 2) For pipe sizes 1-3/8" OD and larger: One inch.
 - b. Jacketing: AL.

END OF SECTION

SECTION 221420**EQUIPMENT INSULATION****PART 1 GENERAL****1.01 RELATED SECTIONS**

- A. Section 201000 - General Mechanical Provisions
- B. Section 202000 - Mechanical Operation and Maintenance Manuals

1.02 QUALITY ASSURANCE

- A. Products shall have flame spread and smoke developed ratings based on test procedures in accordance with NFPA-255 and UL-723. Ratings shall be indicated on the product or on the shipping cartons.
- B. Unless otherwise specified herein, products shall have flame spread ratings not to exceed 25 and smoke developed ratings not to exceed 50.
- C. Products shall comply with the requirements of Oregon Revised Statute (ORS) 453.005 (7) (e), effective January 1, 2011. The referenced statute limits the use of three types of brominated fire retardant chemicals, which are defined as hazardous substances.

1.03 SHOP DRAWINGS, PRODUCT DATA, OPERATION & MAINTENANCE DATA

- A. Submittals required for the products listed in the Product Table, in accordance with Section 201000. Operation & Maintenance Information required as indicated in the Product Table in accordance with Section 202000.
- B. Operation & Maintenance Information requirements indicated by number designation as follows. Refer to Section 202000 for a description of each type of information.
 - 1. Shop Drawings (submittal data)
 - 2. Product Data (submittal data), including documentation of ORS 453.005 (7) (e) compliance.
 - 3. Manufacturer's Operation Manuals
 - 4. Manufacturer's Service and Lubrication Requirements
 - 5. Service Contracts and Field Start-up Reports
 - 6. Cleaning, Certification, and Test Reports
 - 7. System Information
 - 8. Warranties

PRODUCT TABLE	Operation & Maintenance Information							
	1	2	3	4	5	6	7	8
Equipment Insulation		X				X		
Jackets and Covers		X				X		
Accessories		X						

PART 2 PRODUCTS**2.01 EQUIPMENT INSULATION**

- A. Fiberglass Blanket with Vapor Barrier:
 - 1. Type: Flexible blanket with factory applied vapor barrier facing.

2. Density: 0.60 pounds per cubic foot.
 3. Conductivity ("k"): Not to exceed 0.31 at 100 degrees F mean temperature.
 4. Facing: Laminated aluminum foil, glass scrim, and kraft paper vapor barrier; with 2 inch sealing flap.
 5. Facing Permeability: Not to exceed 0.04 perms.
 6. Manufacturer:
 - a. Certain Teed "Standard Duct Wrap, FSK"
 - b. Knauf "Duct Wrap, FSK"
 - c. Manville "Microlite, FSK"
 - d. Owens Corning "All Service Duct Wrap"
- B. Unfaced Fiberglass Blanket:
1. Type: Flexible blanket, unfaced.
 2. Density: 0.60 pounds per cubic foot.
 3. Conductivity ("k"): Not to exceed 0.31 at 100 degrees F mean temperature.
 4. Approved Manufacturers:
 - a. Certain Teed "Standard Duct Wrap"
 - b. Knauf "Duct Wrap"
 - c. Manville "Microlite"
 - d. Owens Corning "All Service Duct Wrap"
- C. Unfaced Fiberglass Board:
1. Type: Rigid board, unfaced.
 2. Density: 3 pounds per cubic foot.
 3. Conductivity ("k"): Not to exceed 0.23 at 75 degrees F mean temperature.
 4. Approved Manufacturers:
 - a. Certain Teed "IB300"
 - b. Knauf "Insulation Board, 3 pcf"
 - c. Manville "814 Spin-Glass"
 - d. Owens Corning "Type 703"
- D. Fiberglass Pipe and Tank Wrap:
1. Type: Pre-formed fiberglass with factory applied vapor barrier facing.
 2. Density: 0.60 pounds per cubic foot.
 3. Conductivity ("k"): Not to exceed 0.31 at 100 degrees F mean temperature.
 4. Facing: Laminated aluminum foil, glass scrim, and kraft paper vapor barrier; with 2 inch sealing tapes.
 5. Facing Permeability: Not to exceed 0.04 perms.
 6. Manufacturer and product: Johns Manville, CertainTeed, Knauf, Owens Corning, or approved, similar to Johns Manville "Micro-Flex Large Diameter Pipe and Tank Wrap."
- E. Calcium Silicate:
1. Type: Rigid, hydrous calcium silicate, block or scored block.
 2. Density: 14 pounds per cubic foot.
 3. Conductivity ("k"): Not to exceed 0.36 at 75 degrees F mean temperature.
 4. Approved Manufacturers:
 - a. Manville "Thermo-12"
 - b. Owens Corning "Kaylo 10"

2.02 JACKETS AND COVERS

- A. Aluminum Jacket and Covers:
1. Type: .016 inch thick aluminum, flat sheet or preformed to fit equipment.
 2. Finish: Stucco embossed pattern.

3. Moisture Barrier: Kraft or polyethylene.
- B. Glass Fabric: 8 ounce minimum per square yard.

2.03 ACCESSORIES

- A. Insulating Cement: Comply with ANSI/ASTM C195.
- B. Finishing Cement: Comply with ASTM C449.
- C. Mastic, Coatings, Tapes, and Adhesives: Comply with manufacturer's installation instructions for each type of insulation.
- D. Wire Mesh: Galvanized, 1 inch hexagonal.

PART 3 EXECUTION

3.01 GENERAL

- A. Verify that equipment has been tested and approved prior to installation of insulation.
- B. Verify that equipment surfaces are clean and dry prior to installation of insulation.
- C. Install products in accordance with manufacturer's instructions.
- D. Install products in accordance with MICA (Midwest Insulation Contractors Association) - National Commercial & Industrial Insulation Standards.
- E. Items not insulated:
 1. Access panels, nameplates, or ASME stamps.
 2. Factory-insulated equipment, except as noted.
 3. Expansion tanks.
- F. Bevel and finish insulation at interruptions.

3.02 FIBERGLASS PIPE AND TANK WRAP

- A. At longitudinal seams lap vapor barrier facing per manufacturer's recommendations and seal with minimum 3" wide insulation manufacturer's FSK tape system.
- B. Staple lapped seams with outward-clenching staples maximum 4" on centers.
- C. Refer to Section 221410 for additional requirements regarding Cold Pipe Applications. On Cold Pipe Applications insulate to provide continuous vapor barrier.
- D. On Cold Pipe Applications seal staples with vapor barrier mastic.

3.03 CALCIUM SILICATE INSULATION

- A. Use scored block or preformed pipe insulation on curved surfaces.
- B. Fill voids with insulating cement.
- C. Secure insulation with stainless steel tie wires and full coverage of wire mesh.
- D. Cover wire mesh with a 1/4 inch thick coating of finishing cement, troweled smooth.
- E. Finish with glass fabric and lagging adhesive, unless noted otherwise. On cold equipment, apply full coating of vapor barrier mastic.

3.04 ELASTOMERIC FOAM INSULATION

- A. Secure with contact cement approved by insulation manufacturer.
- B. Apply full coverage of contact cement to insulation and to surface of equipment.
- C. Seal joints and seams with contact cement.
- D. On outdoor installations and installations where painting is required by Section 099100, provide two coats of insulation manufacturer's weather-resistant finish in lieu of paint.

3.05 ALUMINUM JACKETS AND COVERS

- A. Overlap seams 2 inches minimum.
- B. Secure with aluminum bands or #8 x 1/2 inch galv. sheet metal screws 6 inches maximum on center.
- C. Seal per manufacturer's recommendations.

3.06 APPLICATION TO EQUIPMENT

- A. Air Separators, Heating Water:
 - 1. Insulation Type:
 - a. Option 1: Oversize Fiberglass Pipe Insulation, in accordance with Section 221410.
 - b. Option 2: Fiberglass Pipe and Tank Wrap.
 - 2. Insulation Thickness: To match adjacent pipe insulation. Refer to Section 221410.
 - 3. Do not insulate removable strainer access cover.
- B. Shell and Tube Heat Exchangers (HE-1):
 - 1. Insulation Type:
 - a. Option 1: Oversize Fiberglass Pipe Insulation, in accordance with Section 221410.
 - b. Option 2: Fiberglass Pipe and Tank Wrap.
 - c. Option 3: Calcium Silicate.
 - 2. Insulation Thickness: To match adjacent pipe insulation. Refer to Section 221410
- C. Condensate Return Pumps (CRU-1):
 - 1. Insulation Type: Calcium Silicate.
 - 2. Insulation Thickness: 2 inches.
 - 3. Insulate receiver only. Bevel and finish insulation around pumps and level controls.
- D. Base-Mounted Chilled Water Pumps (CHWP-1):
 - 1. Insulation Type: Unfaced Fiberglass Board and Blanket.
 - 2. Insulation Thickness: Minimum 2 inches.
 - 3. Cover: Aluminum.
 - 4. Fabricate removable aluminum box around pump casing. Line with fiberglass board and fill voids with fiberglass blanket insulation.
 - 5. Seal cover seams with vapor barrier mastic.
 - 6. Do not insulate motor.

END OF SECTION

SECTION 222000**METERS AND GAUGES****PART 1 GENERAL****1.01 RELATED SECTIONS**

- A. Section 201000 - General Mechanical Provisions
- B. Section 202000 - Mechanical Operation and Maintenance Manuals

1.02 SHOP DRAWINGS, PRODUCT DATA, OPERATION & MAINTENANCE DATA

- A. Submittals required for the products listed in the Product Table, in accordance with Section 201000. Operation & Maintenance Information required as indicated in the Product Table in accordance with Section 202000.
- B. Operation & Maintenance Information requirements indicated by number designation as follows. Refer to Section 202000 for a description of each type of information.
 - 1. Shop Drawings (submittal data)
 - 2. Product Data (submittal data)
 - 3. Manufacturer's Operation Manuals
 - 4. Manufacturer's Service and Lubrication Requirements
 - 5. Service Contracts and Field Start-up Reports
 - 6. Cleaning, Certification, and Test Reports
 - 7. System Information
 - 8. Warranties

PRODUCT TABLE	Operation & Maintenance Information							
	1	2	3	4	5	6	7	8
Meters		X	X	X	X			
Gauges		X						

PART 2 PRODUCTS**2.01 METERS**

- A. Makeup Water Meter:
 - 1. Type: Disc, totalizing. Positive displacement chamber.
 - 2. Construction: Bronze housing, bronze register cover, bronze bottom plate, thermoplastic measuring chamber, "O" ring on chamber outlet port, local register.
 - 3. Maximum Rated Operating Pressure: 150 psig.
 - 4. Maximum Rated Operating Temperature: 80 deg. F.
 - 5. Connection: Threaded.
 - 6. Register: Mechanical totalizing type. Hermetically sealed.
 - 7. Capacity: 1/2 gpm to 30 gpm.
 - 8. Size: 5/8 inch x 5/8 inch x 3/4 inch.
 - 9. Manufacturer: Badger Model 25 (bronze), or approved.

2.02 GAUGES

- A. Temperature Gauges:
 - 1. Dial: Three inch bi-metal.
 - 2. Case: Stainless steel.

3. Dial: White.
 4. Numbers: Black.
 5. Stem: Four inch stainless steel.
 6. Socket: Brass separable.
 7. Connection: Back or bottom as required.
 8. Range:
 - a. Domestic Hot Water, 50 to 300 deg. F.
 - b. Heating Water, 50 to 300 deg. F.
 - c. Chilled Water, 25 to 125 deg. F.
 9. Manufacturer: Weksler, Weiss, Marshalltown, Ashcroft or approved. Similar to Weksler Bi-metal Thermometer.
- B. Pressure Gauges:
1. Dial: 3-1/2 inch.
 2. Case: Drawn steel, rust resistant, baked black enamel finish.
 3. Tube: Bronze bourdon, brass movement.
 4. Range:
 - a. High Pressure Steam: 0-200 psig.
 - b. All Others: 0-100 psig.
 5. Connection: Union with lever handle gauge cock.
 6. Steam Applications: Provide siphon between gauge and steam flow.
 7. Manufacturer: Marshalltown, Weksler, Weiss, or approved. Similar to Marshalltown No. 23 or Weksler Type AA1.
- C. Pressure Gauges, subject to pressure damage:
1. Dial: 3-1/2 inch.
 2. Case: Stainless steel, hermetically sealed.
 3. Tube: Type 316 stainless steel.
 4. Movement: Stainless steel, liquid-filled.
 5. Range:
 - a. Minimum: 0 psig.
 - b. Maximum: Double the normal operating pressure.
 6. Connection: Union with lever handle gauge cock.
 7. Pressure Snubber: In-line, brass filter type.
 8. Manufacturer: Marshalltown, Weksler, Weiss, or approved. Similar to Weksler Type BY4C gauge with BW42 pressure snubber.

PART 3 EXECUTION

3.01 GENERAL

- A. Provide lengths of straight pipe upstream and downstream from meters, in accordance with manufacturer's recommendations.
- B. Provide back or bottom connection gauges as required to permit reading of gauge from standing position on floor. Where possible, install gauges to permit reading of related temperature or pressure gauges from the same standing position.

END OF SECTION

SECTION 222100

PUMPS

PART 1 GENERAL

1.01 RELATED SECTIONS

- A. Section 201000 - General Mechanical Provisions
- B. Section 202000 - Mechanical Operation and Maintenance Manuals
- C. Section 205100 - Motors

1.02 SHOP DRAWINGS, PRODUCT DATA, OPERATION & MAINTENANCE DATA

- A. Submittals required for the products listed in the Product Table, in accordance with Section 201000. Operation & Maintenance Information required as indicated in the Product Table in accordance with Section 202000.
- B. Operation & Maintenance Information requirements indicated by number designation as follows. Refer to Section 202000 for a description of each type of information.
 - 1. Shop Drawings (submittal data)
 - 2. Product Data (submittal data)
 - 3. Manufacturer's Operation Manuals
 - 4. Manufacturer's Service and Lubrication Requirements
 - 5. Service Contracts and Field Start-up Reports
 - 6. Cleaning, Certification, and Test Reports
 - 7. System Information
 - 8. Warranties

PRODUCT TABLE	Operation & Maintenance Information							
	1	2	3	4	5	6	7	8
In-Line Pumps		X	X	X				X
Base Mounted Pumps		X	X	X				X

PART 2 PRODUCTS

2.01 DOMESTIC WATER PUMPS

- A. Domestic Hot Water Circulating Pump (DP-1):
 - 1. Design: In-line booster pump, all bronze construction.
 - 2. Impeller: Cast brass.
 - 3. Seal: Carbon/ceramic mechanical.
 - 4. Bearings: Oil lubricated, bronze sleeve type.
 - 5. Coupler: Flexible spring type.
 - 6. Motor: Open drip-proof, resiliently supported in steel frame, oil lubricated sleeve bearings, integral overload protection.
 - 7. Thermal Overload:
 - a. Integral on motors less than 1/2 HP.
 - b. 1/2 HP and above provided under Division 26.
 - 8. Capacity: See schedule on Drawings.
 - 9. Manufacturer: Bell & Gossett, Amtrol, Paco, Peerless, Armstrong, Taco, Grundfos, or approved. Similar to Bell & Gossett Series 100, PR, HV, or PD.

2.02 HYDRONIC PUMPS

- A. In-line Pump (HWP-1 & 2):
 - 1. Design: Close-coupled, vertical in-line.
 - 2. Body: Cast iron.
 - 3. Trim: Bronze fitted.
 - 4. Impeller: Cast bronze. Hydraulically and dynamically balanced.
 - 5. Shaft: Alloy steel with bronze sleeve covering wetted area under seal.
 - 6. Ends: Flanged for in-line mounting.
 - 7. Bearings: Sealed ball type.
 - 8. Seal: Carbon/ceramic mechanical, internally self-flushing.
 - 9. Access: Serviceable without disturbing pipe connections.
 - 10. Motor: Open drip-proof, resiliently supported in steel frame, grease lubricated ball bearings, non-overloading.
 - 11. Thermal Overload:
 - a. Integral on motors less than 1/2 HP.
 - b. 1/2 HP and above, provided under Division 26.
 - 12. Capacity: See schedule on drawings.
 - 13. Manufacturer: Bell & Gossett, Amtrol, Paco, Peerless, Armstrong, Taco, Aurora, Grundfos, or approved. Similar to Bell & Gossett Series 80.
- B. Base Mounted Pump (CHWP-1):
 - 1. Body: Cast iron.
 - 2. Trim: Bronze fitted.
 - 3. Casing: Vertical, split.
 - 4. Ends: Flanged.
 - 5. Impeller: Enclosed bronze, dynamically balanced.
 - 6. Seal: Mechanical.
 - 7. Sleeve: Replaceable, precision ground.
 - 8. Bearings: Regreasable ball bearing.
 - 9. Mounting: Pump and motor on a common fabricated steel frame.
 - 10. Coupler: With guard.
 - 11. Capacity: See schedule on Drawings.
 - 12. Manufacturer: Bell & Gossett, Taco, Armstrong, Weinman, Amtrol, Paco, Peerless, Allis Chalmers, Aurora, Grundfos, or approved. Similar to Bell & Gossett Series 1510.

PART 3 EXECUTION

3.01 GENERAL

- A. Install in accordance with manufacturer's recommendations.
- B. Support pipes adjacent to pumps, so that no weight is carried on pump casings.
- C. Decrease from line size with reducers at pump connections.
- D. Provide factory trimmed impeller, where necessary, to achieve scheduled performance.

3.02 BASE MOUNTED PUMPS

- A. Installation:
 - 1. Install pump on inertia base, with 1 inch shims placed on both sides of pump anchor bolts.
 - 2. Level pump and bolt to the inertia base.
 - 3. Align pump/motor/drive as recommended by manufacturer (before pipe connections are made).

4. Fill inside of pump base with non-shrinking grout. Grout to flow around wedges or shims in place.
 5. Complete pipe connections.
 6. Re-align pump/motor/drive as recommended by manufacturer.
- B. Certify alignment prior to start-up.

END OF SECTION

SECTION 224000

PLUMBING FIXTURES

PART 1 GENERAL

1.01 RELATED SECTIONS

- A. Section 201000 - General Mechanical Provisions
- B. Section 202000 - Mechanical Operation and Maintenance Manuals

1.02 SHOP DRAWINGS, PRODUCT DATA, OPERATION & MAINTENANCE DATA

- A. Submittals required for the products listed in the Product Table, in accordance with Section 201000. Operation & Maintenance Information required as indicated in the Product Table in accordance with Section 202000.
- B. Operation & Maintenance Information requirements indicated by number designation as follows. Refer to Section 202000 for a description of each type of information.
 - 1. Shop Drawings (submittal data)
 - 2. Product Data (submittal data)
 - 3. Manufacturer's Operation Manuals
 - 4. Manufacturer's Service and Lubrication Requirements
 - 5. Service Contracts and Field Start-up Reports
 - 6. Cleaning, Certification, and Test Reports
 - 7. System Information
 - 8. Warranties

PRODUCT TABLE	Operation & Maintenance Information							
	1	2	3	4	5	6	7	8
Water Closets		X						
Urinals		X						
Lavatories		X						
Sinks		X						
Water Coolers and Drinking Fountains		X	X	X				X
Supply Connections		X						
Hydrants and Hose Bibbs		X						
Floor Drains and Floor Sinks		X						
Fixture Carriers (include with applicable fixture)		X						
Closet Seats (include with applicable fixture)		X						
Faucets (include with applicable fixture)		X						

PART 2 PRODUCTS

2.01 WATER CLOSETS

- A. WC-1:
 - 1. Usage: Standard height, wall-mounted HET water closet.
 - 2. Accessibility: Not handicap accessible.

3. Fixture:
 - a. Description: Wall-mounted, wall outlet, elongated bowl, top spud, 1.28 gallon siphon jet flush. Provide bolt caps with water closet.
 - b. Overall Dimensions: 26 inches x 14 inches.
 - c. Minimum MaP test performance: 1000 grams.
 - d. Material: Vitreous china.
 - e. Color: White.
 - f. Manufacturer: American Standard, Briggs, Eljer, Kohler, Sloan or approved. Similar to American Standard AFWall Flowise Model 3351.128.
4. Flush Valve:
 - a. Description: Chrome plated body, multi-filtered bypass, chloramine resistant diaphragm, ADA compliant handle, vandal resistant stop cap with set screw, sweat solder adapter with cover tube, and cast wall flange with set screw.
 - b. Stops: Screw driver type. Vacuum breaker.
 - c. Inlet Adapter: Thread-to-solder, with escutcheon and casing tube.
 - d. Gallons per Flush: 1.28
 - e. Manufacturer: Sloan, Zurn or approved. Similar to Sloan Royal 111-1.28.
5. Seat:
 - a. Material: Solid white reinforced plastic.
 - b. Bumper: Non metallic.
 - c. Concealed check.
 - d. Hinge with insert molded integrally in seat.
 - e. Manufacturer: Church, Bemis, American Standard, Olsonite, Beneke or approved. Similar to Church 9500C seat.
6. Carrier:
 - a. Base Supports: Floor-mounted, adjustable cast iron.
 - b. Face plate: Cast iron, adjustable, with neoprene gasket.
 - c. Waste fitting: Cast iron with anchor foot. Vertical or horizontal, as required. Vent and/or side inlets, as required.
 - d. Fixture cap nuts: Chrome-plated.
 - e. Fixture outlet gasket: Neoprene.
 - f. Manufacturer: Jay R. Smith, Mifab, Wade, Zurn, Watts or approved. Similar to Jay R. Smith 100 and 200 Series.

B. WC-2:

1. Usage: Handicap height, wall-hung water closet.
2. Accessibility: ADA Compliant.
3. All components same as WC-1, except for mounting height.

2.02 URINALS**A. U-1:**

1. Usage: Wall-hung urinal.
2. Accessibility: Not handicap accessible.
3. Fixture:
 - a. Description: Wall-hung, top spud, 0.5 gpf siphon jet, privacy shields, vitreous china.
 - b. Overall Dimensions: 28 inches x 18 inches x 14 inches.
 - c. Material: Vitreous china.
 - d. Color: White.
 - e. Manufacturer: American Standard, Briggs, Eljer, Kohler, Sloan or approved. Similar to American Standard Model 6590.001.

4. Carrier:
 - a. Uprights: Floor-mounted, round or rectangular steel tubing.
 - b. Upper Hanger Plate: Adjustable, to match hangers furnished with fixture.
 - c. Bottom Bearing Plate: Adjustable, with bearing studs to match fixture.
 - d. Manufacturer: Jay R. Smith, Mifab, Wade, Zurn, Watts or approved. Similar to Jay R. Smith Figures 636-637.
 5. Sensor Flush Valve:
 - a. Description: Chrome plated body, multi-filtered bypass, chloramine resistant diaphragm, vandal resistant stop cap with set screw, sweat solder adapter with cover tube, and cast wall flange with set screw, battery powered sensor, mechanical manual override.
 - b. Stops: Screwdriver type. Vacuum breaker.
 - c. Inlet Adapter: Thread-to-solder, with escutcheon and casing tube.
 - d. Gallons per Flush: 0.5
 - e. Manufacturer: Sloan, Zurn or approved. Similar to Sloan Royal 186-0.5-SMO.
- B. U-2:
1. Usage: Handicap height, wall-hung urinal.
 2. Accessibility: ADA Compliant.
 3. All components same as U-1, except for mounting height.

2.03 LAVATORIES

- A. L-1:
1. Usage: Counter mounted lavatory.
 2. Accessibility: ADA Compliant.
 3. Fixture:
 - a. Description: Self-rimming, front overflow, faucet holes on 4 inch centers.
 - b. Dimensions: 20 inches x 17 inches overall x 6 inches deep.
 - c. Material: Vitreous china.
 - d. Color: White.
 - e. Manufacturer: American Standard, Briggs, Eljer, Kohler or approved. Similar to American Standard Aqualyn, Model 0476.028.
 4. Fittings:
 - a. Faucet: Sensor operated, battery-powered, single temperature, 4 inch base plate, 4-1/2 inch spout, 0.5 gpm vandal-resistant aerator, back checks, chrome finish. Sloan, Chicago, Zurn, Delta or approved. Similar to Sloan Model EBF-650
 - b. Drain: Heavy cast brass grid strainer, 1-1/4 inch, 17 gauge tubular brass tailpiece. McGuire, American Standard, Kohler or approved. Similar to McGuire Model 155A.
 - c. Mixing Valve: Provide MV-1 per 224100.
 5. Carrier:
 - a. Uprights: Floor-mounted, round or rectangular steel tubing.
 - b. Type: Concealed arms.
 - c. Manufacturer: Jay R. Smith, Mifab, Wade, Zurn, Watts or approved. Similar to Jay R. Smith 700 series.

2.04 SINKS

- A. S-1:
1. Usage: Janitor's Room mop service basin with Cleaning Solution Connection.
 2. Accessibility: Not handicap accessible.
 3. Fixture:
 - a. Description: One piece, floor mounted.

- b. Overall Dimensions: 24 inch x 24 inch x 10 inch.
 - c. Material: Molded stone.
 - d. Accessories: 30 inch hose with 3/4 inch brass coupling and stainless steel hose bracket.
 - e. Color: White.
 - f. Manufacturer: Fiat, Crane, Mustee, Florestone or approved. Similar to Fiat Model MSB-2424.
4. Fittings:
 - a. Faucet: Wall-mounted service type, 6 inch spout with integral vacuum breaker, 3/4 inch threaded hose outlet, adjustable centers, chrome plated. Chicago, Zurn or approved. Similar to Chicago Model 886-HC.
 - b. Supplies: 1/2 inch ball valve and check in HW and CW supplies for isolation. See Part 3, Execution.
 - c. Drain: Factory installed stainless steel grid strainer. See Drawings for outlet size.
 5. CSC:
 - a. Description: Auxiliary tap for cleaning solution connection. Brass wall faucet with metal wheel handle.
 - b. Manufacturer: Woodford, Chicago, Zurn, Delta, Moen, or approved. Similar to Woodford Model 26P.
- B. S-2:
1. Usage: Break Room sink.
 2. Accessibility: ADA Compliant.
 3. Fixture:
 - a. Description: Single compartment self-rimming sink, 19 inch x 16 inch x 6 inch deep bowl, 3-hole faucet punch, screw-type J-clamps, 8 inch centers, 3-1/2 inch drain.
 - b. Overall dimensions: 22 inch x 22 inch.
 - c. Material: 18 gauge type 304 stainless steel, sound insulated on underside.
 - d. Manufacturer: Elkay, Just or approved. Similar to Elkay Lustertone Model LRAD-2222.
 4. Fittings:
 - a. Faucet: Single lever side valve with side spray, 10 inch gooseneck spout, 1.5 gpm aerator, adjustable limit stop, chrome finish. Chicago, Zurn, or approved. Similar to Chicago Model 2304.
 - b. Drain: Stainless steel cup strainer, strainer basket, and tailpiece. Similar to Elkay LK-99.
 - c. Instant Hot Water Dispenser: Provide HD-1.
 - d. Garbage Disposer: Provide GD-1.
- C. S-3:
1. Usage: Conference Room sink.
 2. Accessibility: ADA Compliant.
 3. Fixture:
 - a. Description: Single compartment self-rimming sink, 16 inch x 11-1/2 inch x 6 inch deep bowl, 3-hole faucet punch, screw-type J-clamps, 8 inch centers, 3-1/2 inch drain.
 - b. Overall dimensions: 19 inch x 18 inch.
 - c. Material: 18 gauge type 304 stainless steel, sound insulated on underside.
 - d. Manufacturer: Elkay, Just or approved. Similar to Elkay Lustertone Model LRAD-1918.
 4. Fittings:
 - a. Faucet: Single lever side valve, two-hole mount, 10 inch gooseneck spout, 1.5 gpm aerator, adjustable limit stop, chrome finish. Chicago, Zurn, or approved. Similar to

- Chicago Model 2302.
 - b. Drain: Stainless steel cup strainer, strainer basket, and tailpiece. Similar to Elkay LK-99.
 - c. Instant Hot Water Dispenser: Provide HD-1.
- D. S-4:
1. Usage: Faculty Lounge sink.
 2. Accessibility: ADA Compliant.
 3. Fixture:
 - a. Description: Double compartment self-rimming sink, two 13-1/2 inch x 16 inch x 6 inch deep bowls, 4-hole faucet punch, screw-type J-clamps, rear-set 3-1/2 inch drains.
 - b. Overall dimensions: 33 inch x 21 inch.
 - c. Material: 18 gauge type 304 stainless steel, sound insulated on underside.
 - d. Manufacturer: Elkay, Just or approved. Similar to Elkay Lustertone Model LRAD-3321.
 4. Fittings:
 - a. Faucet: Single lever side valve with side spray, 10 inch gooseneck spout, 1.5 gpm aerator, adjustable limit stop, chrome finish. Chicago, Zurn, or approved. Similar to Chicago Model 2304.
 - b. Drain: Stainless steel cup strainer, strainer basket, and tailpiece. Similar to Elkay LK-99.
 - c. Instant Hot Water Dispenser: Provide HD-1.
 - d. Garbage Disposer: Provide GD-1.

2.05 SINK ACCESSORIES

- A. HD-1:
1. Instant Hot Water Dispenser:
 - a. Description: Chrome-plated faucet with self-closing valve, 6 inch spout, insulated tank with drain plug, adjustable thermostat (160 deg. F to 210 deg. F).
 - b. Approvals: NSF, IAPMO, UL listed.
 - c. Capacity: 60 cups of 190 degrees F water per hour.
 - d. Electrical: 750 watts, 6.25 amps, 120 volt, single phase, three-prong plug.
 - e. Warranty: 3 Years parts and labor.
 - f. Manufacturer: In-Sink-Erator or approved. Similar to In-Sink-Erator Model H770-SS.
- B. GD-1:
1. Garbage Disposal:
 - a. Description: Continuous feed, single direction, in-sink garbage disposal unit.
 - b. Construction: Stainless steel grinding elements, stainless steel shredder ring. One piece polypropylene stopper.
 - c. Operation: Wall switch activated.
 - d. Electrical: 3/4 horsepower, 120 volt, 8.1 amps. Manual reset overload. Minimum 24 inch pigtail cord with 3-prong plug.
 - e. Grinder Chamber Capacity: 40 oz.
 - f. Warranty: 6 Years parts and labor.
 - g. Manufacturer: In-Sink-Erator or approved. Similar to In-Sink-Erator Evolution Essential.

2.06 DRINKING FOUNTAINS AND WATER COOLERS

- A. DF-1:
1. Usage: Dual-height Water Cooler and Bottle Filling Station.
 2. Accessibility: ADA Compliant.

3. Fixture:
 - a. Description: Dual-height wall-mounted water cooler with bottle filling station, front push-button control on water cooler, electronic sensor activated bottle filling station with automatic 30-second shut-off timer, flex-guard bubbler, lead free, filter.
 - b. Material: Type 304, 18 gauge satin finish stainless steel.
 - c. Carrier: Mounting plate with floor mounted support carrier.
 - d. Manufacturer: Haws, Oasis, Elkay, Halsey Taylor or approved. Similar to Elkay Model LZSTL8WSLK.

2.07 SUPPLY CONNECTIONS

- A. IM-1:
 1. Ice Maker Connection:
 - a. Description: Recessed, removable face plate, compression angle valve.
 - b. Overall Dimensions: 11-1/2 inches wide x 9-1/2 inches high.
 - c. Material: 18 gauge galvanized steel.
 - d. Connections: 1/2 inch FIP inlet x 1/4 inch OD outlet, supply connection 1/2 inch MPT or 5/8 inch sweat connection.
 - e. Manufacturer: Guy Gray or approved. Similar to Guy Gray Model BIM875.

2.08 HYDRANTS AND HOSE BIBBS

- A. HB-1:
 1. Usage: Toilet room hose bibb.
 2. Accessibility: Not handicap accessible.
 3. Fixture:
 - a. Description: Interior polished chrome wall faucet with ASSE 1052 compliant backflow preventer, and removable tee key.
 - b. Manufacturer: Woodford, Chicago, Zurn or approved. Similar to Woodford Model 26P.
- B. HB-2:
 1. Usage: Mechanical room and interior non-public service area hose bibb.
 2. Accessibility: Not handicap accessible.
 3. Fixture:
 - a. Description: Interior brass wall faucet with ASSE 1052 compliant backflow preventer, and wheel handle.
 - b. Manufacturer: Woodford, Chicago, Zurn or approved. Similar to Woodford Model 26P.

2.09 FLOOR DRAINS AND FLOOR SINKS

- A. FD-1:
 1. Body: Coated cast iron, flashing collar with seepage openings, trap primer connection.
 2. Outlet Size: See Drawings.
 3. Strainer: Round, nickel bronze, adjustable height.
 4. Manufacturer: Jay R. Smith, Josam, Jonespec, Mifab, Wade, Watts, Zurn or approved. Similar to Jay R. Smith 2005-A.
- B. FS-1:
 1. Body: 12 inch x12 inch x 6 inch acid resisting enamel on cast iron, seepage flange.
 2. Outlet Size: See Drawings.
 3. Grate: Half Full, Three-quarter top grate, one piece.
 4. Strainer: Cast aluminum dome strainer, retained in recessed opening.

5. Manufacturer: American Standard, Kohler, Jay R. Smith, Josam, Jonespec, Mifab, Wade, Watts, Zurn or approved. Similar to Jay R. Smith Model 3140.

PART 3 EXECUTION

3.01 GENERAL

- A. Install in accordance with manufacturer's instructions.
- B. Install fixture traps easily removable for servicing and cleaning.
- C. Seal fixtures to wall and floor surfaces with sealant. Color to match fixture.
- D. Adjust stops or valves for intended water flow rate to fixtures without splashing, noise or overflow.

3.02 ADA COMPLIANCE

- A. Americans with Disabilities Act (ADA):
 1. All plumbing fixtures noted to be ADA compliant must be installed in accordance with current ADA requirements. Height, clearances, and controls shall comply with ADA requirements and applicable codes in addition to specific requirements listed here.
- B. Water Closets:
 1. Locate flush lever on wide side of water closet area. Verify configuration prior to ordering tank type water closets.
 2. Mount wall-hung water closets with seat to finish floor dimension of 17 to 19 inches.
- C. Urinals:
 1. Mount wall-hung urinals with front rim to finish floor dimension of 17 inches maximum.
- D. Lavatories:
 1. Insulate waste and hot water pipes under fixture.
 2. Mount counter lavatories in minimum 22 inch deep counter installed 2 inches minimum from front edge of counter. Mount lavatory with rim to finish floor dimension of 34 inches maximum. Note that sink rim and counter top are not flush for drop-in style lavatories.
- E. Sinks:
 1. Insulate waste and hot water pipes under fixture.

3.03 INSTALLATION

- A. Water Closets:
 1. Install carriers plumb.
 2. Closet Bowl Gaskets: Sponge rubber (wax gaskets not allowed).
- B. Urinals:
 1. Coordinate with Division 26 for installation of hard wired flush valves. Obtain Architect's approval of transformer location before installation. A single transformer may power up to six fixtures if located on the same wall.
- C. Lavatories:
 1. Provide individual waste drop to below floor at concealed arm carriers installed in walls with cavities six inches or less wide.
 2. Coordinate with Division 26 for installation of hard wired faucets. Obtain Architect's approval of transformer location before installation. A single transformer may power up to four fixtures if located on the same wall.

D. Janitor's Sinks:

1. Supply Valves: Locate isolation valves in ceiling space or wall cavity. Access door required where piping is inaccessible.
2. CSC: Provide cleaning solution connection at locations shown on Drawings. See Detail on Drawings.

E. Stainless Steel Counter Mounted Sinks:

1. Coordinate with Division 26 for installation of 120V circuit and receptacle in cabinet space.
2. Coordinate with Division 11 for installation of faucets, fittings and accessories in cabinet tops.
3. Connect hot water dispenser supply to cold water (CW) system. Do not connect to domestic hot water (HW).
4. Install hot water dispenser on left side and faucet side valve on right side of spout. Obtain Architect's approval of locations before holes are made and items installed.
5. Coordinate installation with garbage disposal where required.

F. Floor Drains and Floor Sinks:

1. Install with top of drain flush with finished floor.
2. Prime drain trap from nearest water closet or primer valve.

END OF SECTION

SECTION 224100

PLUMBING SPECIALTIES

PART 1 GENERAL

1.01 RELATED SECTIONS

- A. Section 201000 - General Mechanical Provisions
- B. Section 202000 - Mechanical Operation and Maintenance Manuals
- C. Section 224000 - Plumbing Fixtures

1.02 SHOP DRAWINGS, PRODUCT DATA, OPERATION & MAINTENANCE DATA

- A. Submittals required for the products listed in the Product Table, in accordance with Section 201000. Operation & Maintenance Information required as indicated in the Product Table in accordance with Section 202000.
- B. Operation & Maintenance Information requirements indicated by number designation as follows. Refer to Section 202000 for a description of each type of information.
 - 1. Shop Drawings (submittal data)
 - 2. Product Data (submittal data), including documentation of ORS 453.005 (7) (e) compliance.
 - 3. Manufacturer's Operation Manuals
 - 4. Manufacturer's Service and Lubrication Requirements
 - 5. Service Contracts and Field Start-up Reports
 - 6. Cleaning, Certification, and Test Reports
 - 7. System Information
 - 8. Warranties

PRODUCT TABLE	Operation & Maintenance Information							
	1	2	3	4	5	6	7	8
Fixture Traps		X						
Stops and Supplies		X						
Trap and Supply Insulation		X						
Cleanouts		X						
Water Hammer Arrestors		X						
Trap Primers		X	X					
Backflow Prevention Devices		X	X	X	X	X		X
Thermostatic Mixing Valves	X	X	X	X				X
Balancing Valves for Domestic Hot Water Recirc.		X	X					
Pressure Reducing Valves		X	X	X				
Thermal Expansion Tanks		X	X					X
Water Heater Drain Pans	X	X						
Water Heater Flexible Connections (Water)		X						

PART 2 PRODUCTS

2.01 FIXTURE TRAPS

- A. P-Traps, Exposed Locations:
 - 1. Materials: Chrome plated brass, 17 gauge minimum.
 - 2. Joints: Metal to metal ground.
 - 3. Flange: Chrome-plated steel.
 - 4. Manufacturer: American Standard, Kohler, Dearborn Brass, McGuire, Zurn, EBC, or approved.
- B. P-Traps, Concealed within chases, walls, or underfloor:
 - 1. Materials: One piece cast iron.
 - 2. Joints: No-hub.

2.02 STOPS AND SUPPLIES

- A. Stops and Supplies:
 - 1. Valve: Chrome-plated brass, angle pattern, loose key.
 - 2. Keys: Provide 2 keys for first valve and 1 additional key for each additional 10 valves.
 - 3. Inlet: 1/2 inch copper, compression fitting, with chrome-plated cover sleeve and stainless steel escutcheon.
 - 4. Outlet: 3/8 inch copper, compression fitting.
 - 5. Supply Riser: 3/8 inch flexible copper, non-corrugated, chrome-plated, with nosepiece and length to suit fixture served.
 - 6. Manufacturer: Brasscraft, T&S, McGuire, Robert Manufacturing, Chicago, Eastman, EBC, Zurn, or approved. Similar to McGuire "Standard" 2165CCLK or 2166CCLK.

2.03 TRAP AND SUPPLY INSULATION

- A. Trap and Supply Insulation Kits:
 - 1. Complies with ADA requirements for insulating pipes and fittings under handicapped accessible fixtures.
 - 2. Material: Molded closed cell vinyl.
 - 3. Components: Pre-molded to fit trap, tail piece, wall bend, supplies, and stops.
 - 4. Burning Characteristics: Self-extinguishing when tested in accordance with ASTM D635.
 - 5. Color: White.
 - 6. Manufacturer: McGuire, Truebro, EBC, or approved. Similar to McGuire "ProWrap".
 - 7. Products shall comply with the requirements of Oregon Revised Statute (ORS) 453.005 (7) (e), effective January 1, 2011. The referenced statute of limits the use of three types of brominated fire retardant chemicals, which are defined as hazardous substances.

2.04 CLEANOUTS AND CLEANOUT COVERS

- A. Wall Cleanouts, Interior Finished Areas:
 - 1. Plug: Cast iron spigot ferrule with bronze, taper thread.
 - 2. Cover: Round nickel bronze frame with cover, perimeter vandal proof screws, anchoring lugs.
 - 3. Manufacturer: Jay R. Smith, Josam, Jonespec, Mifab, Wade, Watts, Zurn, or approved. Similar to Jay R. Smith 4436-U-NB.
- B. Wall Cleanouts, Interior Unfinished Areas and Concealed:
 - 1. Plug: Bronze, taper thread.
 - 2. Cover: Shallow stainless steel or deep chrome plated bronze, secured to plug with countersunk, vandal proof screw.

3. Manufacturer: Jay R. Smith, Josam, Jonespec, Mifab, Wade, Watts, Zurn, or approved. Similar to Jay R. Smith 4472-U (shallow) or 4715-U (deep).
- C. Floor Cleanouts, Finished Areas:
1. Body: Coated cast iron two piece, adjustable.
 2. Plug: Bronze, taper thread.
 3. Cover: Nickel bronze, secured to body with vandal proof screws.
 4. Adjustable Carpet Clamp Frame: Required when cleanout is located in carpeted area.
 5. Manufacturer: Jay R. Smith, Josam, Jonespec, Mifab, Wade, Watts, Zurn, or approved. Similar to Jay R. Smith 4023 (4023-x in carpeted areas).
- D. Floor Cleanouts, Unfinished Areas:
1. Body: Coated cast iron, two piece, adjustable.
 2. Plug: Bronze, taper thread.
 3. Cover: Cast iron, heavy duty, with vandal proof, center-securing screw.
 4. Manufacturer: Jay R. Smith, Josam, Jonespec, Mifab, Wade, Watts, Zurn, or approved. Similar to Jay R. Smith 4243.
- E. Outside Cleanouts:
1. Body: Cast iron, free of housing.
 2. Housing: Coated cast iron, double flanged.
 3. Cover: Heavy-duty cast iron, secured to housing with vandal proof screws.
 4. Plug: Bronze, taper thread.
 5. Manufacturer: Jay R. Smith, Josam, Jonespec, Mifab, Wade, Watts, Zurn, or approved. Similar to Jay R. Smith 4253.

2.05 WATER HAMMER ARRESTORS

- A. Water Hammer Arrestors:
1. Type: Factory pressurized and sealed, with stainless steel bellows or brass piston.
 2. Testing and Fixture Unit Ratings: In accordance with Plumbing and Drainage Institute (PDI) Standard WH-201.
 3. Size: Refer to Part 3, Execution.
 4. Manufacturer: Jay R. Smith, Josam, Mifab, Precision Plumbing Products (PPP), Sioux Chief, Wade, Watts, Zurn, or approved. Similar to Jay R. Smith "Hydrotrol" or PPP "SC" series.

2.06 TRAP PRIMERS

- A. Flush Valve Primer Fitting:
1. Type: Diverts water to trap when flush valve is activated.
 2. Description: Replaces standard flush valve flush connection. Includes chrome-plated tee, tubing, and escutcheon.
 3. Manufacturer: Primer fitting shall be a standard option supplied by the flush valve manufacturer. Similar to Sloan VBF-72-A1.
- B. Trap Primer Valve:
1. Type: Delivers a metered amount of water to traps when activated by pressure fluctuations in the line.
 2. Description: Brass body, activated by 5 Psig fluctuation, integral backflow preventer.
 3. Accessories: Isolation valve with sweat connections and screwdriver slot operator. Provide distribution unit and manifold as required.
 4. Manufacturer/Model: Precision Plumbing Products, Jay R. Smith, Josam, Mifab, Sioux Chief, Wade, Watts, Zurn or approved. Similar to Precision Plumbing Products "Mini-Prime".

C. Trap Primer Station:

1. Type: Delivers an equal, metered amount of water to multiple traps using electronically activated solenoid valve.
2. Capacity: Serves between 4 and 30 individual traps. See Drawings for quantity served.
3. Description: Factory assembled, pre-piped, bronze body ball valve isolation, water hammer arrestor, electronic brass body solenoid valve, with type "L" copper manifold with brass 1/2 inch compression fitting and orifice for each trap served.
4. Electronics: Single point 120 volt, single phase connection, manual override switch, minimum 5 amp breaker, 24 hour geared timer with relay and 5 second dwell function, UL listed and certified.
5. Accessories: 16 gauge steel enclosure for surface or flush mounting, screwdriver type access door for flush installations.
6. Manufacturer/Model: Precision Plumbing Products "Prime Time" or approved.

2.07 BACKFLOW PREVENTION DEVICES**A. Atmospheric Vacuum Breaker:**

1. Materials: Brass with polished chrome finish, bronze internal trim.
2. Disc Float: Silicone, rated for 210°F at 125 psig. Closes vent on minimum flow.
3. Manufacturer: Watts, Febco, Conbraco, Zurn/Wilkins or approved. Similar to Watts 288A-C.

B. Pressure Vacuum Breaker:

1. Body: Bronze.
2. Pressure-Temperature: Maximum 210 deg. F at 150 psig. Minimum 15 psig. Rated for continuous pressure.
3. Vent Disc: Silicone rubber.
4. Features: Test cocks, bronze ball valve shut-offs.
5. Manufacturer: Watts, Febco, Conbraco, Zurn/Wilkins or approved. Similar to Watts 800.

2.08 THERMOSTATIC MIXING VALVES**A. Mixing Valve (MV-1):**

1. Features: Adjustable temperature control, straight checkstops, 1/2 inch IPS connections, compensates for fluctuations in supply temperature and pressure.
2. Certification: ASSE 1016.
3. Capacity: 0.5 gpm to 3.0 gpm flow range, maximum 20 psi pressure differential at 2.2 gpm flow.
4. Manufacturer: Powers, Leonard, Symmons, Lawler or approved. Similar to Powers Hydroguard Series 480.

2.09 BALANCING VALVES FOR DOMESTIC HOT WATER RECIRCULATION**A. Balancing Valves:**

1. Type: Calibrated balance valve with connections for attaching differential pressure meter.
2. Materials: Bronze.
3. Valve Style: Y pattern globe.
4. Meter Connections: With built-in check valves.
5. Operator: Minimum four full 360 degree hand wheel turns.
6. Connections: Threaded.
7. Maximum Operating Pressure: 250 psig minimum.
8. Maximum Operating Temperature: 250 deg. F. minimum.
9. Manufacturer: Armstrong CBV-T Series or Grinnell GBV Series.

2.10 PRESSURE REGULATING DEVICES

- A. Pressure Reducing Valve, Water:
 - 1. Body: Bronze.
 - 2. Seat: Renewable steel.
 - 3. Strainer: Integral stainless steel.
 - 4. Diaphragm: High temperature.
 - 5. Range: Adjustable.
 - 6. Relief: Built in by-pass not allowing reduced pressure to exceed main pressure.
 - 7. Manufacturer: Watts, Cash-Acme, McDonnell-Miller, Wilkins or approved. Similar to Watts Model U5B (U5BLP for reduced pressures below 25 psig).
- B. Pressure Reducing Valve, Water:
 - 1. Body: Bronze.
 - 2. Seat: Renewable monel.
 - 3. Diaphragm: Nylon reinforced neoprene.
 - 4. Strainer: Close-coupled, bronze body, Y-pattern.
 - 5. Manufacturer: Wilkins, Watts or approved. Similar to Wilkins Model 500 YSBR.

2.11 THERMAL EXPANSION TANKS

- A. Thermal Expansion Tanks:
 - 1. Type: In-line, pre-pressurized diaphragm, suitable for potable water systems.
 - 2. Working Pressure: ASME certification for 150 psig.
 - 3. Plastic Liner: NSF approved.
 - 4. Tank Volume: 2.1 gallons.
 - 5. Manufacturer: Amtrol, Watts, Zurn-Wilkins or approved. Similar to Amtrol Therm-X-Trol ST-5-C.

2.12 WATER HEATER DRAIN PAN

- A. Drain Pan:
 - 1. Material: Galvanized steel.
 - 2. Drain: Side outlet at bottom of pan. Size shall be 3/4 inch or as shown on Drawings, whichever is larger.
 - 3. Size and Arrangement: Round or square, large enough to accommodate maximum heater dimension, with minimum of 1 inch clearance on all sides and all components accessible for maintenance, minimum 2 inch depth.

2.13 WATER HEATER FLEXIBLE CONNECTIONS

- A. Water:
 - 1. Corrugated seamless copper.
 - 2. Integral dielectric union ends.
 - 3. Iron pipe size.
 - 4. 24 inches maximum length.
 - 5. Manufacturer: Brasscraft, Roberts Manufacturing, Eastman or approved.

PART 3 EXECUTION

3.01 CLEANOUTS

- A. Provide cleanouts where indicated on Drawings and additional cleanouts as required to meet code requirements.
- B. Install in accordance with cleanout details on drawings.

- C. Location: Cleanouts may be located within a 5 foot radius of where shown on drawings at Architect's discretion.
- D. Wall Cleanouts: Provide deep cover where pipe hub extends beyond face of finished wall.
- E. Floor Cleanouts: Provide floor and outside cleanouts for all locations shown on Drawings. Floor and outside cleanouts are not to be deleted or replaced by other types without Engineer's approval.

3.02 WATER HAMMER ARRESTORS

- A. Provide water hammer arrestors as follows:
 - 1. Where indicated on Drawings.
 - 2. Ahead of each solenoid valve.
 - 3. In cold water headers serving two or more fixtures.
- B. Provide water hammer arrestors which have PDI size ratings indicated on Drawings. Where size is not indicated on Drawings, Contractor shall size as follows:
 - 1. Calculate total fixture units, based on Oregon State Plumbing Specialty Code Table A-2, Appendix A.
 - 2. Size each water hammer arrestor according to following PDI Standard WH-201 ratings for systems up to 65 PSI working pressure:
 - a. 1-11 fixture units, PDI Size A.
 - b. 12-32 fixture units, PDI Size B.
 - c. 33-60 fixture units, PDI Size C.
 - d. 61-113 fixture units, PDI Size D.
 - e. 114-154 fixture units, PDI Size E.
 - f. 155-330 fixture units, PDI Size F.
 - 3. For systems over 65 PSI working pressure, provide the next larger size water hammer arrestor than listed above.
- C. Installation:
 - 1. Install in accordance with PDI Standard WH-201.

3.03 TRAP PRIMERS

- A. Install "pressure-drop" gravity type trap primers a minimum of one foot above the finished floor for every 20 feet of primer line served.

3.04 BACKFLOW PREVENTION DEVICES

- A. Provide access and clearances required for testing and maintenance.

3.05 BALANCING VALVES FOR DOMESTIC HOT WATER RECIRCULATION

- A. Globe Style Balancing Valves:
 - 1. Install valve with a minimum of 10 pipe diameters of straight pipe upstream of valve and 5 pipe diameters of straight pipe downstream of valve.

END OF SECTION

SECTION 225100

HYDRONIC SPECIALTIES

PART 1 GENERAL

1.01 RELATED SECTIONS

- A. Section 201000 - General Mechanical Provisions
- B. Section 202000 - Mechanical Operation and Maintenance Manuals

1.02 SHOP DRAWINGS, PRODUCT DATA, OPERATION & MAINTENANCE DATA

- A. Submittals required for the products listed in the Product Table, in accordance with Section 201000. Operation & Maintenance Information required as indicated in the Product Table in accordance with Section 202000.
- B. Operation & Maintenance Information requirements indicated by number designation as follows. Refer to Section 202000 for a description of each type of information.
 - 1. Shop Drawings (submittal data)
 - 2. Product Data (submittal data), including documentation of ORS 453.005 (7) (e) compliance.
 - 3. Manufacturer's Operation Manuals
 - 4. Manufacturer's Service and Lubrication Requirements
 - 5. Service Contracts and Field Start-up Reports
 - 6. Cleaning, Certification, and Test Reports
 - 7. System Information
 - 8. Warranties

PRODUCT TABLE	Operation & Maintenance Information							
	1	2	3	4	5	6	7	8
Air Control Devices		X		X				
Expansion Tanks	X	X	X	X	X			
Chemical Feeder		X						
Coil Piping Package (provide coil schedule, with flows and corresponding equipment tags.)		X						
Testing and Balancing Devices		X	X	X	X			
Suction Diffusers		X		X				
Relief Valves		X		X				

PART 2 PRODUCTS

2.01 AIR CONTROL DEVICES

- A. Automatic Air Vents:
 - 1. Construction: Cast brass, with female threaded inlet port at base, and male thread at vent port.
 - 2. Operation: Float valve.
 - 3. Size: 1/2 inch inlet, 1/8 inch outlet (1/2 inch male thread connection).
 - 4. Rated Working Pressure: 150 psig minimum at 210 deg. F.
 - 5. Manufacturer: Spirotherm, or approved. Similar to Spirotherm Spirotop.

- B. Manual Air Vents:
1. Description: Full line size tee with 6 inch high nipple, up to a 1/4 inch standard port ball valve, with 1/4 inch soft copper tube down to accessible location, terminating with 1/4 inch threaded bronze plug.
 2. Refer to detail on Drawings for additional requirements.
- C. Air Eliminator / Dirt Separator (AS-1):
1. Description: Coalescing type, microbubble air and dirt separator.
 2. Air Separation: 100% of the free air and entrained air, and up to 99.5% of the dissolved air.
 3. Dirt Separation: Minimum 80% of particles 30 micron and larger within 100 passes.
 4. Tank:
 - a. Steel with dirt collection chamber.
 - b. Blowdown connection with valve.
 - c. Valved side tap to flush floating dirt and for initial system bleeding of air.
 - d. Removable lower head.
 5. Rated Working Pressure: 150 psig at 270 deg. F.
 6. Coalescing Medium: Copper.
 7. Automatic Air Vent: Integral, brass, float-activated.
 8. Connections: Flanged.
 9. Size: 4 inches.
 10. Capacity: 145 gpm, 1 ft. hd. pressure drop.
 11. Manufacturer: Spirotherm, Taco, or approved. Similar to Spirotherm "Spirovent Air Eliminator / Dirt Separator".

2.02 EXPANSION TANKS

- A. Expansion Tanks (ET-1):
1. Type: Pre-pressurized, replaceable bladder.
 2. Bladder: Heavy duty butyl rubber, pressurized as indicated in schedule.
 3. Tank: Steel with lifting lugs and seismic restraint brackets. Vertical or horizontal arrangement as indicated in schedule.
 4. Connections/Tapping:
 - a. Flanged bladder access port
 - b. Threaded system connection
 - c. Charging valve
 - d. Tank drain.
 5. Construction: ASME rated for 125 psig working pressure and 240 deg F operating temperature.
 6. Finish: Factory enamel.
 7. Size and Capacity: Refer to schedule on Drawings.
 8. Manufacturer: Bell and Gossett, Amtrol, Thrush, Armstrong, Wheatley, Taco, or approved. Similar to Bell and Gossett Series "B".

2.03 CHEMICAL FEEDER

- A. Chemical Feeder:
1. Type: Pressure pot feeder.
 2. Rated working Pressure: 200 psig.
 3. Body: Steel, with connection at domed bottom for complete drainage.
 4. Cap: Iron.
 5. Seal: "O" ring.
 6. Capacity: Two gallon minimum.
 7. Manufacturer: J.L. Wingert Co., Mogul, or approved. Similar to Wingert DB-2HD.

2.04 COIL PIPING PACKAGE

- A. General: Refer to Coil Piping detail on drawings for component configuration.
- B. Ball Valves (Shutoff):
 - 1. Type: Full port.
 - 2. Ports: P/T Ports
 - 3. Union: Forged brass.
 - 4. Body: Bronze.
 - 5. Rated Working Pressure: Minimum of 150 psig steam; 400 psig WOG.
 - 6. Locking Handle: Lever handle.
 - 7. Ends: Threaded or sweat connection.
 - 8. Stem and Ball: Stainless steel, or chrome-plated bronze or brass.
 - 9. Seat and Seals: EPDM, Teflon, TFE, or Buna-N.
- C. Flow Control Valve Assembly (FCV):
 - 1. Type: Automatic, pressure compensating, flow limiting valves.
 - 2. Sizing: Line size body with cartridge sized to provide flow rates indicated on Drawings.
 - 3. Control Range: 2-32 psig differential pressure.
 - 4. Cartridge: Removable, spring-loaded stainless steel cup.
 - 5. Body: Brass, with threaded connections to unions.
 - 6. Pipe Connections: Threaded or sweat connections to unions.
 - 7. Unions: Two, O-ring or bronze seat, to permit removal of body without disassembly of inlet or outlet piping.
 - 8. Accuracy: Plus or minus 5 percent, at differential pressure within control range.
 - 9. Pressure Test Valves: Two 1/4 inch extended pressure / temperature test plugs, as specified in this Section.
 - 10. Tag: Metal body tag plus hanging metal or plastic tag and chain indicating model, gpm flow rate, psid control range, and associated unit or zone.
 - 11. Manufacturer's Warranty: 5 years.
- D. Y-Strainer:
 - 1. Body: brass.
 - 2. Blow-Off Drain: Hose end connection with cap and chain.
 - 3. Rated Working Pressure: 125 psig minimum.
 - 4. Pattern: Self cleaning Y with blow-off connection.
 - 5. Basket: 20 mesh monel.
- E. Unions at Coil/Flexible pipe connections:
 - 1. Body: Bronze at copper pipe.
 - 2. Rated Working Pressure: 125 psig minimum.
 - 3. Seat: Brass.
 - 4. Supply Side: P/T test valve.
 - 5. Return Side: Air Vent.
- F. Flexible Metal Hose (Final Connections to Coils):
 - 1. Description: Fire retardant hose assembly, stainless steel braided wire covering SAE 20R3 EPDM inner liner.
 - 2. Ends: Threaded brass fittings. All end connections shall be crimped to meet stated pressure ratings. serrated/slip fit connections are not acceptable.
 - 3. Temperature Rating: 200 deg. F.
 - 4. Minimum Working Pressure: 300 psig (3/4 inch) size at 200 deg. F.
 - 5. Warranty: 36 months.

- G. Manufacturer: Griswold, Bell and Gossett, Nexus, or approved. Similar to Griswold Consolidated Coil Connections.

2.05 TESTING AND BALANCING DEVICES

- A. Pressure / Temperature Test Plugs:
1. Type: Automatic-sealing port to receive a 1/8 inch o.d. pressure or temperature probe.
 2. Body and Cap: Brass.
 3. Size: 1/2 inch N.P.T.
 4. Core: Dual seal, elastomeric, rated for 275 deg. F maximum operating temperatures.
 5. Extension: For up to 2 inch insulation thickness.
 6. Manufacturer: Sisco, Peterson Equipment Co., Hydro Temp, Flow Design Inc., or approved. Similar to Sisco P/T Plug Model BNO-500.
- B. Orifice Flow Meter:
1. Type: Orifice insert with pressure readout valves on upstream and downstream sides.
 2. Body: Cast iron, wafer style, for installation between 125, 150, 250, or 300 psig ANSI flanges.
 3. Readout Valves: With integral check valves and gasketed caps.
 4. Calibrated Nameplate: Permanently attached, relates differential pressure to rate of flow.
 5. Differential Pressure Meter:
 - a. Type: Portable, with hoses and carrying case.
 - b. Hose Connections: Compatible with readout valves.
 - c. Pressure Range: Suitable for orifice pressure drop at system design flow.
 - d. Number Required: One for each required pressure range.
 6. Manufacturer: Bell and Gossett, Taco, Armstrong, Gerand, or approved. Similar to Bell and Gossett Model OP.
- C. Flow Control Valves, 2 inch and smaller:
1. Type: Automatic, pressure compensating, flow limiting valves.
 2. Sizing: Line size body with cartridge sized to provide flow rates indicated on Drawings.
 3. Control Range: 2-32 psig differential pressure.
 4. Cartridge: Removable, spring-loaded stainless steel cup.
 5. Body: Brass, with threaded connections to unions.
 6. Pipe Connections: Threaded or sweat connections to unions.
 7. Unions: Two, O-ring or bronze seat, to permit removal of body without disassembly of inlet or outlet piping.
 8. Accuracy: Plus or minus 5 percent, at differential pressure within control range.
 9. Pressure Test Valves: Two 1/4 inch extended pressure / temperature test plugs, as specified in this Section.
 10. Tag: Metal body tag plus hanging metal or plastic tag and chain indicating model, gpm flow rate, psid control range, and associated unit or zone.
 11. Manufacturer's Warranty: 5 years.
 12. Manufacturer: Griswold, Flow Design Inc., Bell and Gossett, Nexus, or approved.
- D. Balancing Valves:
1. Type: Calibrated balance valve with connections for attaching differential pressure meter.
 2. Body: Bronze or brass.
 3. Valve Style: Ball or globe.
 4. Meter Connections: With built-in check or shut-off valves.
 5. Operator: Square head with pointer or handwheel with memory stop.

6. Connections:
 - a. Pipe Sizes up to 3 inch: Threaded.
 - b. Pipe Sizes greater than 3 inch: Flanged.
7. Maximum Operating Pressure: 125 psig minimum.
8. Maximum Operating Temperature: 250 deg. F minimum.
9. Manufacturer: Bell & Gossett, Griswold, Wheatley, Armstrong, Tour & Anderson, Taco, Griswold, Flow Design Inc., Nexus, or approved. Similar to Bell & Gossett series "Circuit Setter".

2.06 SUCTION DIFFUSERS

- A. Suction Diffuser:
 1. Body: Angle type with inlet vanes.
 2. Perforated Cylinder: With fine mesh temporary start-up strainer.
 3. Maximum Pressure Differential: Pump shut-off head.
 4. Minimum Free Area: Five times area of pump suction opening.
 5. Foot Support: Adjustable.
 6. Size: Inlet pipe size or as indicated on the Drawings.
 7. Manufacturer: Bell & Gossett, Thrush, Taco, Wheatley, Armstrong or approved. Similar to Bell & Gossett "Suction Diffuser".

2.07 RELIEF VALVES

- A. Relief Valves:
 1. Construction: ASME Section VIII, liquid rated for water side heat exchangers.
 2. Limits: 3 to 300 psig, -320 to 406 deg. F.
 3. Body and Bonnet: Bronze/brass.
 4. Seat/Seal Material: Ethylene propylene.
 5. Spring: Stainless steel, with lift lever.
 6. Capacity: Equal to equipment capacity, set at 125 psig.
 7. Manufacturer: Kunkle, McDonnell-Miller, Watts, Cash-Acme, Bell & Gossett, Wheatley, or approved. Similar to Kunkle model 912.

PART 3 EXECUTION

3.01 GENERAL

- A. Install products in accordance with manufacturer's recommendations.

3.02 AIR CONTROL DEVICES

- A. Automatic Air Vents:
 1. Provide where indicated on Drawings.
 2. Provide pipe from air vent discharge to floor drain, or as indicated on Drawings.
- B. Manual Air Vents:
 1. Provide at system high points and where shown on Drawings.

3.03 EXPANSION TANKS

- A. Expansion Tanks (Bladder Type):
 1. Install in accordance with Manufacturers recommendations.
 2. Installation:
 - a. Remove plug or pipe cap from system connection.
 - b. Remove plug covering air charge valve.

- c. Before making connections to tank, verify tank air charge is equal to scheduled system fill pressure.
 - d. Adjust tank air charge as required.
 - e. Replace air valve plug.
 - f. Connect tank to system.
 - g. Set makeup water pressure regulator at scheduled fill pressure.
 - h. Fill hydronic system.
3. If fill pressure is required to be adjusted:
- a. Adjust makeup water pressure regulator to new fill pressure.
 - b. Close expansion tank isolation valve.
 - c. Open drain valve.
 - d. Remove plug covering air charge valve.
 - e. Release or add air as necessary to set tank charge pressure equal to the adjusted fill pressure.
 - f. Close drain valve.
 - g. Replace air valve plug.
 - h. Open expansion tank isolation valve to system.

3.04 TESTING AND BALANCING DEVICES

- A. Inspect flow control valves to determine if they have temporary start-up strainers. Remove start-up strainers after piping has been flushed.

3.05 SUCTION DIFFUSERS

- A. Support from floor with pipe and flange supports independent of pumps.
- B. Remove temporary start-up strainer after piping has been flushed.

END OF SECTION

SECTION 225200**STEAM AND STEAM CONDENSATE SPECIALTIES****PART 1 GENERAL****1.01 RELATED SECTIONS**

- A. Section 201000 - General Mechanical Provisions
- B. Section 202000 - Mechanical Operation and Maintenance Manuals
- C. Section 205100 - Motors

1.02 SHOP DRAWINGS, PRODUCT DATA, OPERATION & MAINTENANCE DATA

- A. Submittals required for the products listed in the Product Table, in accordance with Section 201000. Operation & Maintenance Information required as indicated in the Product Table in accordance with Section 202000.
- B. Operation & Maintenance Information requirements indicated by number designation as follows. Refer to Section 202000 for a description of each type of information.
 - 1. Shop Drawings (submittal data)
 - 2. Product Data (submittal data)
 - 3. Manufacturer's Operation Manuals
 - 4. Manufacturer's Service and Lubrication Requirements
 - 5. Service Contracts and Field Start-up Reports
 - 6. Cleaning, Certification, and Test Reports
 - 7. System Information
 - 8. Warranties

PRODUCT TABLE	Operation & Maintenance Information							
	1	2	3	4	5	6	7	8
Steam Traps		X						
Steam Vacuum Breakers		X						
Pressure Relief Valves		X						
Condensate Return Units		X						

PART 2 PRODUCTS**2.01 STEAM TRAPS**

- A. Inverted Bucket:
 - 1. Body: Cast iron.
 - 2. Bucket: Brass or stainless steel, inverted.
 - 3. Lever: Stainless steel.
 - 4. Seat and Plunger: Removable stainless steel.
 - 5. Maximum Rated Operating Pressure: 200 psig minimum.
 - 6. Cover: Removable, with working parts accessible without disturbing piping.
 - 7. Rated Capacity: Unless otherwise noted on Drawings, size each trap for the two times rated steam demand of equipment served, at a pressure drop of 1/2 psig.
 - 8. Manufacturer: Trane, Armstrong, Hoffman, MEPCO, Illinois, Sarco, or approved.

- B. Float and Thermostatic (F&T):
1. Float: Brass or stainless steel.
 2. Bellows: Thermostatic for venting air.
 3. Water Hammer Protection: Brass shield cup.
 4. Cover: Removable with working parts accessible without disturbing piping.
 5. Rated Capacity: Unless otherwise noted on Drawings, size each trap for two times rated steam demand of equipment served, at a pressure drop of 1/2 psig.
 6. Manufacturer: Trane, Armstrong, Hoffman, MEPCO, Illinois, Sarco, or approved.

2.02 STEAM VACUUM BREAKERS

- A. Steam Vacuum Breakers:
1. Type: Adjustable. Factory set to open at 2 inches h.g. vacuum.
 2. Adjustment Range: 0.25 to 20 inches h.g. (mercury).
 3. Rated Working Pressure: 150 psig.
 4. Manufacturer: Hoffman No. 62 or approved.

2.03 CONDENSATE RETURN UNITS

- A. Condensate Return Unit (CRU-1):
1. Type: Factory packaged duplex pump and receiver assembly.
 2. Receiver: Cast iron with anchor legs.
 3. Pumps:
 - a. Type: Centrifugal, Bronze fitted.
 - b. Maximum Water Temperature: 210 deg. F.
 4. Control Panel:
 - a. Factory mount on receiver.
 - b. Alternator: Automatic electric.
 - c. Hand-off-auto switch with pilot lights.
 - d. Magnetic starters and circuit breakers.
 5. Controls:
 - a. Level switches to operate both pumps if one pump does not maintain water level.
 - b. High water alarm with silencing switch.
 6. Capacity: As scheduled on Drawings.
 7. Manufacturer: Hoffman, Sarco, Weil, Chicago, Paco, Economy, Skidmore, Weinman, Federal, MEPCO, Domestic, Aurora, Shipco, or approved.

PART 3 EXECUTION

3.01 GENERAL

- A. Install products in accordance with manufacturer's recommendations.

END OF SECTION

SECTION 225400**PIPING SYSTEMS CLEANING, DISINFECTION AND TREATMENT****PART 1 GENERAL****1.01 RELATED SECTIONS**

- A. Section 201000 - General Mechanical Provisions
- B. Section 202000 - Mechanical Operation and Maintenance Manuals

1.02 SECTION INCLUDES

- A. Disinfection and bacteriological testing of Domestic Water Systems.
- B. Cleaning and chemical treatment of Heating Water Systems.
- C. Cleaning and chemical treatment of Chilled Water Systems.

1.03 QUALIFICATIONS

- A. Work of this section shall be performed by an approved firm specializing in cleaning, disinfection, and treatment of piping systems. Work shall be performed by qualified personnel with chemical and laboratory experience. Water samples to be tested by a bacteriological laboratory or testing facility certified by the State of Oregon.
- B. Approved Firms:
 - 1. Mount Hood Chemical Corporation - Portland, Oregon
 - 2. Chemcoa - Tualatin, Oregon
 - 3. Hydro-Chlor - Pleasant Hill, Oregon

1.04 SHOP DRAWINGS, PRODUCT DATA, OPERATION & MAINTENANCE DATA

- A. Submittals required in accordance with Section 201000. Operation & Maintenance Information required in accordance with Section 202000.
- B. Provide cover sheet with each report containing:
 - 1. Project name and location
 - 2. Architect
 - 3. Engineer
 - 4. Mechanical Contractor
 - 5. Cleaning, Disinfection, Treatment Firm
- C. Bind report in 3 ring binder, properly indexed.
- D. Submit three copies.
- E. 30 days after Contract is awarded, submit 3 copies of preliminary field test reports to be used for recording procedure/readings during cleaning/disinfection/chemical treatment work to Engineer for review. Reports to include (as a minimum) all data required elsewhere in this Section.
- F. Provide Final Report prior to Contractor's application for substantial completion.
- G. Submittals required for the following:
 - 1. Domestic Water System:
 - a. Disinfection Procedure Report, containing:
 - 1) Name and location of the job site and date when disinfection was performed.
 - 2) Material used for disinfection.

- 3) Retention period of disinfectant in piping system.
- 4) Concentration (PPM) of disinfectant during retention (initial and residual).
- 5) Concentration (PPM) of disinfectant after flushing system.
- 6) Statement that disinfection was performed as specified.
- 7) Signature and address of company/person performing disinfection.
- b. Bacteriological Test Report, containing:
 - 1) Name and location of the job site and date when samples were obtained.
 - 2) Name and address of State certified laboratory or testing facility that performed tests (include lab certification number).
 - 3) The coliform organism count.
2. Closed Loop Hydronic Water Systems:
 - a. Products used for chemical treatment.
 - b. Cleaning Procedure Report, containing:
 - 1) Name and location of the job site and date when system cleaning was performed.
 - 2) Identification of system flushing point(s).
 - 3) Material used for cleaning.
 - 4) Cleaning solution circulation time - record start and end time.
 - 5) Statement that system cleaning was performed as specified.
 - 6) Signature and address of company/person performing cleaning.
 - c. Cleaning, Passivation, and Chemical Treatment Procedure and Testing Report, containing:
 - 1) Name and location of the job site and date when procedure was performed.
 - 2) Chemicals used for cleaning procedure.
 - 3) Circulation period of cleaning solution in piping system.
 - 4) Chemicals used for passivation procedure.
 - 5) Concentration (PPM) of passivation chemical (initial and residual).
 - 6) Chemicals used for chemical treatment procedure.
 - 7) Concentration (PPM) of corrosion inhibitor (initial and residual).
 - 8) Makeup water meter readings at completion of initial procedure.
 - 9) Concentration (PPM) of corrosion inhibitor and makeup water meter readings at monthly intervals (to 1 year).
 - 10) Total amount of corrosion inhibitor added to the piping system.
 - 11) Statement that procedure was performed as specified.
 - 12) Signature and address of company/person performing procedures.

PART 2 PRODUCTS

2.01 CLOSED LOOP WATER SYSTEM CHEMICALS

- A. Pipe System Pre-Cleaner:
 1. Alkaline Phosphate (i.e. Tri-Sodium Phosphate - TSP) based cleaner/degreaser.
 2. Mt. Hood Chemical "Sterling Pre-Cleaner", Chemcoa 725 or approved.
- B. Water System Conditioner:
 1. Concentrated liquid water conditioner for use in domestic, potable, and cooling water applications.
 2. Mt. Hood Chemical "Polyquest" or approved.
- C. Corrosion Inhibitor:
 1. Sodium Silicate or Sodium Nitrite/Borate inhibitor solution suitable for ferrous and non-ferrous piping systems.
 2. Mt. Hood Chemical "CorStop Inhibitor #34" or approved.

PART 3 EXECUTION

3.01 DOMESTIC WATER SYSTEM

- A. Notify Architect twenty-four (24) hours prior to performing disinfection.
- B. Disinfection: The domestic (potable) water system shall be disinfected prior to use in accordance with Oregon Administrative Rules, Section 333-61-0050; Oregon Health Division, Public Water Systems, Part (11), "Disinfection of Facilities" and AWWA C651, in addition to the following procedure:
 - 1. Flush piping system with clean, potable water to remove any debris or foreign material until only potable water discharges from outlets. Provide temporary piping or hoses, remove any plugs or caps, and open valves as necessary to flush entire system including dead-end headers and risers. Sectionalize piping system to obtain a minimum of six (6) feet per second flushing velocity. Remove all temporary hoses and piping after flushing. Clean all strainers and remove faucet aerators, to be replaced after disinfection is complete.
 - 2. Provide a valved service tap at the water service entrance, downstream of the backflow preventer, for use as a chlorine injection point. Inject chlorine at a constant rate using a proportioning pump or similar device. Open section and zone valves.
 - 3. Fill piping system and/or parts thereof with a water-chlorine solution of least fifty (50) parts per million chlorine. Fully open each outlet during injection until chlorine residual concentration at all outlets is no less than fifty (50) parts per million.
 - 4. Close outlet valves and faucets and secure. Allow solution to stand in retention for minimum twenty-four (24) hours. After retention, verify residual level of chlorine remains at fifty (50) parts per million. If less, repeat process as described above.
 - 5. Following the twenty-four (24) hour retention, flush the system with clean, potable water until the chlorine residual in the discharged flushing water does not exceed the chlorine residual in the potable water source, or is less than one (1) part per million.
- C. Bacteriological Water Analysis: Upon completion of disinfection, contractor shall obtain and submit for testing one water sample from the most remote hot and cold water outlets in building.
- D. Approval: If the disinfection certification or bacteriological analysis report does not satisfy the above minimum requirements, the entire disinfection and testing procedure must be repeated. Under no circumstances shall the contractor permit the use of any portion of the domestic water systems until disinfection and testing results have been accepted by the Engineer.

3.02 CLOSED LOOP HYDRONIC WATER SYSTEMS (CHS, CHR, HS, HR)

- A. Scope of Work:
 - 1. Flush, clean/degrease, passivate, and chemically treat closed loop hydronic water piping systems immediately after pressure testing
 - 2. Provide flushing pipe connections where required for this work.
 - 3. At completion of procedure install threaded caps at flushing fittings.
- B. Cleaning of Piping Systems:
 - 1. Flush piping with domestic water supplied at flushing fittings and drain completely.
 - 2. Clean strainers.
 - 3. Furnish a temporary circulating pump and connect at flushing fittings.
 - 4. Fill piping system with clean water and add Pipe System Pre-Cleaner at a proportion of 1 pound per 50 gallons, or as directed by chemical manufacturer.
 - 5. Circulate Pipe System Pre-Cleaner solution for minimum of 4 hours.

6. Remove temporary pump, thoroughly flush piping system with domestic water, and drain completely.
 7. Clean strainers.
- C. System Passivation:
1. Fill piping system with clean water and add Water System Conditioner at chemical pot feeder to a proportion of 500-1000 ppm.
 2. Using system pump, circulate Water System Conditioner solution for minimum of 4 hours.
 3. Drain piping system completely.
 4. Clean strainers.
- D. System Chemical Treatment:
1. Fill piping system with clean water.
 2. Using system pump, circulate water while venting air from piping system. Add make up water as required.
 3. Add Corrosion Inhibitor at chemical pot feeder to a proportion of 800-1200 ppm.
 4. Operate system pumps circulating solution for minimum 24 hours.
 5. Take sampling of system water and test Corrosion Inhibitor concentration. If found outside specified range, add Corrosion Inhibitor as required.
 6. Record makeup water meter reading.
 7. Retest Corrosion Inhibitor concentration monthly for period of one year, recording makeup water meter reading each time. If concentration is found outside specified range, add Corrosion Inhibitor as required.

END OF SECTION

SECTION 230700

DUCTWORK INSULATION

PART 1 GENERAL

1.01 RELATED SECTIONS

- A. Section 201000 - General Mechanical Provisions
- B. Section 202000 - Mechanical Operation and Maintenance Manuals

1.02 QUALITY ASSURANCE

- A. Products shall have flame spread and smoke developed ratings based on test procedures in accordance with NFPA-255 and UL-723. Ratings shall be indicated on the product or on the shipping cartons.
- B. Unless otherwise specified herein, products shall have flame spread ratings not to exceed 25 and smoke developed ratings not to exceed 50.
- C. Products shall comply with the requirements of Oregon Revised Statute (ORS) 453.005 (7) (e), effective January 1, 2011. The referenced statute limits the use of three types of brominated fire retardant chemicals, which are defined as hazardous substances.

1.03 SHOP DRAWINGS, PRODUCT DATA, OPERATION & MAINTENANCE DATA

- A. Submittals required for the products listed in the Product Table, in accordance with Section 201000. Operation & Maintenance Information required as indicated in the Product Table in accordance with Section 202000.
- B. Operation & Maintenance Information requirements indicated by number designation as follows. Refer to Section 202000 for a description of each type of information.
 - 1. Shop Drawings (submittal data)
 - 2. Product Data (submittal data), including documentation of ORS 453.005 (7) (e) compliance.
 - 3. Manufacturer's Operation Manuals
 - 4. Manufacturer's Service and Lubrication Requirements
 - 5. Service Contracts and Field Start-up Reports
 - 6. Cleaning, Certification, and Test Reports
 - 7. System Information
 - 8. Warranties

PRODUCT TABLE	Operation & Maintenance Information							
	1	2	3	4	5	6	7	8
Duct Insulation		X				X		
Accessories		X						

PART 2 PRODUCTS

2.01 DUCT INSULATION

- A. Fiberglass Blanket with Vapor Barrier:
 - 1. Type: Flexible blanket with factory applied vapor barrier facing.
 - 2. Conductivity ("k"): Not to exceed 0.30 at 100 degrees F mean temperature.

3. Facing: Laminated aluminum foil, glass scrim, and kraft paper vapor barrier; with 2 inch sealing flap.
 4. Facing Permeability: Not to exceed 0.04 perms.
 5. Manufacturer and Model: Johns Manville, Certain Teed, Knauf, Owens Corning, or approved, equal to Manville "Microlite FSK".
- B. Flexible Duct Liner:
1. Type: Flexible fiberglass liner in roll form with black mat coating exposed to airstream.
 2. Noise Reduction Coefficient: Not less than 0.7, in accordance with ASTM C-423-81a.
 3. Conductivity ("k"): Not to exceed 0.24 at 75 degrees F mean temperature.
 4. Maximum Service Velocity: Not less than 4,000 feet per minute.
 5. Manufacturer: CertainTeed, Knauf, Owens Corning, Johns Manville, or approved. Similar to Johns Manville "Duct Liner PM."
- C. Rigid Duct Board:
1. Type: Rigid board with factory applied vapor barrier facing.
 2. Conductivity ("k"): Not to exceed 0.31 at 100 degrees F mean temperature.
 3. Facing: Laminated aluminum foil, glass scrim, and kraft paper vapor barrier; with 2 inch sealing flap.
 4. Facing Permeability: Not to exceed 0.04 perms.
 5. Manufacturer: Johns Manville Series 800 FSK or approved.
- D. Elastomeric Foam:
1. Type: Flexible, closed cell, Elastomeric sheet.
 2. Conductivity ("k"): Not to exceed 0.27 at 75 degrees F mean temperature.
 3. Flame Spread Rating: Not to exceed 25.
 4. Smoke Developed Rating: Not to exceed 50.
 5. Approved Manufacturer: Armstrong SA duct liner.

2.02 ACCESSORIES

- A. Mastic, Coatings, Tapes, and Adhesives: Comply with manufacturer's installation instructions for each type of insulation.
- B. Weld Pins:
1. Type: Retainer disk attached to pin, for resistance welding to duct surface after liner is in place.
 2. Retainer Disk: Not less than 0.75 square inches.
 3. Pin: 0.1 inch shorter than liner thickness. Pins shall not protrude into airstream.
 4. Manufacturer: Similar to Duro-Dyne "CP Series Clip-Pins."
- C. Stick Pins:
1. Type: Perforated base with protruding pin, for gluing to duct surface prior to application of liner.
 2. Pin: 0.25 inches longer than liner thickness.
 3. Self-locking Washer: Attaches to pin after application of liner.
 4. Manufacturer: Similar to Gemco series PH.

PART 3 EXECUTION

3.01 GENERAL

- A. Prior to installation of insulation, verify that:
1. Ductwork has been tested and approved.
 2. Duct seams have been sealed.

3. Duct surfaces are clean and dry.
- B. Do not insulate the following:
 1. Pre-insulated underground ducts.
 2. Ducts constructed of fiberglass duct board, unless otherwise noted.
 3. Duct access doors. Tape insulation to duct around duct access door
- C. Install products in accordance with manufacturer's recommendations.
- D. Install products in accordance with MICA (Midwest Insulation Contractors Association) - National Commercial & Industrial Insulation Standards.
- E. Definitions:
 1. Outside Air Ducts: Ducts conveying untempered outside air.
 2. Conditioned space: An area or room within a building being heated or cooled, containing uninsulated ducts, or with a fixed opening directly into an adjacent conditioned space.

3.02 FIBERGLASS BLANKET INSULATION WITH VAPOR BARRIER

- A. Fully wrap duct, with facing to the outside.
- B. Overlap vapor barrier facing 2 inches minimum at seams and joints.
- C. Seal all seams, joints, and penetrations with foil-faced pressure sensitive tape of same material as insulation facing, to provide a continuous vapor barrier.
- D. On ducts 24 inches or more in width, secure insulation on underside of ducts with stick pins 18 inches maximum on center, 6 inches minimum from edges of duct. Cut pins off flush with washer and seal with vapor barrier tape.

3.03 DUCT LINER

- A. Apply 100 percent coverage of approved adhesive to inside of duct.
- B. Cover interior of duct with liner, with mat coating of liner toward the airstream.
- C. Seams and joints shall be neatly butted, with edges coated with adhesive.
- D. Coat leading edges with adhesive or provide liner with factory-applied edge coating.
- E. Install weld pins, spaced according to liner manufacturer's instructions, not greater than 18 inches on center or greater than 3 inches from any edge.
- F. Weld pins shall be resistance welded to duct with a machine similar to Duro-Dyne "Pinspotter."

3.04 APPLICATION TO DUCT SYSTEMS

- A. Supply Air Ducts Located in Conditioned Spaces, Except Ducts with Duct Liner:
 1. Insulation Type: Fiberglass Blanket with Vapor Barrier.
 2. Insulation Thickness: 1.5 inches.
- B. Supply Air Ducts, Inside Building, Outside of building insulation envelope, Except Ducts with Duct Liner:
 1. Insulation Type: Fiberglass Blanket with Vapor Barrier:
 2. Insulation Value as Installed: R-5 minimum.
 3. Insulation Thickness: 1-1/2 inches.
- C. Supply Air Ducts, With Duct Liner, Located in Conditioned Spaces:
 1. Insulation Type: Duct Liner.
 2. Insulation Thickness: 1 inch.

- D. Return Air Ducts, Inside Building, Outside of building insulation envelope, Except Ducts with Duct Liner:
 - 1. Insulation Type: Fiberglass Blanket with Vapor Barrier.
 - 2. Insulation Value as Installed: R-5 minimum
 - 3. Insulation Thickness: 1-1/2 inches.
- E. Return Air Ducts, With Duct Liner, Located in Conditioned Spaces:
 - 1. Includes ducts indicated on Drawings to have liner.
 - 2. Insulation Type: Duct Liner.
 - 3. Insulation Thickness: 1 inch.
- F. Outside Air Intake Ducts, Located in Conditioned Spaces:
 - 1. Insulation Type: Fiberglass Blanket with Vapor Barrier.
 - 2. Insulation Thickness: 1.5 inches.
- G. Exhaust Air Ducts, With Duct Liner, Inside Building:
 - 1. Includes ducts indicated on Drawings to have liner.
 - 2. Insulation Type: Duct Liner.
 - 3. Insulation Thickness: 1 inch.
- H. Plenums:
 - 1. In built-up plenums for outside air and exhaust air:
 - a. Option 1: Duct liner on top and side walls, external ductboard insulation on bottom of plenum.
 - b. Option 2: Internal elastomeric foam insulation.
 - c. Thickness and installed R-value: as specified for connected ductwork.

END OF SECTION

SECTION 230900**CONTROLS****PART 1 GENERAL****1.01 RELATED SECTIONS**

- A. Section 201000 - General Mechanical Provisions
- B. Section 202000 - Mechanical Operation and Maintenance Manuals
- C. Section 205200 - Variable Frequency Drives
- D. Section 206000 - Mechanical Identification
- E. Section 209100 - Testing, Adjusting, and Balancing
- F. Section 231000 - Controls Sequence of Operations
- G. Section 233600 - Air Terminal Units
- H. Section 237200 - Heat Recovery Units
- I. Section 237300 - Air Handling Units
- J. Section 238110 - Split System Air Conditioning Units

1.02 WORK INCLUDED

- A. Building Automation System (BAS) Contractor shall provide and install: A fully integrated Building System (BAS), incorporating direct digital control (DDC) for energy management, equipment monitoring and control, and subsystems with open communications capabilities as herein specified.
- B. Provide engineering, installation, calibration, software, software programming, and checkout for complete and fully operational BAS. The following shall be included:
 - 1. Prepare individual hardware layouts, interconnection drawings, and software configuration from project design data.
 - 2. Implement the detailed design for analog and binary objects, system databases, graphic displays, logs, and management reports based on control descriptions, logic drawings, configuration data, and bid documents.
 - 3. Design, provide, and install equipment cabinets, panels, data communication network cables needed, and associated hardware.
 - 4. Electronic controls for items indicated on Drawings and described hereinafter including sensors, switches, relays, transformers, thermostats, temperature sensors, control panels and central processing hardware and software.
 - 5. Graphics programming for systems and functions indicated and required. Include integration of new system and updating building floor plans with Owner's existing campus system and graphics standards.
 - 6. Install interconnecting cables between supplied cabinets, application controllers, and input/output devices.
 - 7. Removal of all vestiges of existing pneumatic controls components and peripherals, including, but not limited to the following: compressed air tubing, thermostats, switches, pneumatic controllers, and damper operators. Not all components which must be removed are indicated on drawings.
 - 8. Provide complete manufacturer's specifications for items that are supplied. Include vendor name of every item supplied.

9. Provide supervisory specialists and technicians at the job site to assist in each phase of system installation, startup, and commissioning.
10. A comprehensive operator and technician training program as described herein.
11. As-built documentation, operator's terminal software, diagrams, and other associated project operational documentation (such as technical manuals) on approved media, the sum total of which accurately represents the final system.
12. New sensors, dampers, valves, and install only new electronic actuators. No used components shall be used as any part or piece of installed system.
13. Adjustment and validation of control system. System testing. System demonstration to Mechanical Engineer and Owner's Representative.
14. No gateways shall be used for communication to controllers installed under this section. Gateways may be used for communication to existing systems or to systems installed under other sections.

1.03 WORK BY OTHERS

- A. Installation of wells, valves, taps, dampers, flow switches, flow stations, etc. furnished by BAS manufacturer.
- B. Provided under Division 26:
 1. Wiring of power feeds to disconnects where starters or VFD's are furnished as an integral part of equipment.
 2. Wiring between disconnects and starters to electrical motors and variable speed drives where starters or drives are not an integral part of equipment.

1.04 SYSTEM DESCRIPTION

- A. System shall use the BACnet protocol for communication to the operator workstation or web server and for communication between control modules. BACnet protocol shall be ANSI/ASHRAE Standard 135-2004 or higher. This system will control mechanical equipment, including unitary equipment such as VAV terminal units, heat pumps, fan coils, AC units, etc. and air handlers, boilers, chillers, and any other listed equipment using native BACnet compliant components. Non BACnet compliant or proprietary equipment or systems (including gateways) shall not be acceptable and are specifically prohibited.
- B. The control system shall consist of a high-speed, peer-to-peer network of DDC controllers and a web-based operator interface. Depict each mechanical system and building floor plan by a point-and-click graphic. A web server with a network interface card shall gather data from this system and generate web pages accessible through a conventional web browser on each PC connected to the network. Operators shall be able to perform all normal operator functions through the web browser interface.
- C. The system shall directly control HVAC equipment as specified in Section 231000 – Controls Sequence of Operations. Furnish energy conservation features such as optimal start and stop, night setback, request-based logic, and demand level adjustment of setpoints as specified in the sequence.
- D. Building controllers shall include complete energy management software, including scheduling building control strategies with optimum start and logging routines. Energy management software and firmware shall be resident in field hardware and shall not be dependent on the operator's terminal. Operator's terminal software is to be used for access to field-based energy management functions only. Provide zone-by-zone direct digital logic control of space temperature, scheduling, runtime accumulation, equipment alarm reporting, and override timers for after-hours usage.

- E. Schedules, I/O points, setpoints, trends, and alarms specified in Section 231000 - "Controls Sequence of Operations" shall be BACnet objects.
- F. Application specific controllers for each equipment type (VAV Terminal Unit), air handler, central plant equipment, and any other piece of controlled equipment shall be fully programmable. Application specific controllers shall be mounted near the controlled equipment.

1.05 APPROVED CONTROL SYSTEMS AND VENDORS

- A. Direct Digital Control system components and shall be as manufactured, designed, and installed by: JCI, installed by local or regional factory branch.
- B. The above list is alphabetical and does not indicate preference. Inclusion on this list does not guarantee acceptance of products or installation. Control systems shall comply with the terms of this specification.
 - 1. The Contractor shall use only operator workstation software, controller software, custom application programming language, and controllers from the corresponding manufacturer and product line unless Owner approves use of multiple manufacturers.
 - 2. Other products specified herein (such as sensors, valves, dampers, and actuators) need not be manufactured by the above manufacturers.

1.06 QUALITY ASSURANCE

- A. The BAS system shall be designed and installed, commissioned and serviced by manufacturer factory trained personnel employed manufacturer or manufacturer representative. Manufacturer shall have an in-place support facility within 2 hours response time of the site with technical staff, spare parts inventory and necessary test and diagnostic equipment. Distributors or licensed installing contractors are not acceptable.
- B. Materials and equipment shall be the catalogued products of manufacturers regularly engaged in production and installation of automatic temperature control systems and shall be manufacturer's latest standard design that complies with the specification requirements.
- C. BAS peer-to-peer network controllers, central system controllers and local user displays shall be UL Listed under Standard UL 916, category PAZX.
- D. Electronic equipment shall conform to the requirements of FCC Regulation, Part 15, Governing Radio Frequency Electromagnetic Interference and be so labeled.

1.07 REFERENCE STANDARDS

- A. The latest edition of the following standards and codes in effect and amended as of supplier's proposal date, and any applicable subsections thereof, shall govern design and selection of equipment and material supplied:
 - 1. American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE).
 - 2. ANSI/ASHRAE Standard 135-2004, BACnet.
 - 3. International Building Code (IBC), 2009, including local amendments.
 - 4. UL 916 Underwriters Laboratories Standard for Energy Management Equipment. Canada and the US.
 - 5. National Electrical Code (NEC).
 - 6. FCC Part 15, Subpart J, Class A
 - 7. EMC Directive 89/336/EEC (European CE Mark)
 - 8. UL-864 UUKL listing for Smoke Controls for any equipment used in smoke control sequences
- B. City, county, state, and federal regulations and codes in effect as of contract date.

PRODUCT TABLE	Operation & Maintenance Information							
	1	2	3	4	5	6	7	8
Index sheet, listing contents in alphabetical order							X	
Trunk cable schematic showing remote electronic panel locations, and trunk data.							X	
List of connected data points, including panels to which they are connected and input device (detector, thermostat, etc.)							X	
Software programming literature.							X	
Conduit routing diagrams							X	

1.09 TRAINING

- A. Contractor shall provide training in operation, maintenance, and programming of DDC system for Owner Designated Personnel. Training shall be presented by factory trained instructor, provided through installing control system manufacturer, to give full instruction to designated personnel in operation of system installed. Instructors shall be thoroughly familiar with subject matter they are to teach. Training shall conform to, and include, the following:
 - 1. Provide 24 hours of training for Owner’s designated operating personnel.
 - 2. Students shall be provided with binder containing product and system specific training modules for system installed. Minimum of one copy per student plus one extra copy.
 - 3. Training shall be held during normal working hours of 8:00 am to 4:30 PM weekdays, on dates and times as selected by Owner.
 - 4. Explanation of drawings, operations and maintenance manuals.
 - 5. Walk-through of job to locate control components.
 - 6. Operator workstation and peripherals.
 - 7. DDC controller and ASC operation/function.
 - 8. Operator control functions including graphic generation and field panel programming.
 - 9. Operation of portable operator’s terminal.
 - 10. Explanation of adjustment, calibration and replacement procedures.
- B. Provide for video recording of full extent of Training sessions. Provide two copies of recorded sessions to Owner in DVD format.
- C. Since Owner may require personnel to have more comprehensive understanding of hardware and software, additional training must be available from the Contractor. If such training is required by Owner, it will be contracted at a later date.
- D. Provide application engineer to instruct owner in operation of systems and equipment.
- E. Provide system operator’s training to include (but not limited to) such items as the following: modification of data displays, alarm and status descriptors, requesting data, execution of commands and request of logs.

1.10 WARRANTY

- A. Warranty shall cover costs for parts, labor, associated travel, and expenses for a period of one year from completion of system acceptance.
- B. Hardware and software personnel supporting this warranty agreement shall provide on-site or off-site service in a timely manner after failure notification to the vendor. The maximum acceptable response time to provide this service at the site shall be 24 hours Monday through Friday, 48 hours on Saturday and Sunday. Factory authorized warranty service shall be available on site within 4 hours of a call for service.

- C. This warranty shall apply equally to both hardware and software.
- D. Warrant labor and materials for specified control system free from defects for a period of 24 months after final acceptance. Failures on control systems that include all computer equipment, transmission equipment and all sensors and control devices during warranty period shall be adjusted, repaired, or replaced at no additional cost or reduction in service to Owner.
- E. Work shall have a single warranty date, even if Owner receives beneficial use due to early system start-up. If specified work is split into multiple contracts or a multi-phase contract, each contract or phase shall have a separate warranty start date and period.
- F. Provide upgrades and updates to operator workstation software, project-specific software, graphic software, database software, and controller firmware at no additional charge during warranty period. Do not install upgrades or updates without Owner's authorization.

PART 2 PRODUCTS

2.01 GENERAL

- A. The Building Management System (BMS) shall use an open architecture and fully support a multi-vendor environment. To accomplish this effectively, the BMS shall not be limited to a single open communication protocol standard, but to also integrate a wide variety of third-party devices and applications via additional protocols and through the latest software standards. The system shall be designed for use on the Internet, or intranets using off the shelf, industry standard technology compatible with other owner provided networks.
- B. The Building Management System shall consist of the following:
 - 1. Standalone Network Automation Engine(s)
 - 2. DDC Controllers (unitary, etc.)
 - 3. Distributed User Interfaces
 - 4. Network processing, data storage and communications equipment
 - 5. Other components required for a complete and working BMS
- C. The system shall be modular in nature, and shall permit expansion of both capacity and functionality through the addition of sensors, actuators, controllers and operator devices, while re-using existing controls equipment.
- D. System architectural design shall eliminate dependence upon any single device for alarm reporting and control execution. The failure of any single component or network connection shall not interrupt the execution of control strategies at other operational devices.

2.02 BMS ARCHITECTURE

- A. Automation Network:
 - 1. The automation network shall be based on a PC industry standard of Ethernet TCP/IP. Where used, LAN controller cards shall be standard "off the shelf" products available through normal PC vendor channels.
 - 2. The BMS shall network multiple user interface clients, automation engines, system controllers and application-specific controllers. Provide application and data server(s) as required for systems operation.
 - 3. The automation network shall be capable of operating at a communication speed of 100 Mbps, with full peer-to-peer network communication.
 - 4. Network Control Engines (NCE) shall reside on the automation network.
 - 5. The automation network will be compatible with other enterprise-wide networks. Where indicated, the automation network shall be connected to the enterprise network and share resources with it by way of standard networking devices and practices.

- B. Control Network:
 - 1. Network Automation Engines shall provide supervisory control over the control network and shall support the Bacnet communication protocol:
 - 2. Control networks shall provide either “Peer-to-Peer,” Master-Slave, or Supervised Token Passing communications, and shall operate at a minimum communication speed of 9600 baud.
 - 3. DDC Controllers shall reside on the control network.
- C. Integration:
 - 1. Hardwired:
 - a. Analog and digital signal values shall be passed from one system to another via hardwired connections.
 - b. There will be one separate physical point on each system for each point to be integrated between the systems.
 - 2. Direct Protocol (Integrator Panel):
 - a. The BMS system shall include appropriate hardware equipment and software to allow bi-directional data communications between the BMS system and 3rd party manufacturers’ control panels. The BMS shall receive, react to, and return information from multiple building systems, including but not limited to the boilers.
 - b. Data required by the application shall be mapped into the Automation Engine’s database, and shall be transparent to the operator.
 - c. Point inputs and outputs from the third party controllers shall have real time interoperability with BMS software features such as: Control Software, Energy Management, Custom Process Programming, Alarm Management, Historical Data and Trend Analysis, Totalization, and Local Area Network Communications.

2.03 USER INTERFACE

- A. Web Based User Interface:
 - 1. All features and functions of the dedicated user interface previously defined in this document shall be available on any computer connected directly or via a wide area or virtual private network (WAN/VPN) to the automation network.
 - 2. Provide Owner with required setup information for system monitoring on a designated computer or workstation.
- B. User Interface Application Components:
 - 1. Operator Interface:
 - a. An integrated browser based client application shall be used as the user operator interface program.
 - b. Inputs, Outputs, Setpoints, and all other parameters as defined within Part 3, shown on the design drawings, or required as part of the system software, shall be displayed for operator viewing and modification from the operator interface software.
 - c. The user interface software shall provide help menus and instructions for each operation and/or application.
 - d. Controller software operating parameters shall be displayed for the operator to view/modify from the user interface. These include setpoints, alarm limits, time delays, PID tuning constants, run-times, point statistics, schedules, and so forth.
 - e. The Operator Interface shall incorporate comprehensive support for functions including, but not necessarily limited to, the following:
 - 1) User access for selective information retrieval and control command execution
 - 2) Monitoring and reporting
 - 3) Alarm, non-normal, and return to normal condition annunciation
 - 4) Selective operator override and other control actions

- 5) Information archiving, manipulation, formatting, display and reporting
 - 6) FMS internal performance supervision and diagnostics
 - 7) On-line access to user HELP menus
 - 8) On-line access to current FMS as-built records and documentation
 - 9) Means for the controlled re-programming, re-configuration of FMS operation and for the manipulation of FMS database information in compliance with the prevailing codes, approvals and regulations for individual FMS applications.
- f. The operation of the control system shall be independent of the user interface, which shall be used for operator communications only. Systems that rely on an operator workstation to provide supervisory control over controller execution of the sequences of operations or system communications shall not be acceptable.
2. Navigation Trees:
- a. The system will have the capability to display multiple navigation trees that will aid the operator in navigating throughout all systems and points connected. At minimum provide a tree that identifies all systems on the networks.
 - b. Provide the ability for the operator to add custom trees. The operator will be able to define any logical grouping of systems or points and arrange them on the tree in any order. It shall be possible to nest groups within other groups. Provide at minimum 5 levels of nesting.
 - c. The navigation trees shall be “dockable” to other displays in the user interface such as graphics. This means that the trees will appear as part of the display, but can be detached and then minimized to the Windows task bar or closed altogether. A simple keystroke will reattach the navigation to the primary display of the user interface.
3. Alarms:
- a. Alarms shall be routed directly from Network Automation Engines to PC. It shall be possible for specific alarms from specific points to be routed to specific PCs and servers. The alarm management portion of the user interface shall, at the minimum, provide the following functions:
 - 1) Log date and time of alarm occurrence.
 - 2) Generate a “Pop-Up” window, with audible alarm, informing a user that an alarm has been received.
 - 3) Allow a user, with the appropriate security level, to acknowledge, temporarily silence, or discard an alarm.
 - 4) Provide an audit trail on hard drive for alarms by recording user acknowledgment, deletion, or disabling of an alarm. The audit trail shall include the name of the user, the alarm, the action taken on the alarm, and a time/date stamp.
 - 5) Provide the ability to direct alarms to an e-mail address or cell phone. This must be provided in addition to the pop up window described above. Systems that use e-mail and cell phone as the exclusive means of annunciating alarms are not acceptable.
 - 6) Any attribute of any object in the system may be designated to report an alarm.
 - 7) The FMS shall annunciate diagnostic alarms indicating system failures and non-normal operating conditions
 - 8) The FMS shall annunciate application alarms at minimum, as required by Part 3.
4. Reports and Summaries:
- a. Reports and Summaries shall be generated and directed to the user interface displays, with subsequent assignment to printers, or disk. As a minimum, the system shall provide the following reports:
 - 1) All points in the BMS
 - 2) All points in each BMS application

- 3) All points in a specific controller
 - 4) All points in a user-defined group of points
 - 5) All points currently in alarm
 - 6) All points locked out
 - 7) All BMS schedules
 - 8) All user defined and adjustable variables, schedules, interlocks and the like.
 - 9) Summaries and Reports shall be accessible via standard UI functions and not dependent upon custom programming or user defined HTML pages.
 - 10) Selection of a single menu item, tool bar item, or tool bar button shall print any displayed report or summary on the system printer for use as a building management and diagnostics tool.
 - 11) The system shall allow for the creation of custom reports and queries via a standard web services XML interface and commercial off-the-shelf software such as Microsoft Access or Microsoft Excel.
5. Schedules:
- a. A graphical display for time-of-day scheduling and override scheduling of building operations shall be provided. At a minimum, the following functions shall be provided:
 - 1) Weekly schedules
 - 2) Exception Schedules
 - 3) Monthly calendars.
 - b. Weekly schedules shall be provided for each group of equipment with a specific time use schedule.
 - c. It shall be possible to define one or more exception schedules for each schedule including references to calendars
 - d. Monthly calendars shall be provided that allow for simplified scheduling of holidays and special days for a minimum of five years in advance. Holidays and special days shall be user-selected with the pointing device or keyboard, and shall automatically reschedule equipment operation as previously defined on the exception schedules.
 - e. Changes to schedules made from the User Interface shall directly modify the Network Automation Engine schedule database.
 - f. Selection of a single menu item or tool bar button shall print any displayed schedule on the system printer for use as a building management and diagnostics tool.
6. Password:
- a. Multiple-level password access protection shall be provided to allow the user/manager to user interface control, display, and database manipulation capabilities deemed appropriate for each user, Based on an assigned password.
 - b. Each user shall have the following: a user name (24 characters minimum), a password (12 characters minimum), and access levels.
 - c. The system shall allow each user to change his or her password at will.
 - d. When entering or editing passwords, the system shall not echo the actual characters for display on the monitor.
 - e. A minimum of five levels of access shall be supported individually or in any combination as follows:
 - 1) Level 1 = View Data
 - 2) Level 2 = Command
 - 3) Level 3 = Operator Overrides
 - 4) Level 4 = Database Modification
 - 5) Level 5 = Database Configuration
 - 6) Level 6 = All privileges, including Password Add/Modify
 - f. A minimum of 100 unique passwords shall be supported.

- C. Each Automation Engine shall have the capability to store multiple samples for each physical point and software variable based upon available memory, including an individual sample time/date stamp. Points may be assigned to multiple history trends with different collection parameters.
- D. Trend and change of value data shall be stored within the engine and exports shall be as requested by the user.
 - 1. Trend data viewing and analysis:
 - a. Provide a trend viewing utility that shall have access to all database points.
 - b. It shall be possible to retrieve any historical database point for use in displays and reports by specifying the point name and associated trend name.
 - c. The trend viewing utility shall have the capability to define trend study displays to include multiple trends
 - d. Displays shall be able to be single or stacked graphs with on-line selectable display characteristics, such as ranging, color, and plot style.
 - e. Display magnitude and units shall both be selectable by the operator at any time without reconfiguring the processing or collection of data. This is a zoom capability.
 - f. Display magnitude shall automatically be scaled to show full graphic resolution of the data being displayed.
 - g. Trend studies shall be capable of calculating and displaying calculated variables including highest value, lowest value and time based accumulation.

2.04 BUILDING CONTROLLER

- A. General Requirements:
 - 1. Building Controller shall be of modular construction such that various modules may be selected to fit the specific requirements of a given project. Modules shall consist of a power supply module, a BACnet Ethernet-MS/TP module, a BACnet MS/TP only module and a modem module for telephone communication as a minimum. Ethernet communications and controllers including central plant controllers, advanced application specific controllers and unitary controllers supplied by BMS manufacturer shall utilize the BACnet protocol standard.
 - 2. Modules shall be selected to fit the particular project application. Up to 7 modules shall be powered by a single power supply module. Modules shall be panel mounted on DIN rail for ease of addition and shall be interconnected via simple plug in cable. A module in the middle shall be replaceable without removing any other modules.
 - 3. Modules shall be capable of providing global control strategies for the system based on information from any objects in the system regardless if the object is directly monitored by the building controller module or by another controller. The software program implementing these strategies shall be completely flexible and user definable. Software tools necessary for programming shall be provided as part of project software. Any systems utilizing factory pre-programmed global strategies that cannot be modified by field personnel on-site, via a wide area network or downloaded via remote communications are not acceptable. Changing global strategies via firmware changes is also unacceptable.
 - 4. Programming shall be object-oriented using control function blocks, supporting DDC functions, 1000 Analog Values and 1000 Binary Values. Flowcharts shall be generated and automatically downloaded to controller. Programming tool shall be supplied and be resident on workstation. The same tool shall be used for controllers.
 - 5. Provide means to graphically view inputs and outputs to each program block in real-time as program is executing. This function may be performed via the operator's workstation or field computer.
 - 6. Controller shall have a memory needed to ensure high performance and data reliability.

- Battery shall provide power for orderly shutdown of controller and storage of data in nonvolatile flash memory. Battery backup shall maintain real-time clock functions for a minimum of 20 days.
7. Global control algorithms and automated control functions shall execute via 32-bit processor.
 8. Schedules:
 - a. Each building controller module shall support a minimum of 80 BACnet Schedule Objects and 80 BACnet Calendar Objects.
 - b. Building controller modules shall provide normal 7 day scheduling, holiday scheduling and event scheduling.
 9. Logging Capabilities:
 - a. Each building controller shall log as minimum 320 values. Any object in the system (real or calculated) may be logged. Sample time interval shall be adjustable at the operator's workstation.
 - b. Logs may be viewed both on-site and off-site via WAN or remote communication.
 - c. Building controller shall periodically upload trended data to networked operator's workstation for long term archiving if desired.
 - d. Archived data stored in database format shall be available for use in third-party spreadsheet or database programs.
 10. Alarm Generation:
 - a. Alarms may be generated within the system for any object change of value or state either real or calculated. This includes things such as analog object value changes, binary object state changes, and various controller communication failures.
 - b. Each alarm may be dialed out as noted elsewhere.
 - c. Alarm log shall be provided for alarm viewing. Log may be viewed on-site at the operator's terminal or off-site via remote communications.
 - d. Controller must be able to handle up to 320 alarm setups stored as BACnet event enrollment objects – system destination and actions individually configurable.
 11. Activity Logging:
 - a. Tenant Activity logging shall be supported by Building Controller Module. Each independent module shall support a minimum of 80 zones.
 - b. Tenant Activity logging shall functions as defined in section 2.1.K of this specification.
 12. Standard BACnet object types supported shall include as a minimum: Analog Value, Binary Value, Calendar, Device, File, Group, Notification Class, Program and Schedule object types. Proprietary object types, if used in the system, shall be thoroughly documented and provided as part of the submittal data. Necessary tools shall be supplied for working with proprietary information.
 13. The Building Controller shall comply with Annex J of the BACnet specification for IP connections. This device shall use Ethernet to connect to the IP internetwork, while using the same Ethernet LAN for non-IP communications to other BACnet devices on the LAN. Must support interoperability on wide area networks (WANs) and campus area networks (CANs) and function as a BACnet Broadcast Management Device (BBMD).
 14. Refer to section 22.2, BACnet Functional Groups, and Annex L in the BACnet standard for a complete list of the services that must be directly supported to provide each of the functional groups listed above. Proprietary services, if used in the system, shall be thoroughly documented and provided as part of the submittal data. Necessary tools shall be supplied for working with proprietary information.
 - a. BACnet Conformance: Device shall communicate directly via these BACnet LANs as a native BACnet device and shall support simultaneous routing functions between supported LAN types. Global controller shall be BTL Certified BACnet B-BC profile.

Including BACnet services necessary to provide the following BACnet functional groups:

- 1) Clock Functional Group
- 2) Files Functional Group
- 3) Reinitialize Functional Group
- 4) Device Communications Functional Group
- 5) Event Initiation Functional Group

B. Ethernet – MS/TP Module:

1. Ethernet – MS/TP Module shall support every function as listed under paragraph A, General Requirements, of this section and the following.
2. Communication with operator workstation and application specific controllers shall be via BACnet. Building controller Ethernet – MS/TP module shall incorporate as a minimum, the functions of a 2-way BACnet router. Controller shall route BACnet messages between the high-speed LAN (Ethernet 10/100MHz) and master slave token passing (MS/TP) LAN. Ethernet – MS/TP module shall also route messages from other Building Controller modules onto the BACnet Ethernet network.
 - a. MS/TP LAN must be software configurable from 9.6 to 76.8Kbps.
 - b. The RJ-45 Ethernet connection must accept either 10Base-T or 100Base-TX BACnet over twisted pair cable (UTP).
 - c. Ethernet – MS/TP module shall as a minimum support MS/TP and Ethernet BACnet LAN types.

C. MS/TP Module:

1. MS/TP Module shall support every function as listed under paragraph A, General Requirements, of this section and the following.
2. Building Controller MS/TP module communications shall be via BACnet master slave token passing (MS/TP) LAN to advanced application and application specific controllers. MS/TP module shall also route messages to Ethernet-MS/TP module for communication over WAN.
 - a. MS/TP LAN must be software configurable from 9.6 to 76.8Kbps
 - b. Configuration shall be via RS-232 connection.
 - c. MS/TP module shall as a minimum support MS/TP BACnet LAN type.

D. Power Supply Module:

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

2.05 EXPANDABLE CENTRAL PLANT APPLICATION CONTROLLERS

A. General:

1. Expandable application controller shall be capable of providing control strategies for the system based on information from any or connected inputs. The program that implements these strategies shall be completely flexible and user definable. Any systems utilizing factory pre-programmed global strategies that cannot be modified by field personnel on-site via simple download are not acceptable. Changing global strategies via firmware changes is also unacceptable. Program execution of controller shall be a minimum of once per second.
2. Programming shall be object-oriented using control program blocks. Controller shall support a minimum of 500 Analog Values and 500 Binary Values. Each and every analog

and binary value shall support standard BACnet priority arrays. Programming tool shall be provided with system and shall be the same tool that is used to program the Building Controller. Flowcharts shall be generated and automatically downloaded to controller. No re-entry of database information shall be necessary.

3. Provide means to graphically view inputs and outputs to each program block in real-time as program is executing. This function may be performed via the operator's terminal or field computer.
4. Controller shall have adequate data storage to ensure high performance and data reliability. Battery shall retain static RAM memory and real-time clock functions for a minimum of 1.5 years (cumulative). Battery shall be a field-replaceable (non-rechargeable) lithium type. Unused battery life shall be 10 years.
5. The onboard, battery-backed real time clock must support schedule operations and trend logs.
6. Global control algorithms and automated control functions should execute via 32-bit processor.
7. Controller shall include both on-board 10BASE-T/100BASE-TX Ethernet BACnet communications over twisted pair cable (UTP) and shall include BACnet IP communication. In addition, controller shall include BACnet PTP connection port.
8. The base unit of the controller shall host up to 8 expansion modules with various I/O combinations. These inputs and outputs shall include universal 12-bit inputs, binary triac outputs, and 8-bit switch selectable analog outputs (0-10V or 0-20 mA). Inputs shall support 3K and 10K thermistors, 0-5VDC, 0-10VDC, 4-20mA, dry contacts and pulse inputs directly.

B. BACnet Conformance:

1. Central Plant/AHU Controller shall as a minimum support Point-to-Point (PTP), MS/TP and Ethernet BACnet LAN types. It shall communicate directly via these BACnet LANs as a native BACnet device and shall support simultaneous routing functions between supported LAN types. Building controller shall be BTL Certified BACnet B-AAC profile. Including BACnet services necessary to provide the following BACnet functional groups support BACnet services necessary to provide the following BACnet functional groups:
 - a. Clock Functional Group
 - b. Files Functional Group
 - c. Reinitialize Functional Group
 - d. Device Communications Functional Group
 - e. Event Initiation Functional Group
2. Refer to section 22.2, BACnet Functional Groups, and Annex L in the BACnet standard for a complete list of the services that must be directly supported to provide each of the functional groups listed above. Necessary tools shall be supplied for working with proprietary information.
3. Standard BACnet object types supported shall include as a minimum: Analog Input, Binary Input, Analog Output, Binary Output, Analog Value, Binary Value, Device, File, Group, Event Enrollment, Notification Class, Program and Schedule object types. Necessary tools shall be supplied for working with proprietary information.
4. The Controller shall comply with Annex J of the BACnet specification for IP connections. This device shall use Ethernet to connect to the IP internetwork, while using the same Ethernet LAN for non-IP communications to other BACnet devices on the LAN. Must support interoperability on wide area networks (WANs) and campus area networks (CANs) and function as a BACnet Broadcast Management Device (BBMD).

C. Schedules:

1. Each Central Plant/AHU controller shall support a minimum of 50 BACnet Schedule

Objects.

D. Logging Capabilities:

1. Each controller shall support a minimum of 200 trend logs. Any object in the system (real or calculated) may be logged. Sample time interval shall be adjustable at the operator's workstation.
2. Controller shall periodically upload trended data to system server for long term archiving if desired.
3. Archived data stored in database format shall be available for use in third-party spreadsheet or database programs.

E. Alarm Generation:

1. Alarms may be generated within the system for any object change of value or state either real or calculated. This includes things such as analog object value changes, binary object state changes, and various controller communication failures.
2. Alarm log shall be provided for alarm viewing. Log may be viewed on-site at the operator's terminal or off-site via remote communications.
3. Controller must be able to handle up to 200 alarm setups stored as BACnet event enrollment objects – system destination and actions individually configurable.

2.06 CENTRAL PLANT AND AIR HANDLER APPLICATION CONTROLLERS

- A. Provide one or more native BACnet application controllers for each air handler and provide native BACnet application controllers as needed for central plant control that adequately cover objects listed in object list. Controllers shall interface to building controller via MS/TP LAN using BACnet protocol. No gateways shall be used. Controllers shall include input, output and self-contained logic program as needed for complete control of units. Controllers shall be fully programmable. Programming tool shall be resident on operator workstation and be the same tool as used for the building controller. No auxiliary or non-BACnet controllers shall be used.
- B. BACnet Conformance:
 1. Application controllers shall as a minimum support MS/TP BACnet LAN types. They shall communicate directly via this BACnet LAN at 9.6, 19.2, 38.4 and 76.8 Kbps, as native BACnet devices. Application controllers shall be BTL Certified BACnet B-ASC profile. Including BACnet services necessary to provide the following BACnet functional groups and support BACnet services necessary to provide the following BACnet functional groups:
 - a. Files Functional Group
 - b. Reinitialize Functional Group
 - c. Device Communications Functional Group
 2. Refer to section 22.2, BACnet Functional Groups, and Annex L in the BACnet standard, for a complete list of the services that must be directly supported to provide each of the functional groups listed above. Proprietary services, if used in the system, shall be thoroughly documented and provided as part of the submittal data. Necessary tools shall be supplied for working with proprietary information.
 3. Standard BACnet object types supported shall include as a minimum—Analog Input, Analog Output, Analog Value, Binary Input, Binary Output, Binary Value, Device, File, and Program object types. Proprietary object types, if used in the system, shall be thoroughly documented and provided as part of the submittal data. Necessary tools shall be supplied for working with proprietary information.
- C. Application controllers shall include universal inputs with 10-bit resolution that accept 3K and 10K thermistors, 0–10VDC, 0–5 VDC, 4–20 mA and dry contact signals. Any input on a controller may be either analog or digital with a minimum of 3 inputs that accept pulses.

Controller shall also include support and modifiable programming for interface to intelligent room sensor with digital display. Controller shall include binary and analog outputs on board. Analog outputs shall be switch selectable as either 0–10VDC or 0–20mA. Software shall include scaling features for analog outputs. Application controller shall include 24VDC voltage supply for use as power supply to external sensors.

- D. Program sequences shall be stored on board application controller in EEPROM or flash memory. No batteries shall be needed to retain logic program. Program sequences shall be executed by controller 10 times per second and capable of multiple PID loops for control of multiple devices. Calculations shall be completed using floating-point math and system shall support display of information in floating-point nomenclature at operator's terminal. Programming of application controller shall be completely modifiable in the field over installed BACnet LANs or remotely via modem interface. Operator shall program logic sequences by graphically moving function blocks on screen and tying blocks together on screen. Application controller shall be programmed using programming tools as described in operator's terminal section.
- E. Application controller shall include support for intelligent room sensors. Display on intelligent room sensor shall be programmable at application controller and include an operating mode and a field service mode. Button functions and display data shall be programmable to show specific controller data in each mode based on which button is pressed on the sensor. See sequence of operation for specific display requirements at intelligent room sensor.

2.07 APPLICATION SPECIFIC CONTROLLERS (HEAT PUMPS, AC UNITS, FAN COILS, UNIT VENTILATORS)

- A. Provide one native BACnet Application Specific Controller (ASC) for each piece of unitary mechanical equipment that adequately covers objects listed in object list for unit or a BACnet communicating programmable thermostat. Controllers shall interface to building controller via MS/TP LAN using BACnet protocol. No gateways shall be used. Controllers shall include input, output and self-contained logic program as needed for complete control of unit.
- B. BACnet Conformance:
 - 1. ASCs shall as a minimum support MS/TP BACnet LAN types and shall communicate directly via this BACnet LAN, as a native BACnet device. Application specific controllers shall be BTL Certified BACnet B-ASC profile. Including BACnet services necessary to provide the following BACnet functional groups and support BACnet services necessary to provide the following BACnet functional groups:
 - a. Files Functional Group
 - b. Reinitialize Functional Group
 - c. Device Communications Functional Group
 - 2. Refer to section 22.2, BACnet Functional Groups, and Annex L in the BACnet standard for a complete list of the services that must be directly supported to provide each of the functional groups listed above. Proprietary services, if used in the system, shall be thoroughly documented and provided as part of the submittal data. Necessary tools shall be supplied for working with proprietary information.
 - 3. Standard BACnet object types supported shall include as a minimum—Analog Input, Analog Output, Analog Value, Binary Input, Binary Output, Binary Value, Device, File and Program Object Types. Proprietary object types, if used in the system, shall be thoroughly documented and provided as part of the submittal data. Necessary tools shall be supplied for working with proprietary information.
- C. ASCs shall include universal inputs with 10-bit resolution that can accept 3K and 10K thermistors, 0–5 VDC, 4–20 mA, dry contact signals and a minimum of 3 pulse inputs. Any

input on controller may be either analog or digital. Controller shall also include support and modifiable programming for interface to intelligent room sensor. Controller shall include binary outputs on board with analog outputs as needed.

- D. Program sequences shall be stored on board controller in EEPROM or flash memory. No batteries shall be needed to retain logic program. Program sequences shall be executed by controller 10 times per second and shall be capable of multiple PID loops for control of multiple devices. Programming of application specific controller shall be completely modifiable in the field over installed BACnet LANs or remotely via modem interface. Operator shall program logic sequences by graphically moving function blocks on screen and tying blocks together on screen. Application specific controller shall be programmed using same programming tools as building controller and as described in operator workstation section. Programming tools shall be provided and installed as part of system.
- E. ASC shall include support for intelligent room sensor. Display on room sensor shall be programmable at controller and include an operating mode and a field service mode. Button functions and display data shall be programmable to show specific controller data in each mode based on which button is pressed on the sensor. See sequence of operation for specific display requirements at intelligent room sensor.

2.08 APPLICATION SPECIFIC CONTROLLERS, VAV TERMINAL UNITS (SINGLE DUCT)

- A. Provide one native BACnet ASC for each VAV terminal unit that adequately covers objects listed in object list for unit. Controllers shall interface to building controller via MS/TP LAN using BACnet protocol. No gateways shall be used. Controllers shall include on board CFM flow sensor, inputs, outputs and programmable, self-contained logic program as needed for control of units.
- B. BACnet Conformance:
 - 1. ASCs shall as a minimum support MS/TP BACnet LAN types. They shall communicate directly via this BACnet LAN at 9.6, 19.2, 38.4 and 76.8 Kbps, as a native BACnet device. Application controllers shall be BTL Certified BACnet B-ASC profile. Including BACnet services necessary to provide the following BACnet functional groups and support BACnet services necessary to provide the following BACnet functional groups:
 - a. Files Functional Group
 - b. Reinitialize Functional Group
 - c. Device Communications Functional Group
 - 2. Refer to section 22.2, BACnet Functional Groups, and Annex L in the BACnet standard, for a complete list of the services that must be directly supported to provide each of the functional groups listed above. Proprietary services, if used in the system, shall be thoroughly documented and provided as part of the submittal data. Necessary tools shall be supplied for working with proprietary information.
 - 3. Standard BACnet object types supported shall include as a minimum—Analog Input, Analog Output, Analog Value, Binary Input, Binary Output, Binary Value, Device, File and Program Object Types. Proprietary object types, if used in the system, shall be thoroughly documented and provided as part of the submittal data. Necessary tools shall be supplied for working with proprietary information.
- C. ASCs shall include universal inputs with 10-bit resolution that can accept 3K and 10K thermistors, 0–5 VDC, and dry contact signals. Inputs on controller may be either analog or digital. Controller shall also include support and modifiable programming for interface to intelligent room sensor with digital display. Controller shall also include binary outputs on board. For applications using variable speed parallel fans, provide a single analog output selectable for 0-10 V or 0-20 mA control signals. ASC shall include microprocessor driven flow

sensor for use in pressure independent control logic. Terminal units shall be controlled using pressure independent control algorithms and flow readings shall be in CFM.

- D. Program sequences shall be stored on board application controller in EEPROM or flash memory. No batteries shall be needed to retain logic program. Program sequences shall be executed by controller 10 times per second and shall be capable of multiple PID loops for control of multiple devices. Programming of application controller shall be completely modifiable in the field over installed BACnet LANs or remotely via modem interface. Operator shall program logic sequences by graphically moving function blocks on screen and tying blocks together on screen. ASC shall be programmed using the same programming tool as Building Controller and as described in operator workstation section. Programming tools shall be provided as part of system.
- E. ASC shall include support for intelligent room sensor (see Section 2.9.B.) Display on room sensor shall be programmable at application controller and include an operating mode and a field service mode. Button functions and display data shall be programmable to show specific controller data in each mode based on which button is pressed on the sensor. See sequence for specific display requirements for intelligent room sensor.
- F. On board flow sensor shall be microprocessor driven and precalibrated at the factory. Precalibration shall be at 16 flow points as a minimum. Factory calibration data shall be stored in EEPROM or flash memory. Calibration data shall be field adjustable to compensate for variations in VAV terminal unit type and installation. Calibration parameters shall be adjustable through intelligent room sensor. Operator workstation, portable computers and special hand-held field tools shall not be needed for field calibration.
- G. Provide duct temperature sensor at discharge of each VAV terminal unit that is connected to controller for reporting back to operator workstation.

2.09 NETWORKED THERMOSTAT (TEC)

- A. The networked thermostat shall be capable of controlling two- or four-pipe fan coils, cabinet unit heaters or other similar equipment.
- B. The TEC shall communicate over the Field Controller Bus using BACnet Standard MS/TP Bus Protocol ASHRAE SSPC-135, Clause 9.
- C. The TEC shall be BACnet Testing Labs (BTL) certified and carry the BTL Label.
 - 1. The TEC shall be tested and certified as a BACnet Application Specific Controller (B-ASC).
 - 2. A BACnet Protocol Implementation Conformance Statement shall be provided for the TEC.
 - 3. The Conformance Statement shall be submitted 10 days prior to bidding.
- D. The Networked Thermostat shall support remote read/write and parameter adjustment from the web based User Interfaceable through a Network Automation Engine.
- E. The Networked Thermostat shall include an intuitive User Interface providing plain text messages.
 - 1. Two line, 8 character backlit display
 - 2. LED indicators for Fan, Heat, and Cool status
 - 3. Five (5) User Interface Keys
 - a. Mode
 - b. Fan
 - c. Override

- d. Degrees C/F
- e. Up/Down
- 4. The display shall continuously scroll through the following parameters:
 - a. Room Temperature
 - b. System Mode
 - c. Schedule Status – Occupied/Unoccupied/Override
 - d. Applicable Alarms
- F. The Networked Thermostat shall provide the flexibility to support any one of the following inputs:
 - 1. Integral Indoor Air Temperature Sensor
 - 2. Duct Mount Air Temperature Sensor
 - 3. Remote Indoor Air Temperature Sensor with Occupancy Override and LED Indicator
 - 4. Two configurable binary inputs
- G. The Networked Thermostat shall provide the flexibility to support any one of the following outputs:
 - 1. Three Speed Fan Control
 - 2. Two On/Off
 - 3. Two Floating
 - 4. Two Proportional (0 to 10V)
- H. The Networked Thermostat shall provide a minimum of six (6) levels of keypad lockout.
- I. The Networked Thermostat shall provide the flexibility to adjust the following parameters:
 - 1. Adjustable Temporary Occupancy from 0 to 24 hours
 - 2. Adjustable heating/cooling deadband from 2° F to 5° F
 - 3. Adjustable heating/cooling cycles per hour from 4 to 8
- J. Where required by application and indicated on plans or room schedules provide the Networked Thermostat with an integral Passive Infra-Red (PIR) occupancy sensor.
- K. The Networked Thermostat shall employ nonvolatile electrically erasable programmable read-only memory (EEPROM) for all adjustable parameters.

2.10 PRIMARY CONTROL DEVICES

- A. General:
 - 1. Major components shall conform to following requirements. Provide additional components as required for complete system.

2.11 CONTROL DAMPER ACTUATORS

- A. Damper Actuators:
 - 1. Damper operators shall be electronic type and shall be fully proportioning unless otherwise specified. Damper operators shall have metal bodies. Operators shall have ample power to overcome friction of damper linkage and air pressure acting on damper blades plus 50% safety factor. Damper operator mounting arrangement shall be outside airstream wherever possible. Operators shall have external adjustable stops to limit stroke. Operator linkage arrangement shall be such as to permit normally open or normally closed positions of damper as indicated.
 - 2. Outside air, return air, relief air, and exhaust air damper actuators shall be mechanical spring return. Capacitors or other non-mechanical forms of fail-safe are not acceptable. The actuator mounting arrangement and spring return feature shall permit normally open or normally closed positions of the damper as required.

3. One electronic actuator shall be direct shaft mounted per damper section. No connecting rods or jackshafts shall be needed. Small outside air and return air economizer dampers may be mechanically linked together if one actuator has sufficient torque to drive both and damper drive shafts are both horizontal installed.
4. Multi-section dampers with electric actuators shall be arranged so that each damper section operates individually. One electronic actuator shall be direct shaft mounted per damper section. (See below execution section for more installation details.)
5. Electric damper actuators (including VAV box actuators) shall be direct shaft mounted and use a V-bolt and toothed V-clamp causing a cold weld effect for positive gripping. Single bolt or setscrew type fasteners are not acceptable.
6. Air handler damper actuators shall utilize analog control (2-10vdc, 4-20ma), floating control is not acceptable.
7. VAV terminal unit damper actuation shall be floating type or analog (2-10vdc, 4-20ma).
8. Normal (fail) Position:
 - a. Outside Air: Normally closed, spring return.
 - b. Return Air: Normally open, spring return.
 - c. Relief Air: Normally closed, spring return.
 - d. Exhaust Air: Normally closed, spring return.

2.12 CONTROL VALVES AND ACTUATORS

A. General:

1. The BAS contractor shall furnish all specified motorized control valves and actuators, and shall furnish control wiring to actuators.
2. Automatic control valves shall be equal percentage flow characteristic type for linear coil output.
3. Valves shall be sized by Control Manufacturer and be provided with actuators of sufficient power for duty intended.
4. Control valves shall be two-way or three-way type single seated globe type for two-position or modulating service as shown.
5. Valve body and actuator selections shall be sufficient to handle system pressure and ambient temperature and shall close against differential pressures encountered.
6. Valve Construction:
 - a. 1/2 inch through 1 inch:
 - 1) Valves shall be constructed with cast bronze or brass body, stainless steel trim and threaded ends.
 - b. 1-1/4 inch through 2 inch:
 - 1) Valves shall be constructed with cast bronze or brass body, stainless steel trim and threaded ends.
 - 2) For special duty, valves may be selected by Control Manufacturer to have either bronze or cast iron bodies with screwed or flanged ends.
 - c. 2-1/2 inch and above:
 - 1) Valves shall be constructed with cast iron body and have flanged connections, and stainless steel trim.
7. Valve Selection Criteria:
 - a. Sizing:
 - 1) Two position: Line size.
 - 2) Modulating Hot Water: Three psig drop maximum.
 - 3) Modulating Chilled Water: Five psig drop maximum.
 - 4) Modulating Steam: 70% of pressure.
 - b. Normal Position:
 - 1) Heating Water: Normally open.

- 2) Chilled Water Valves: Normally closed.
 - 3) Steam: Normally closed.
 - c. Fail Position:
 - 1) Heating Water (at central heating components): Open.
 - 2) Heating Water (at terminal heating devices): Last position.
 - 3) Chilled Water Valves: Closed.
 - 4) Steam: Closed.
 - d. Capacity: As shown on Drawings.
- B. Valve Actuators, (Terminal Units, Fan Coil Units):
 1. Valve actuators shall be electronic, floating point type, and properly selected for valve body and service.
 2. Actuators shall be fully proportioning or two position and be spring return where fail open or fail closed position is required as defined for intended service, unless defined differently in Sequence of Operation.
- C. Valve Actuators:
 1. Control Valve Actuators (3 inch and smaller):
 - a. Actuators shall have a gear release button on non-spring return models to allow manual setting. The actuator shall have either an insulating air gap between it and the linkage or a non-conducting thermoplastic linkage. Care shall be taken to maintain the actuator's operating temperatures and humidity within its specifications. Pipes shall be fully insulated and heat shields shall be installed if necessary. Condensation may not form on actuators and shall be prevented by a combination of insulation, air gap, or other thermal break.
 - b. The control circuit shall be fully modulating using 2 - 10 volt or 4 - 20 mA signals. Accuracy and repeatability shall be within 1/21 of control signal.
 - c. Valve body and actuators shall be shipped fully assembled and tested at the valve factory prior to shipment.
- D. Quality Assurance for Actuators and Valves:
 1. UL Listed Standard 873 and C.S.A. Class 4813 02 certified.
 2. NEMA 2 rated enclosures for inside mounting, provide with weather shield for outside mounting.
 3. Valves shall meet ANSI Class IV leakage rating.
 4. Five-year manufacturer's warranty. Two-year unconditional and three-year product defect from date of installation.
- E. Acceptable Manufacturers: Belimo, Alerton, Siemens, JCI, or approved.

2.13 SENSORS

- A. Room Temperature Sensors (standard):
 1. DDC room sensor.
 2. 10k Ohm thermister.
 3. Range 40 to 90 deg F with +/- 0.5 degrees F at factory calibrated point of 70 deg F.
 4. Override button for initiation of occupied mode during unoccupied hours.
 5. Set point adjustment: The high accuracy set point adjustment incorporates dual temperature scale indication and an access door that covers the setpoint adjustment switch.
 6. Built-in port allows connection of portable operators terminal to query and modify operating parameters on room level sensor.
 7. Cover color: White.
 8. Model: JCI, or approved.

- B. Room temperature sensor guard:
 - 1. Provide beige metal lockable gym guard for Sensor/Thermostat where indicated on the Drawings or in the Controls Sequence of Operations. Features shall include:
 - a. Solid base with mounting hardware.
 - b. Tumbler style lock with two keys.
 - c. Ventilation openings for accurate thermostatic response.
 - 2. Manufacturer: Siemens, White-Rodgers, or approved.
- C. Temperature sensors:
 - 1. Duct temperature sensors shall be rigid or averaging as required by sequence of operations. Averaging sensors shall have sufficient length to span duct diagonally.
 - 2. Water temperature sensor shall be liquid immersion type, stainless steel thermister, with resistance varying proportionally to temperature. Temperature range shall be suitable for application.
- D. Outside Air Temperature Sensor:
 - 1. Platinum RTD type sensor.
 - 2. Assembly includes platinum RTD sensing element, transmitter and mounting enclosure.
 - 3. Output Signal: 4-20 mA.
- E. Air Static Pressure Sensor:
 - 1. Duct static pressure range: -0.5" to +7.0" w.c.
 - 2. Accuracy: +/-0.05" w.c.
 - 3. Output signal: 4-20 mA.
- F. Flow Switch (Water):
 - 1. Size: For required pipe size.
 - 2. Flow-proving switches shall be either paddle or differential pressure type, as shown.
 - 3. Paddle type switches (water service only) shall be UL listed, SPDT snap-acting with pilot duty rating (125 VA minimum) and shall have adjustable sensitivity with NEMA 1 enclosure unless otherwise specified.
 - 4. Differential pressure type switches (air or water service) shall be UL listed, SPDT snap-acting, pilot duty rated (125 VA minimum), NEMA 1 enclosure, with scale range and differential suitable for intended application or as specified.
 - 5. Operation: Energize with system flow.
 - 6. Materials: Stainless steel, suitable for domestic water service.
- G. Differential Pressure Sensor (water):
 - 1. Type: Wet system differential pressure.
 - 2. Range: 0 to 50 psi.
 - 3. Sensing Accuracy: +/-0.25% of calibrated span.
 - 4. Output Signal: 4-20 mA.
 - 5. Power Input: 24 VAC.
 - 6. Manufacturer: Veris, Setra, Rosemount, or approved. Similar to Veris PW2 series.
- H. High Limit Thermostats:
 - 1. High limit thermostats shall be manual reset type set at 120 degrees F.
- I. Low Limit Thermostats (Freezestat):
 - 1. Electric low temperature detection cut-out and alarm thermostat with remote vapor filled sensing element. Thermostat shall actuate when any one foot length of the element is exposed to temperatures below thermostat setting.
 - 2. Element Length: 20 foot minimum.
 - 3. Contacts: Main and auxiliary contacts. Electrical rating as required for application.

4. Setpoint Adjustment Range: 15 to 55 deg. F.
 5. Differential: 5 deg. F. minimum.
 6. Reset: Manual button.
- J. Current Transformers:
1. Current transformer switches shall be furnished for status purposes in air and water applications.
 2. The current transformers shall be designed to be installed or removed without dismantling the primary bus or cables. The transformer shall be of a split core design. The core and windings shall be completely encased in a UL approved thermoplastic rated 94VA. No metal parts shall be exposed other than the terminals. The current transformers shall meet the following specifications:
 - a. Accuracy: 1% at 5.0 to 25.0 VA accuracy class with U.P.F. burden.
 - b. Provide a disconnect switch for each current transformer.
- K. Air Differential Pressure Switch:
1. Differential pressure switches shall be diaphragm type, with die-cast aluminum housing and adjustable set point. Switch rating shall be a minimum 5 amps at 120 VAC. Switches shall be SPDT and be used for fan status as specified in the point schedule. Switch pressure range shall be suited for application. (e.g. filter 0-2.0", fan status 0-5.0", etc.).

2.14 VENTILATION CONTROL SENSORS

- A. Carbon Dioxide Sensor:
1. Type: Wall mounted, non-dispersive infrared (NDIR), diffusion sampling, 5 year calibration interval.
 2. Measurement range: 0-2000 ppm.
 3. Accuracy: ± 30 ppm.
 4. Repeatability: ± 20 ppm.
 5. Analog Output: 4-20 mA / 0-10 VDC (selectable)
 6. Input Power: 100 ma max, 24 VAC.
 7. Manufacturer: Veris Industries, Inc Model CWE, or approved.

2.15 SPACE PRESSURIZATION SENSORS

- A. Indoor Space Pressure Sensor:
1. Material: aluminum welded casing.
 2. Construction: Ceiling mounted shielded static pressure sensor with multiple sensing ports, pressure impulse suppression chamber, airflow shielding and 1/8 inch FPT takeoff fitting.
 3. Measurement: within 1% of actual pressure value while being subjected to maximum airflow of 1000 fpm from a radial source.
 4. Manufacturer: Paragon, Veris, Mamac, or approved.
- B. Space Differential Pressure Transmitter:
1. Output Signal: 0-5 VDC proportional to the differential of the spaces and reference static pressure input signals.
 2. Span: not greater than three times the design space differential pressure.
 3. Accuracy: $\pm 0.5\%$ of span.
 4. Dead Band and Hysteresis: less than 0.3% of output.
 5. Linearity: within 0.4% of span.
 6. Repeatability: within 0.2% of output.
 7. Response: less than 0.5 second for full span input.
 8. Temperature stability: less than 0.01% output shift per degree temperature change.
 9. Manufacturer: Paragon, Veris, Mamac, or approved.

- C. Outdoor Pressure Sensor (Reference):
 - 1. Material: heavy gauge aluminum with hard-anodized finish and 2 inch diameter FPT connection.
 - 2. Construction: two circular perforated parallel plates with an integral pressure sensing chamber.
 - 3. Measurement: within 2% of actual value when being subjected to varying wind flows with velocities up to 80 miles per hour with approach angles up to 30 degrees to the horizontal.
 - 4. Manufacturer: Paragon, or approved.
- D. Timer switch (mechanical)
 - 1. Type: Spring-wound line voltage, UL Listed, with contact rating and configuration as required by application. Provide 0-to-1/2 hour calibrated dial unless otherwise specified.
 - 2. Timer shall be suitable for flush mounting on control panel face and located on local control panels or where shown.
 - 3. Manufacturer: Intermatic, Mark Time, or equal. Similar to Intermatic FF series.

2.16 METERS

- A. BTU Meters:
 - 1. General: Housed microprocessor with LCD display on housing, totalized Btu/hour output and matched temperature sensors, and flow meter.
 - 2. Sensors:
 - a. Flow meter: Single or dual insertion turbine flow meter. Accuracy +/- 0.5% of rate at the calibrated typical flow rate and within 2% of rate over extended range (minimum 0.4 to 20 feet per second). N.I.S.T. traceable calibration with certification.
 - b. Temperature probes: Solid state temperature supply and return piping sensors with thermowells for pipe insertion. Suitable for 32F to 200F operating range.
 - 3. Provide isolation valve kit to allow removal and servicing of meter while system is operating.
 - 4. Output signal: BACnet MS/TP or IP; or JCI N2.
 - 5. Input Power: 300 mA max, 24 VAC. Provide power connection and transformer.
 - 6. Manufacturer : Onicon, Siemens, Veris Industries, or approved. Similar to Onicon System 10 Series.
- B. Vortex Flow Meters:
 - 1. General: Vortex flow meters for accurately measuring water flow in building supply steam system. Complete with flow meter, transmitter, signal cables and other fittings and devices necessary to provide a complete and operational flow measurement on BMCS.
 - 2. Provide flow and totalization through BAS software of flow per month and per year, in units as directed by the owner.
 - 3. BMS system shall monitor Mlb/Hr, Mlb total, pressure and temperature values.
 - a. Accuracy: Analog output +/- 5% of actual flow rate over entire specified flow range.
 - b. Repeatability: 1.0 % of actual flow rate.
 - c. Output Signal: Analog output, 4-20 ma signal, linear from 0-100 percent output.
 - d. Components:
 - 1) Flow meter: 300 series stainless steel, threaded or ANSI class 150 steel flange pipe connections.
 - 2) Sensor Diaphragm: 316 L stainless steel.
 - 3) Local meter indication gauge.
 - e. Flow Range:
 - 1) Steam Capacity: 15 psig saturated steam, maximum 2000 pounds per hour.
 - 2) Temperature: Rated for 400 deg F entering temperature.
 - f. Manufacturer: Cadillac, Foxboro, or approved.

- C. Digital Energy Monitors (Electrical Service):
1. Provide three phase digital Watt-meters with pre-wired current transmitters. (CT) All Watt-meter electronics shall be housed within the CTs. CTs shall include sizes capable of mounting directly on a power bus. Diagnostics visible to the installing electrician (without an operator tool) shall indicate: proper operation, defective wiring or low power-factor, device malfunction, and over-load condition. The meters shall include the following:
 2. The device shall be UL Listed, and shall comply with ANSI C12.1 accuracy specification. The minimum CT/meter combined accuracy shall be no greater than 1% of reading over the range of 5% to 100% of rated load. The meter shall not require calibration
 3. The Watt-meter shall directly connect to power from 208 through 480 with no potential transformer. Inline fuses for each voltage tap phase shall be included.
 - a. The Watt-meter CTs shall be split-core and at minimum be sized to accommodate loads ranging from 100 to 2400 Amps. The CTs shall be volt-signal type, and shall not require shorting blocks.
 - b. The Watt-meter shall reside directly on the Secondary Network along with other Secondary Network devices. Data transferred shall include:
 - 1) Current
 - 2) Voltage
 - 3) Reactive Power
 - 4) Apparent Power
 - 5) Power Factor
 - 6) Demand, kW
 - 7) Consumption, kWh
 4. Specification Range:
 - a. Three phase installations: 277/480 VAC Delta and Wye; 120/208 VAC Delta and Wye. Coordinate with Division 26 for electrical service sizing, and CT size required.
 5. Enclosure with Display:
 - a. NEMA 1 type, suitable for wall installation.
 - b. LCD display, with backlit background.
 6. Manufacturer: Veris 8163 series or approved.

2.17 MISCELLANEOUS

- A. Condensate Overflow Level Sensor (cooling coil drain pan mounted):
1. Operation: Detects the overflow of water and alarms BAS.
 2. Float switch for installation in drain pan, with attachment to pan rim.
 3. N.C. solid state contacts (opens or closes on alarm).
 4. Input Rating: 24 VAC/DC @ 2.5 A max.
 5. UL 508 for compliance with 2007OMSC 307.2.3.4.
 6. Manufacturer: SMD Research SS3 or approved.
- B. Enclosures
1. All controllers, power supplies and relays shall be mounted in enclosures.
 2. Enclosures may be NEMA 1 when located in a clean, dry, indoor environment. Indoor enclosures shall be NEMA 12 when installed in other than a clean environment. Outdoor enclosures shall be NEMA 3R with provision for ventilation of electrical equipment such as variable speed drives.
 3. Enclosures shall have hinged, locking doors.
 4. Provide laminated plastic nameplates for all enclosures in any mechanical room or electrical room. Include location and unit served on nameplate. Laminated plastic shall be 1/8" thick sized appropriately to make label easy to read.

PART 3 EXECUTION

3.01 CONTROL SYSTEM INSTALLATION (GENERAL)

- A. Install products in accordance with manufacturer's instructions.
- B. Provide miscellaneous devices, hardware, software, interconnections installation and programming required to ensure a complete operating system in accordance with the sequences of operation and point schedules.
- C. Contractor shall collaborate with Owner directly to determine Owner's preference for naming conventions, etc. before entering data in system.
- D. Prepare and start logic control system under provisions of this section.
- E. Provide Owner's Representative with spare parts list. Identify equipment critical to maintaining the integrity of the operating system.

3.02 EXAMINATION:

- A. The project plans shall be thoroughly examined for control device and equipment locations. Any discrepancies, conflicts, or omissions shall be reported to the architect/engineer for resolution before rough-in work is started.
- B. The contractor shall inspect the site to verify that equipment may be installed as shown. Any discrepancies, conflicts, or omissions shall be reported to the engineer for resolution before rough-in work is started.
- C. 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.
- D. The contractor shall examine the drawings and specifications for other parts of the work. If head room or space conditions appear inadequate—or if any discrepancies occur between the plans and the contractor's work and the plans and the work of others—the contractor shall report these discrepancies to the engineer and shall obtain written instructions for any changes necessary to accommodate the contractor's work with the work of others.
- E. Do not begin work until unsatisfactory conditions are resolved.

3.03 ELECTRICAL AND WIRING

- A. Provide wiring as required by functions as specified and as recommended by equipment manufacturers, to serve specified control functions. Provide shielded low capacitance wire for communications trunks.
- B. Wiring shall be installed neatly and professionally, in accordance with Specification Division 26 and national, state and local electrical codes.
- 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 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:
 - 1. Provide required interposing relays for motor starters and contactors.
 - 2. Motor starters, pilot power transformers, and enclosures provided under Division 26. Coordinate 120 VAC or 24 VAC requirements with Division 26.
- E. NEC Class 1 (line voltage) wiring shall be UL Listed in approved conduit according to NEC

and Division 26 requirements.

- F. Low-voltage wiring shall meet NEC Class 2 requirements. (Low-voltage power circuits shall be sub fused when required to meet Class 2 current limit.)
- G. Where NEC Class 2 (current-limited) wires are in concealed and accessible locations, including ceiling return air plenums, approved cables not in conduit may be used provided that cables are UL Listed for the intended application. For example, cables used in ceiling plenums shall be UL Listed specifically for that purpose.
- H. Provide power for control components from nearest electrical control panel or as indicated on the electrical drawings. Provide power required for controls components, as required. Coordinate with electrical contractor
- I. Wiring in mechanical, electrical, or service rooms—or where subject to mechanical damage—shall be installed in conduit. Other wiring to be installed neatly and inconspicuously per local code requirements. If local code allows, control wiring above accessible ceiling spaces may be run with plenum rated cable (without conduit).
- J. Where relays are used to control single phase motors directly, contacts shall be motor rated for not less than horsepower rating of largest motor switched by relay. Provide motor control relays for the following equipment:
 - 1. Exhaust fan EF-2.
 - 2. Heating water pump HWP-3.

3.04 UTILITY MONITORING:

- A. The equipment necessary to monitor the following services will be provided under this section. BAS shall record demand and energy usage on a continuous basis and show measured quantities listed in the “Utility Monitoring Table shown in Section 23 10 00, on the BAS workstation graphics.
- B. Low voltage wiring and connections between monitoring equipment and the BAS system control panel/s shall be provided under this section.

3.05 IDENTIFICATION

- A. Provide nameplates for switches, starters, and control devices in accordance with Section 206000.
- B. Nameplate wording shall be consistent with device names used on shop drawings and in Contract Documents.
- C. Point name and address shall be indicated at each end of control wire connections to DDC equipment.
- D. Identifiers shall match record documents.

3.06 PROTECTION

- A. The contractor shall protect work and material from damage by its employees and/or subcontractors and shall be liable for damage thus caused.
- B. The contractor shall be responsible for its work and equipment until finally inspected, tested, and accepted.

3.07 COORDINATION

- A. Site:

1. The project coordination between trades is the responsibility of the prime contractor who is the one tier higher contractual partner such as mechanical contractor, general contractor, construction manager, owner or owner's representative as applicable.
 2. The controls contractor shall follow prime contractor's job schedule and coordinate project related activities through the prime contractor except otherwise agreed or in minor job site issues. Reasonable judgment shall be applied.
 3. Where the work will be installed in close proximity to, or will interfere with, work of other trades, the contractor shall assist in working out space conditions to make a satisfactory adjustment.
 4. If the contractor deviates from the job schedule and installs work without coordinating with other trades, so as to cause interference with work of other trades, the contractor shall make the necessary changes to correct the condition without extra charge.
 5. Coordinate and schedule work with other work in the same area, or with work that is dependent upon other work, to facilitate mutual progress.
- B. Test and Balance:
1. The contractor shall furnish a single set of all tools necessary to interface to the control system for test and balance purposes.
 2. The contractor shall provide training in the use of these tools. This training will be planned for a minimum of 4 hours.
 3. In addition, the contractor shall provide a qualified technician for duration of 8 hours to assist in the test and balance process.
 4. The tools used during the test and balance process shall be returned at the completion of the testing and balancing.
- C. Life Safety:
1. Duct smoke detectors required for air handler shutdown are supplied under Division 26. The contractor shall interlock smoke detectors to air handlers for shutdown as described in Section 231000 Controls Sequence of Operation.
- D. Coordination with controls specified in other sections or divisions.
1. Other sections and/or divisions of this specification include controls and control devices that are to be part of or interfaced to the control system specified in this section. These controls shall be integrated into the system and coordinated by the contractor as follows:
 - a. All communication media and equipment shall be provided as specified in Part 2, "Communication" of this specification.
 - b. Each supplier of controls product is responsible for the configuration, programming, startup, and testing of that product to meet the sequences of operation described in this section.
 - c. The Contractor shall coordinate and resolve any incompatibility issues that arise between the control products provided under this section and those provided under other sections or divisions of this specification.
 - d. The contractor is responsible for providing all controls described in the contract documents regardless of where within the contract documents these controls are described.
 - e. The contractor is responsible for the interface of control products provided by multiple suppliers regardless of where this interface is described within the contract documents.

3.08 GENERAL WORKMANSHIP

- A. Install equipment, piping, and wiring/raceway parallel to building lines (i.e., horizontal, vertical, and parallel to walls) wherever possible.

- B. Provide sufficient slack and flexible connections to allow for vibration of piping and equipment.
- C. Install all equipment in readily accessible locations as defined by Chapter 1, Article 100, Part A of the National Electrical Code (NEC).
- D. Verify integrity of all wiring to ensure continuity and freedom from shorts and grounds.
- E. All equipment, installation, and wiring shall comply with acceptable industry specifications and standards for performance, reliability, and compatibility and be executed in strict adherence to local codes and standard practices.

3.09 EXISTING EQUIPMENT

- A. Unless otherwise directed, the contractor is not responsible for the repairs or replacement of existing energy equipment and systems, valves, dampers, or actuators. Should the contractor find existing equipment that requires maintenance, the engineer is to be notified immediately.

3.10 LOCATION AND INSTALLATION OF SENSORS AND COMPONENTS

- A. General:
 - 1. Install sensors in accordance with the manufacturer's recommendations.
 - 2. Mount sensors rigidly and adequately for the environment within which the sensor operates.
 - 3. Room temperature sensors shall be installed on concealed junction boxes properly supported by the wall framing.
 - a. Mount space temperature sensors 48 inches above finished floor or adjacent to room light switch/sensor, where shown on Drawings.
 - 4. All wires attached to sensors shall be air sealed in their raceways or in the wall to stop air transmitted from other areas affecting sensor readings.
 - 5. Sensors used in mixing plenums and hot and cold decks shall be of the averaging type.
 - 6. Instruments, switches, transmitters, etc., shall be suitably wired and mounted to protect them from vibration, moisture and high or low temperatures.
 - a. Provide stainless steel or brass thermowells suitable for respective application and for installation under other sections—sized to suit pipe diameter without restricting flow.
 - 7. Low-limit sensors used in mixing plenums shall be installed in a serpentine manner horizontally across the full face of the coil.
 - 8. All pipe-mounted temperature sensors shall be installed in wells. Install all liquid temperature sensors with heat-conducting fluid in thermal wells.
 - 9. Install outdoor air temperature sensors on north wall, complete with sun shield at designated location on Drawings.
 - 10. Locate and install components for easy accessibility; in general, mount 48 inches above floor with minimum 3'-0" clear access space in front of units. Obtain approval on locations from owner's representative prior to installation. This includes, but is not limited to space temperature sensors, carbon dioxide sensors, outside air temperature, etc.
- B. Room Sensors:
 - 1. Provide sensors with occupant override button for the following rooms/space types:
 - a. Offices, classrooms, and conference rooms.
 - 2. Provide blank cover type pressure sensors for the following rooms/space types:
 - a. Mechanical, Server/IT, and storage rooms, corridors/hallways and public areas.
 - 3. Mounting Height: Four feet above finish floor for wall mounted devices, where shown on Drawings.
 - 4. Mounting Height in Hallways, Corridors, and Public Spaces: Six feet above finish floor, unless otherwise indicated on Drawings.

- C. Airflow Monitoring Stations (AFMS):
 - 1. Interface flow measurements with BAS and utilize in Sequence of Operation as described.
- D. Temperature Limit Switches:
 - 1. A temperature limit switch (Low Temperature Detector) shall be provided to sense the temperature.
 - 2. A sufficient number of temperature limit switches shall be installed to provide complete coverage of the duct section.
 - 3. Manual reset limit switches shall be installed in approved, accessible locations where they can be reset easily.
 - 4. The temperature limit switch sensing element shall be installed in a serpentine pattern and in accordance with the manufacturer's installation instructions.
 - 5. Each bend shall be supported with a capillary clip. Provide 1 ft of sensing element for each 1 ft² of coil area.
 - 6. Install limit switch wiring such that temperature limits are in effect with unit running in hand and automatic modes.
- E. Averaging Temperature Sensing Elements:
 - 1. Sensing elements shall be installed in a serpentine pattern.
 - 2. Averaging sensors shall be installed in a serpentine manner vertically across the duct. Each bend shall be supported with a capillary clip.
- F. Air Differential Pressure Switches:
 - 1. Install limit switch wiring such that pressure limits are in effect with unit running in hand and automatic modes.
- G. Differential air static pressure:
 - 1. Supply Duct Static Pressure: Pipe the high-pressure tap to the duct using a pitot tube. Pipe the low-pressure port to a tee in the high-pressure tap tubing of the corresponding building static pressure sensor (if applicable) or to the location of the duct high-pressure tap and leave open to the plenum.
 - 2. Return Duct Static Pressure: Pipe the high-pressure tap to the duct using a pitot tube. Pipe the low-pressure port to a tee in the low-pressure tap tubing of the corresponding building static pressure sensor.
 - 3. Building Static Pressure: Pipe the low-pressure port of the pressure sensor to the static pressure port located on the outside of the building through a high-volume accumulator. Pipe the high-pressure port to a location behind a thermostat cover.
 - 4. The piping to the pressure ports on all pressure transducers shall contain a capped test port located adjacent to the transducer.
 - 5. All pressure transducers, other than those controlling VAV boxes, shall be located in field device panels, not on the equipment monitored or on ductwork.
 - 6. Mount transducers in a location accessible for service without use of ladders or special equipment.
- H. Water Differential pressure sensors:
 - 1. Differential pressure sensors shall be installed with valved taps into the piping to ensure serviceability without draining the system.
 - 2. Sensors shall be mounted with bleed valves.
 - 3. After sensor installation any air shall be eliminated using the bleed valves to ensure reading accuracy.
 - 4. The sensors shall be located to ensure accessibility..
- I. Flow meters:
 - 1. The minimum straight unobstructed piping for the flowmeter installation shall be at least

10 pipe diameters upstream and at least 5 pipe diameters downstream and/or in accordance with the manufacturer's installation instructions.

J. Flow Switches:

1. Use correct paddle for pipe diameter.
2. Adjust flow switch in accordance with manufacturer's instructions.

K. Power Relays:

1. Control relays shall be UL listed plug-in type with dust cover and LED "energized" indicator. Contact rating, configuration, and coil voltage shall be suitable for application.
2. Provide with local HOA switch on relay outlet with LED indicator
3. Manufacturers: RIB, Veris, or approved. Similar to Veris Victory relay series.

3.11 ACTUATORS

A. Mount and link control damper actuators according to manufacturer's instructions.

1. To compress seals when spring-return actuators are used on normally closed dampers, power actuator to approximately 5° open position, manually close the damper, and then tighten the linkage.
2. Check operation of damper/actuator combination to confirm that actuator modulates damper smoothly throughout stroke to both open and closed positions.
3. Provide all mounting hardware and linkages for actuator installation.
4. Dampers: Actuators shall be direct-mounted on damper shaft or jackshaft unless shown as a linkage installation. For low-leakage dampers with seals, the actuator shall be mounted with a minimum 5° available for tightening the damper seals. Actuators shall be mounted following manufacturer's recommendations.
5. Valves: Actuators shall be connected to valves with adapters approved by the actuator manufacturer. Actuators and adapters shall be mounted following the actuator manufacturer's recommendations.

3.12 MISCELLANEOUS WIRING AND CONTROL WORK

A. Split System Heat Pumps/Air Conditioning Units:

1. Provide low voltage control wiring between indoor unit and thermostat. Thermostats furnished with AC units, installed by this section.
2. Set thermostat setpoints and test and adjust controls for specific operation.

B. Install timer switch for EF-2 operation near top of stairs into attic level mechanical/storage area.

3.13 DDC OBJECT TYPE SUMMARY

A. Provide database generation.

B. Displays:

1. System displays shall show analog and binary object types within the system. They shall be logically laid out for easy use by the owner. Provide outside air temperature indication on system displays associated with economizer cycles.
2. Provide software HOAs for major pieces of equipment such as fans, pumps, valves, and dampers.

C. Run Time Totalization:

1. At a minimum, run time totalization shall be incorporated for each monitored supply fan, return fan, exhaust fan, hot water and chilled water pumps. Warning limits for each point shall be entered for alarm and or maintenance purposes.

D. Trendlog:

1. Binary and analog object types (including zones) shall have the capability to be automatically trended.
- E. Alarm:
1. Analog inputs (High/Low Limits) and selected binary input alarm points shall be prioritized and routed (locally or remotely) with alarm message per owner's requirements.
- F. Database Save:
1. Provide back-up database for stand-alone application controllers on disk.

3.14 START-UP AND COMMISSIONING

- A. Utility Energy Monitoring For SEED:
1. Objective:
 - a. SEED guidelines require that major specific end uses be monitored for energy use during 18 months of occupancy, and that the data be collected and reported on a regular basis. This information can be used to manage long-term energy use of the facility and will be used comparatively to determine if the facility uses energy at a rate similar to the rate predicted in the Energy Model. This document outlines the plan for meeting these requirements.
 2. Metering:
 - a. The project will incorporate main building meters with Division 26 providing metering of the main electrical services. In addition, sub-metering will also be installed to the extent possible to isolate energy use of individual systems for SEED. This data will be available to assist troubleshooting high energy use components in the building if the predicted energy use at the end of the 18-month monitoring period is higher than modeled. Data shall be gathered and archived via the building automation system (BAS).
 - b. See Section 231000 - Controls Sequence of Operations – Utility Monitoring for “Utility Metering Table” summarizing the utilities monitored, meters and measured output required.
 3. Data Collection
 - a. Monitoring and Collection: Data for individual equipment meters and summarized data for each metering category will be gathered continuously and trended by the building automation system (BAS).
 - b. The BAS contractor will provide a system with the following features:
 - 1) Monitor "Main Building" meters identified in the “Utility Metering Table”.
 - 2) Performs calculations, conversions, and totalization necessary to report data in required format.
 - 3) Includes a detailed graphic summary screen that clearly organizes and describes metered data.
 - 4) Performs trending and archiving necessary to report data at 15 minute (adjustable) and monthly intervals for a minimum of 24 months after occupancy. Archive media source and methods shall be coordinated with Owner’s personnel.
 - 5) Includes capability for remote workstation monitoring by Owner’s personnel.
 4. Reporting:
 - a. SEED guidelines require that the owner record data for each metering category on a monthly basis by reviewing the data either remotely or on-site at the BAS operator’s workstation. Although SEED guidelines only require monthly reporting of monitored data, it is recommended that all sub-metered data be trended at 15-minute intervals and archived for the duration of the 18-month monitoring period and beyond. Time interval to be verified with Owner’s metering personnel.
 5. Time Frame:

- a. Energy consumption data collection to begin when the following events have occurred:
 - 1) One month after the building is occupied and the first monthly report due one month after collection begins.
 - 2) Completion of Start-Up and Testing described above.
 - 3) Approval to proceed by Owner's project representative and metering personnel.
6. The data collection and reporting to continue for 18 months after the first data collection report is issued.

3.15 DEMONSTRATION

- A. Control equipment shall be tested under operating conditions by a qualified technician in the employ of the Controls Manufacturer, in the presence of Owner's representative or Mechanical Engineer. Upon completion of testing and adjustments, submit written certification to Mechanical Engineer that controls have been calibrated, adjusted and are operating satisfactorily.
- B. Prior to acceptance, the control system shall undergo a series of performance tests to verify operation and compliance with this specification. These tests shall occur after the Contractor has completed the installation, started up the system, and performed his/her own tests.
- C. The tests described in this section are to be performed in addition to the tests that the contractor performs as a necessary part of the installation, start-up, and debugging process and as specified in the "Control System Checkout and Testing" article in Part 3 of this specification. The engineer will be present to observe and review these tests. The engineer shall be notified at least 10 days in advance of the start of the testing procedures.
- D. The demonstration process shall follow that approved in Part 1, "Submittals." The approved checklists and forms shall be completed for all systems as part of the demonstration.
- E. The contractor shall provide at least two persons equipped with two-way communication and shall demonstrate actual field operation of each control and sensing point for all modes of operation including day, night, occupied, unoccupied, fire/smoke alarm, seasonal changeover, and power failure modes. The purpose is to demonstrate the calibration, response, and action of every point and system. Any test equipment required to prove the proper operation shall be provided by and operated by the contractor.
- F. As each control input and output is checked, a log shall be completed showing the date, technician's initials, and any corrective action taken or needed.
- G. Demonstrate the following:
 1. Specified facility management software is installed and operational.
 2. Compliance with sequences of operation through all modes of operation.
 3. Complete operation of operator interface.
 4. DDC control loop response. The contractor shall supply trend data output in a graphical form showing the step response of each DDC control loop. The test shall show the loop's response to a change in set point, which represents a change of actuator position of at least 25% of its full range. The sampling rate of the trend shall be from 10 seconds to 3 minutes, depending on the speed of the loop. The trend data shall show for each sample the set point, actuator position, and controlled variable values. Any loop that yields unreasonably under-damped or over-damped control shall require further tuning by the Contractor.
 5. Demonstrate supply air reset.
 6. BAS system equipment start/stop, and manually start/stop from BAS terminal.
 7. Commandable equipment fails to the desired state on ASC power failure.

8. Equipment under BAS control start and stop automatically as required by the stop/start program or by an operator defined schedule.
 9. Temperature control systems under BAS control operate correctly to maintain respective temperatures within acceptable limits.
 10. Equipment monitored for safety or information purposes generates the required response when a condition needing attention occurs.
 11. Air handlers and fans shut off upon activation of their respective freeze stat or smoke detectors, and remain off until manually reset.
 12. Equipment subject to night setback operation starts automatically when temperature drops to the night setback temperature during unoccupied time.
 13. Optimum start/stop. The contractor shall supply a trend data output showing the capability of the algorithm. The change-of value or change-of-state trends shall include the output status of all optimally started and stopped equipment, as well as temperature sensor inputs of affected areas.
 14. Interface to the building fire alarm system.
- H. Operational logs for each system that indicate all set points, operating points, valve positions, mode, and equipment status shall be submitted to the architect/engineer. These logs shall cover three 48-hour periods and have a sample frequency of not more than 10 minutes. The logs shall be provided in both printed and electronic formats.
- I. Any tests that fail to demonstrate the operation of the system shall be repeated at a later date. The contractor shall be responsible for any necessary repairs or revisions to the hardware or software to successfully complete tests.

END OF SECTION

FSECTION 231000**CONTROLS SEQUENCE OF OPERATIONS****PART 1 GENERAL****1.01 GENERAL**

- A. Provide a complete and operational temperature control and building automation system based on the following points and sequence of operation. The system shall be complete as to sequences and standard control practices. The determined point list is the minimum amount of points that are to be provided. If additional points are required to meet the sequence of operation, they shall be provided.
- B. Definitions and Abbreviations:
 - 1. The following points as defined for each piece of equipment are designated as follows:
 - a. Binary Input (BI) - Defined as any two-state input to controller, such as an alarm, status, etc.
 - b. Binary Output (BO) - Defined as any two-state output from controller, such as start/stop, enable/disable, etc.
 - c. Analog Input (AI) - Defined as any variable input to controller, such as temperature, pressure, position, etc.
 - d. Analog Output (AO) - Defined as any electrical variable output. 0–20mA, 4–20mA and 0–10VDC are the only acceptable analog outputs. The driver for analog outputs must come from both hardware and software resident in the controllers. Transducers will not be acceptable under any circumstance.
 - e. Floating Point Control Output (FO): Use of floating point control will utilize two (2) BO outputs or single AO where indicated.
 - f. Call for Heat: Any heating water coil valve commanded to 5% position or greater for a minimum of five minutes.
- C. Control setpoints noted herein are estimated setpoints for initial start-up. During testing and monitoring, Control Contractor shall be responsible for setpoint adjustment to obtain optimum system performance. Record final settings in Operation and Maintenance Manual.
- D. System setpoints (i.e., temperatures, static pressure, operating times, alarm percentage tolerance, Lead-lag times, etc.) shall be adjustable.
 - 1. Whenever a setpoint is referred to as adjustable in these standards, the setpoint is to be easily and directly adjustable at the Central Facility remote operator's station, and will not require any code modification. This may require assigning virtual points to adjustable setpoints. Frequently adjusted points, including space temperature setpoints, shall be adjustable from the graphics screen (e.g., floor plan screen).
- E. Equipment shut-down to safeties shall not automatically restart, but shall first require manual reset.
- F. Reset loop parameters and setpoints to initial values at the beginning of each operating mode, and after restart due to power failure.
- G. Equipment with VFD's and bypass starters: Safety interlocks and limit controls shall remain in effect during by-pass mode.

PART 2 PRODUCTS - NOT USED**PART 3 EXECUTION****3.01 AIR HANDLING SYSTEM AHU-1 THROUGH AHU-4, AND ASSOCIATED TERM UNITS**

- A. System is a multi-zone, single duct, variable air volume (VAV) system. The VAV air handler includes a supply fan, return fan, hot water preheat coil, chilled water cooling coil, outside air damper, return damper, and relief damper. Terminal units are single duct VAV with hot water reheat coils. The system will operate in various modes of operation including occupied, unoccupied heating, unoccupied cooling, warmup, night flush. System components shall operate in response to the BAS in accordance with these listed operational requirements, control sequences, and set points, subject to safeties.
- B. Equipment (AHU fans, pumps, etc.) with integral VFD/starter HAND-OFF-AUTO switches, (or with separate H-O-A switches provided by Division 26) operational safety interlocks and limit controls shall remain in effect in each switch position, with summary as follows:
 - 1. AUTO: Fan/pump operates in accordance with system control programs, subject to safeties.
 - 2. OFF: Fan off.
 - 3. HAND/VFD BY-PASS: Fan/pump on, speed manually controlled at VFD (where applicable), subject to safeties.
- C. Optimal Start:
 - 1. Warmup Mode
 - a. Enable warmup mode prior to scheduled occupied period based on the time necessary (maximum of 3 hours, adjustable) for the zones to reach their occupied heating setpoints. The start time shall automatically adjust based on changes in outside air temperature and zone temperatures via an optimized start algorithm.
 - b. Air Handler:
 - 1) Supply and return fans operate as in occupied mode.
 - 2) Outside air damper closed, relief air damper closed, return air damper open.
 - 3) Cooling coil operation and economizer cooling are disabled.
 - 4) Preheat coil heating valve modulates to maintain 70 deg F supply air temperature.
 - c. Terminal units operate to maintain occupied zone heating and cooling setpoints. Refer to terminal unit sequence for additional detail.
 - d. Exhaust fan(s) are off.
 - e. Disable warmup mode and switch to occupied mode operation at the beginning of the occupied period.
 - 2. Cooling:
 - a. Enable cooling prior to scheduled occupied time occupied period based on the time necessary (maximum of 1 hour, adjustable) for the zones to reach their occupied cooling setpoints. The start time shall automatically adjust based on changes in outside air temperature and zone temperatures via an optimized start algorithm.
 - b. Air Handler:
 - 1) Supply and exhaust fan operates as in occupied mode.
 - 2) Minimum outside air damper open, relief air damper open, return air damper modulates to occupied supply air temperature.
 - 3) Cooling coil enabled to supply 55 deg F air temperature if optimal start determines that economizer supply air temperature is too high.
 - 4) Heating coil operation disabled.
 - c. Terminal units operate to obtain occupied zone cooling setpoints. Refer to terminal

unit sequence for additional detail.

- d. Disable optimal start cooling mode and switch to occupied mode operation at the beginning of the occupied period.

D. Night Flush Mode:

1. Enable night flush mode when the following conditions are met:
 - a. Time is between 5:00 am (adjustable) and occupied start time, if building schedule will have occupied period the same day.
 - b. Average zone temperature exceeds 74 deg F (adjustable).
 - c. Outside air temperature is below 65 deg F (adjustable) and above 50 deg F (adjustable).
2. Air Handler:
 - a. Operate supply and return fans as in occupied mode; however, set the maximum discharge air pressure setpoint to limit supply flow during night flush mode to 50% of maximum design flow. Coordinate with balancer as necessary to establish max discharge air pressure.
 - b. Preheat coil operation disabled.
 - c. Cooling coil operation disabled.
 - d. Outside air, return air, and relief air dampers operate as in occupied mode to maintain the AHU discharge air temperature at 55 deg F.
3. Terminal units operate to cool spaces to occupied zone heating setpoints. Refer to terminal unit sequence for additional detail.
4. Exhaust fan(s) are on.
5. Disable night flush mode when any of the following occur:
 - a. Occupied period begins.
 - b. Average zone temperature falls below 71 deg F (adjustable).
 - c. Outside air temperature rises above 66 deg F (adjustable).

E. Occupied Mode:

1. Zone temperature setpoints maintained by modulating VAV air valves and heating water valves, in conjunction with modulating components at central unit to maintain setpoints listed for specific system.
2. Fan Modulation and Static Pressure Control:
 - a. Supply and return fan speeds shall modulate through VFD to vary air flow through system.
 - b. Maintain normal static pressure as sensed by static pressure sensor(s) in the supply ducts. Refer to drawings for locations.
 - c. Static Pressure Reset: Establish PID loop to maintain dynamic system static pressure setpoint to maintain space temperature for three zones with greatest cooling demand. Zones selected from user graphic. Return to initial static pressure setpoint for system at beginning of each occupied period, or unoccupied operation mode.
 - d. High limit static pressure switch, located at fan discharge, shuts down supply and return fans if static pressure exceeds 4.5 inches w.g.
 - e. Normal Pressure Setting = 0.75 inches w.g.
 - f. Number of sensors = 1
3. Outside Air Dampers, Automatic Return and Relief:
 - a. Dedicated actuators shall operate outside, return and relief air dampers in accordance with system operating status and supply and return air temperatures.
 - 1) Outside Air Damper:
 - a) Modulating.
 - b) Closed when system is not operating.
 - c) Modulating damper controlled in response to discharge temperature

- required, time of day, outside air ambient sensor, and air flow monitoring station to modulate between minimum outside air and free cooling (economizer). Economizer cycle shall be utilized when outside air temperature is at or below return air temperature.
- d) Closed during unoccupied hour and warm up mode operation, subject to night flush mode.
- 2) Disable economizer operation if heating coil valve is open, through programming.
- b. Return air dampers:
 - 1) Modulating.
 - 2) Damper shall track operation of outside air damper.
 - 3) Full open during unoccupied hour operation, subject to night flush mode.
 - c. Relief damper:
 - 1) Modulating.
 - 2) Damper operates shall track inverse operation of return damper, off common signal. Relief damper fully open when return air damper is fully closed.
 - 3) Closed during unoccupied hour and warm up mode operation, subject to night flush mode.
 - d. AHU Minimum Outside Airflow Control (compensated):
 - 1) Damper Control: Modulate outside air damper to maintain outside airflow setpoint at airflow station.
 - a) Outside Airflow Setpoint: Establish linear airflow requirement between outside air minimums and maximums to air handler supply airflow minimums and maximums.
4. Demand Control Ventilation:
 - a. Ventilation Demand Reset Control: BAS monitors CO2 levels in zones served by the following terminal units: TU-1.109, TU-3.202, TU-3.203, TU-3.208, TU-4.201, TU-4.202, TU-4.203, TU-4.204, TU-4.205, & TU-4.206; and adjusts each corresponding AHU outside airflow in accordance with the following:
 - 1) BAS increases or decreases the “Minimum” outside air setpoint between a “Lower Limit” and “Upper Limit” CFM based on CO2 control levels measured in the spaces. See Demand Control Ventilation mode sequence for Terminal Units hereinafter.
 - 2) Minimum Outside Setpoint Limits:
 - a) “Upper Limit” CFM: Minimum outside air as scheduled on the Drawings.
 - b) “Lower Limit” CFM: 20% (adjustable) of the total supply air CFM.
 - c) Coordinate control and damper adjustments with air balancing agent.
 - d) Outside air flow “Upper Limit” and “Lower Limit” setpoints
 - 3) Outside airflow reduction may be no greater than scheduled ventilation air quantity for each zone as shown on Drawings.
5. Cooling Coil:
 - a. Modulating valve controlled to maintain specified discharge temperature setpoint.
 - b. Supply air temperature reset:
 - 1) Establish PID loop to determine supply temperature setpoint to maintain space temperature for 10% (adjustable) of zones with cooling demand at 90% output or greater.
 - 2) Initial reset cycle loop timing increments:
 - a) Temperature reset up: 1 deg F each 15 minutes.
 - b) Temperature reset down: 1 deg F each 5 minutes.
 - 3) Supply temperature reset shall range from minimum discharge setpoint above up to 65 deg F.

- 4) Discharge temperature shall reset to normal setpoint for system at beginning of each occupied period or unoccupied operation mode.
 - c. Programming shall prohibit simultaneous operation of cooling and preheat coils.
 - d. Initial discharge setpoint = 55 deg F.
 6. Preheat Coil:
 - a. Modulating control valve: Controlled to discharge sensor with 17 foot averaging element to maintain specified leaving air temperature. Disallow preheat coil discharge setpoint to be greater than cooling coil discharge setpoint through programming.
 - b. Initial discharge setpoint = 55 deg F.
 - c. Supply air temperature reset:
 - 1) Supply temperature reset shall range from minimum discharge setpoint above up to 65 deg F.
 - 2) Establish PID loop to determine supply temperature setpoint to maintain space temperature for the 3 zones with cooling demand at 90% output or greater.
 - d. Freeze Protection:
 - 1) Discharge thermostat with 20 foot capillary stops fans through starter circuits, closes outside and relief air dampers, and opens heating coil valve to full flow through coil if discharge drops below 38 deg F.
 - 2) Fans will not restart until thermostat is manually reset.
- F. Unoccupied Modes:
 1. Unoccupied Mode:
 - a. System disabled during scheduled unoccupied periods unless warmup, night flush, unoccupied low limit, unoccupied high limit, or smoke purge modes are enabled. During unoccupied mode the system shall operate as follows:
 - b. Air Handler:
 - 1) Supply and return fans disabled.
 - 2) Outside air damper closed, relief air damper closed, return air damper open.
 - 3) Cooling coil and preheat coil operation disabled, subject to safeties.
 - c. Terminal unit operation is disabled.
 - d. Exhaust fan(s) are off.
 2. Unoccupied Low Limit Mode:
 - a. Enable unoccupied low limit mode when lowest space temperature falls below 55 deg F (adjustable).
 - b. Air Handler:
 - 1) Unit remains un-operational, per unoccupied mode.
 - c. Terminal units operation is disabled.
 - d. Modulate panel radiation control valve to obtain space low limit setpoint.
 - e. Disable unoccupied low limit mode when any of the following occur:
 - 1) When lowest space temperature increases above 60 deg F (adjustable).
 - 2) Warmup mode is enabled.
 - 3) Occupied period begins.
 3. Unoccupied High Limit Mode:
 - a. Enable unoccupied high limit mode when highest space temperature rises above 85 deg F (adjustable).
 - b. Air Handler:
 - 1) Supply and return fans operate as in occupied mode.
 - 2) Minimum outside air damper position set to 0% open.
 - 3) Outside air damper, relief air damper, and return air damper modulate to provide economizer cooling when available as in occupied mode.
 - 4) Cooling coil valve modulates to maintain 55 deg F supply air temperature.

- 5) Preheat coil operation disabled.
 - c. Terminal units operate to maintain unoccupied zone cooling setpoints. Refer to terminal unit sequence for additional detail.
 - d. Disable unoccupied high limit mode when any of the following occur:
 - 1) When average space temperature falls below 80 deg F (adjustable).
 - 2) Warmup mode is enabled.
 - 3) Occupied period begins.
- G. Fire Protection:
1. Duct smoke detector signal from fire alarm panel to shut down AHU system to meet IMC 606. BAS annunciates when a building fire alarm AHU shutdown has occurred.
- H. Input/Output Point Monitoring Summary:
1. As a minimum, the following points and features are to be monitored and alarmed. Control Contractor shall provide additional points necessary to accomplish the sequence of operation and interface with other control equipment.
 2. Inputs:
 - a. AHU Supply fan run status (BI) or (VFD communication)
 - b. AHU Return fan run status (BI) or (VFD communication)
 - c. Supply duct static pressure (AI)
 - d. Outside air temperature (AI)
 - e. AHU Return air temperature (AI)
 - f. AHU Mixed air temperature (AI)
 - g. AHU Supply air temperature (AI)
 - h. Outside air flow quantity (AI)
 - i. Mixed air plenum low pressure (BI)
 - j. AHU Filter Differential Pressure (AI)
 3. Outputs:
 - a. AHU Supply fan start/stop (BO) or (VFD communication)
 - b. AHU Return fan start/stop (BO) or (VFD communication)
 - c. Supply fan VFD modulation (BO) or (VFD communication)
 - d. Return fan VFD modulation (BO) or (VFD communication)
 - e. Outside air damper (AO)
 - f. Return air damper (AO)
 - g. Relief air damper (AO)
 - h. Preheat Coil Valve (AO)
 - i. Cooling Coil Valve (AO)
 - j. Supply duct static pressure (AO)
 4. General Alarms (any unscheduled fan shutdown):
 - a. Air handling unit control panel communication failure
 - b. Mixed air high/low temperature
 - c. AHU Supply fan failure (annunciated)
 - d. AHU Return fan failure (annunciated)
 - e. Freeze shutdown (annunciated)
 - f. Supply air low temperature limit (annunciated)
 - g. Supply duct static pressure high/low limit
 - 1) Alarm at excess of 15% above or below setpoint.
 - h. Zone temperature high/low limit
 - 1) Alarm at excess of 3% above or below setpoint.
- I. Terminal Units, TUs associated with each AHU system:
1. Control damper and coil control valve at coil shall modulate in response to Space Sensor

- for that zone, in accordance with heating, cooling, and deadband temperature setpoints.
2. Provide sensor downstream of each terminal unit to monitor supply air temperature.
 3. Optimal Start/Warm-up:
 - a. Primary Airflow Settings:
 - 1) Maximum = Scheduled Primary CFM (adjustable)
 - b. Primary Damper Operation:
 - 1) Modulate damper to maintain maximum primary airflow setpoint when zone temperature is below occupied heating setpoint.
 - 2) Modulate damper to minimum primary flow when zone temperature reaches or rises above the occupied heating setpoint.
 - c. Heating Coil Valve Position: Modulating.
 4. Night Flush/Optimal Start, Pre-cooling:
 - a. Primary Airflow Settings:
 - 1) Maximum = Scheduled Primary CFM (adjustable)
 - b. Primary Damper Operation: Modulate damper to maintain maximum primary airflow setpoint when zone temperature is above occupied heating setpoint. Close damper (to zero flow) when zone temperature reaches or drops below the occupied heating setpoint.
 - c. Heating Coil Valve Position: Closed.
 5. Occupied Operation:
 - a. Zone temperature setpoints maintained by modulating terminal unit air valves and heating water valves, in conjunction with modulating components at central unit to maintain setpoints listed for specific system.
 - b. Heating setpoint = 70 deg F.
 - c. Cooling setpoint = 75 deg F.
 - d. Damper Position:
 - 1) Cooling: Damper modulates to meet cooling requirement.
 - 2) Dead-band region: Damper at minimum setpoint.
 - 3) Heating: Damper to modulate to minimum setpoint before opening heating coil valve.
 - e. Valve Position:
 - 1) Cooling: Control valve positioned to stop water flow through coil.
 - 2) Dead-band region: Control valve positioned to stop water flow through coil.
 - 3) Heating: Control valve modulates to meet heating requirement.
 6. Unoccupied Operation During Occupied Hours:
 - a. Zones included: Where indicated on Drawings in Terminal Unit Schedule as having "Occupancy Sensor Control".
 - b. Occupancy sensors provided under Division 26.
 - c. If, after 15 minutes, no occupants are sensed in given area, VAV terminal units serving that area shall reduce flow to 50% of heating or 20%, whichever is lower, subject to maintaining temperature in accordance with night setback operation. Terminal units shall return to Occupied Mode operation immediately upon sensing occupancy in space during normally occupied hours.
 - d. For zones with more than one room, occupancy sensors shall be connected in series or parallel (depending on N.O. or N.C. contacts) for single zone input to equipment controller.
 7. Unoccupied Modes:
 - a. Terminal units will signal the AHU unit to operate on call cooling supply air.
 - b. Unoccupied Low Limit Mode:
 - 1) Heating setpoint = 60 deg F.
 - 2) Terminal unit operation is disabled.

- 3) Space heating requirement met by panel radiators.
- c. Unoccupied High Limit Mode:
 - 1) Cooling setpoint = 80 deg F. Call for cooling initiates at 5 deg F above unoccupied setpoint. System shall remain ON until space temperature is reaches unoccupied setpoint.
- d. Unoccupied hour override switch:
 - 1) Applies during scheduled building unoccupied periods.
 - 2) When activated by space occupant, the switch shall temporarily activate the affected terminal unit and AHU to occupied operational mode.
 - 3) After expiration of preset time, system shall return to unoccupied mode.
 - 4) Time duration for change over to occupied mode shall be adjustable from 1/2 to 3 hours. Initially set for 3 hour.
8. Demand Control Ventilation:
 - a. When space temperature is above cooling setpoint, zone is in cooling mode. Heating valve fully closed and damper modulates as required by flow control loop to maintain flow setpoint. Carbon dioxide sensor installed where shown on Drawings measures CO2 level in space served. Establish PID loop to perform calculations for zone air flow required.
 - b. Loop output to determine "ventilation minimum" zone air flow setpoint as required to maintain CO2 setpoint. Maximum output limit: maximum cooling airflow as scheduled on drawings, Minimum output limit: 20% of maximum cooling airflow.
 - c. Maintain the room CO2 level setpoint of 800 parts per million, by adjusting the zone damper until either the maximum or minimum CFM setpoints are reached.
 - d. See "Ventilation Demand Reset Control" under Air Handling System Sequence of Operation.
9. Radiation Valve Position:
 - a. Enabled only when zone is in call for heating with loop input of 50% or greater, subject to unoccupied low limit mode.
 - b. When zone temperature is less than its heating setpoint, and the TU serving the space is in deadband or heating, modulate radiation control valve to maintain space heating setpoint.
10. Input/Output Point Monitoring Summary:
 - a. As a minimum, the following points and features are to be monitored and alarmed. Control Contractor shall provide additional points necessary to accomplish sequence of operation and interface with other control equipment.
 - b. Inputs:
 - 1) Terminal unit supply air temperature (AI)
 - 2) Terminal unit air flow, cfm (AI)
 - 3) Space Temperatures (AI) (each zone)
 - 4) Zone CO2 Sensor (AI) (each zone)
 - c. Outputs:
 - 1) Heating Coil Valve (AO) (each zone)
 - 2) Terminal unit damper position (AO) (each zone)
 - 3) Radiation valve position (AO) or (FO) (each zone)
 - d. General Alarms:
 - 1) Zone temperature high/low limit
 - a) Alarm at excess of 3% above or below setpoint

3.02 AIR HANDLING SYSTEM HRU-1

A. HEAT RECOVERY AIR HANDLER SYSTEM

- B. HRU-1 is a supply and exhaust fan system with heating and chilled water coils, and heat pipe heat recovery. AHU system is a constant volume system, and operates during occupied hours and when commanded on to maintain unoccupied temperature setpoints. Fans are off unless occupancy is scheduled, or high or low limit temperature maintenance is required.
- C. Fan starter functionality:
 - 1. AUTO: Fan operates in accordance with system control programs, subject to safeties.
 - 2. OFF: Fan off.
 - 3. HAND: Fan operates as follows, subject to safeties.
 - 4. Fan with VFD: Fan on, speed manually controlled at VFD, subject to safeties.
- D. Warmup Mode/Optimal Start:
 - 1. Enable warmup mode prior to scheduled occupied period based on the time necessary (maximum of 3 hours, adjustable) for the zones to reach occupied heating setpoints. The start time shall automatically adjust based on changes in outside air temperature and zone temperatures via an optimized start algorithm.
 - 2. Air Handler:
 - a. Supply and exhaust fans operate as in occupied mode.
 - b. Damper set as in occupied mode.
 - c. Heating coil operations to deliver full heating capacity to spaces served.
 - 3. Disable warmup mode and switch to occupied mode operation at the beginning of the occupied period.
- E.
- F. AHU Automatic Dampers:
 - 1. Individual dedicated actuators shall operate outside, face and by-pass, and exhaust air dampers in accordance with system operating status and supply and return air temperatures.
 - 2. Automatic Exhaust, and Outside Air Dampers:
 - a. Outside Air Damper:
 - 1) Two-position.
 - 2) Closed when HRU is not operating.
 - b. Exhaust damper:
 - 1) Two-position.
 - 2) Closed when HRU is not operating.
 - c. Heat pipe face-and-bypass damper:
 - 1) Modulating.
 - 2) Face damper normally open, bypass closed, subject to economizer and heat exchanger defrost modes.
- G. Cooling Coil:
 - 1. Modulate cooling coil control valve in accordance with space cooling requirements.
 - 2. Cooling coil shall be enabled, when the outside air temperature is 60 deg (adjustable), or higher.
 - 3. Programming shall prohibit simultaneous operation of cooling and heating coils.
- H. Heating Coil:
 - 1. Control valve modulates in accordance with space heating requirements. Controlled by discharge thermostat with 17 foot averaging element. Disallow heating coil discharge set point to be greater than cooling coil discharge set-point through programming.
 - 2. Local circulating pump, HWP-3: Activated when system is in heating mode and as indicated herein. Pump off in dead-band or cooling mode.

- a. If HWP-3 fails to start on command, an alarm is generated.
3. Modulating control valve: Controlled to maintain specified discharge air temperature in rooms served, using average readings.
4. Disallow pre-heat coil operation when outside air temperature is at or above discharge set-point through programming.
5. Upon unit startup, if outside air temperature is 45 deg F (adjustable) or lower, open heating coil valve to 50% position (adjustable), for one minute period (initial setting, adjustable) to warm coil prior to starting fan. After period has elapsed, start fan and reset coil valve position to maintain discharge air temperature.
6. Low Limit Temperature Control:
 - a. Supply air temperature sensor shall open heating coil valve to full flow through heating coil if discharge drops below 45 deg F.
 - b. Low limit alarm shall be annunciated at the BAS.
 - 1) System returns to "normal" operation when thermostat senses 65 deg F.
- I. Freeze Protection:
 1. Discharge thermostat with 20 foot capillary stops fans through starter circuits, closes outside and relief air dampers, and activates HWP-3 circulating pump, opens heating coil valve to full flow through coil if discharge drops below 38 deg F.
- J. Heat pipe economizer mode:
 1. Enable mode if outside air temperature is between unit supply air temperature and return air temperature.
 2. Drive damper face closed/bypass open to prevent heat recovery when condition allows outside air cooling.
 3. Disable mode when rising outside air temperature matches return air temperature, and drive damper to face open/bypass closed.
- K. Heat Pipe Defrost Mode:
 1. As exhaust stream air temperature downstream of the heat pipe approaches 35 deg F (adjustable), modulate face closed/bypass damper open, 50% (adjustable) initially.
 2. As exhaust air temperature downstream of heat pipe rises, modulate damper to face open/bypass damper closed.
- L. Input/Output Point Monitoring Summary:
 1. As a minimum, the following points and features are to be monitored and alarmed. Control Contractor shall provide additional points necessary to accomplish the sequence of operation and interface with other control equipment.
 2. Inputs:
 - a. Space temperature (AI) (Typical of 2)
 - b. Supply fan run status (BI).
 - c. Exhaust fan run status (BI).
 - d. Outside air temperature (AI).
 - e. Exhaust air temperature upstream of HR coil (AI).
 - f. Exhaust air temperature downstream of HR coil (AI).
 - g. Supply air temperature downstream of HR coil (AI).
 - h. Supply air temperature downstream of heating coil (AI)
 - i. Preheat coil pump status (BI)
 - j. HWP-3 status (DI) (CT)
 3. Outputs:
 - a. Supply Fan start/stop (BO)
 - b. Exhaust Fan start/stop (BO)
 - c. Outside Air damper (BO)

- d. Exhaust Air damper (BO).
 - e. Heating Coil Valve (AO).
 - f. Cooling Coil Valve (AO)
 - g. Heat Pipe Face and bypass damper (AO)
 - h. Preheat coil pump start/stop (BO)
 - i. HWP-3 start/stop (DO)
4. General Alarms:
- a. Air handling unit control panel communication failure.
 - b. VFD communication failure.
 - c. Supply fan failure (annunciated).
 - d. Exhaust fan failure (annunciated).
 - e. Freeze shutdown (annunciated).
 - f. Supply air low temperature limit (annunciated).
 - g. Preheat coil pump failure (annunciated)

3.03 BASEMENT MECHANICAL ROOM

- A. Area ventilated by exhaust fan and gravity outside air duct, each with automatic damper shutoff.
- B. EF-3 provides space ventilation and cooling for contiguous area, in conjunction with outside air supplied through a gravity duct. Automatic damper on outside air duct is normally closed, and opens in conjunction with EF-3 operation.
- C. Fan operates when space temperature is at or above 85 degrees.
- D. Monitor operation of fan with CT switch.
- E. If exhaust fan fails
- F. Input/Output Point Monitoring Summary:
 - 1. As a minimum, the following points and features are to be monitored and alarmed. Control Contractor shall add additional points necessary to accomplish sequence of operation and interface with other control equipment.
 - 2. Inputs:
 - a. Mechanical room space temperature (AI)
 - 3. Outputs:
 - a. EF-3 automatic damper (BO)
 - b. Mechanical room ventilation duct damper (BO)
 - 4. General Alarms :
 - a. Fan motor failure (annunciated)
 - b. Low space temperature (below 40 deg F)

3.04 ATTIC MECHANICAL ROOM AND STORAGE AREA

- A. Area ventilated by exhaust fan and gravity outside air duct, each with automatic damper shutoff. Unit heaters provide heating for storage spaces, and minimum temperature protection for contiguous attic area.
- B. EF-1 provides space ventilation and cooling for contiguous area, in conjunction with outside air supplied through a gravity duct. Automatic damper on outside air duct is normally closed, and opens in conjunction with EF-1 and/or EF-2 operation.
 - 1. Fan operates when space temperature is at or above 80 degrees.
 - 2. Utilize unit heater space temperature sensors for monitoring space temperature.
- C. EF-2 provides space ventilation for storage areas, when activated by manual space timer. When timer is turned on, fan runs (and if mechanical area outside air automatic damper is closed,

damper opens) for duration of timer signal.

- D. Unit heaters UH-1 & UH-2:
 - a. Heating water control valve opens and unit heater fan operates in response to wall mounted space sensor subject to safeties:
 - a) Unit Heater on = 55 deg F.
 - b) Unit Heater off = 60 deg F.
 - b. Unit Heater fan operation monitored with a current transformer switch.
- E. Input/Output Point Monitoring Summary:
 - 1. As a minimum, the following points and features are to be monitored and alarmed. Control Contractor shall add additional points necessary to accomplish sequence of operation and interface with other control equipment.
 - 2. Inputs:
 - a. South Storage area space temperature (AI)
 - b. North storage area space temperature (AI)
 - 3. Outputs:
 - a. UH-1 fan start/stop (BO)
 - b. UH-2 fan start/stop (BO)
 - c. UH-1 heating water valve position (BO)
 - d. UH-2 heating water valve position (BO)
 - e. EF-1 automatic damper (BO)
 - f. Ventilation duct damper (BO)
 - 4. General Alarms :
 - a. Unit Heater fan failure (annunciated)
 - b. Low space temperature (below 40 deg F)

3.05 HEATING WATER SYSTEM

- A. Heating water system utilizes steam to hot water heat exchanger, with steam from the campus central plant. Condensate is returned to campus pumped return system with a Condensate Return Unit (CRU-1) which will have high water alarm. Two heating water circulating pumps HWP-1 & HWP-2 will be with lead-lag operation with distribution to the mechanical rooms, and throughout the building with connections to radiation heating and air terminal unit heating coils. Heating water temperature will be controlled with a reset schedule based on outside air temperature.
- B. Heating water system shall be enabled when all of the following are true:
 - 1. Any hot water heating coil or device calls for heat.
 - 2. Outside air temperature is below heating water reset schedule maximum outdoor temperature.
- C. Heating Water Circulating Pumps HWP-1 & HWP-2
 - 1. Pumps operate subject to integral HAND-OFF-AUTO switches on VFDs.
 - a) AUTO: Pumps operate in lead-lag arrangement subject to BAS. Lead pump shall activate if there is a requirement for heating received from any portion of system served.
 - b) OFF: Pumps inoperative
 - c) HAND: Lead Pump operates.
 - d) Lead-Lag Operation: Lead pump to alternate once per month. If lead pump fails for 15 seconds, as sensed by VFD, lag pump shall start and an alarm is sent the BAS.
 - 2. Heating Water Pump VFD Operation:
 - a. VFD modulates to maintain constant pressure in heating water piping based on

- differential pressure sensor. Determine minimum suitable pump motor speed in conjunction with Owner provided balancing agent.
- b. VFD modulates to maintain constant pressure in heating water piping based on differential pressure sensor, initially set at 10 psi.
 - c. When the lead pump is enabled to operate, following a receipt of start signal, a 30 minute (adjustable) minimum run time shall be established
 - d. On failure of the lead pump, the lag pump shall start and the lead pump shall turn off and set an alarm.
- D. Heat Exchanger (HE-1):
1. Water Temperature Control: Temperature sensor in heating supply water shall modulate steam regulating valves in sequence to maintain heating supply temperature at outlet of heat exchanger, initially set at 160 deg F LWT. Sensors in heating supply and return water to monitor temperature at BAS.
 2. Steam vortex flow meter to monitor and totalize building steam mass flow. Meter to provide continuous reporting of flow rate to the BAS. Display steam flow in lb/hr at BAS graphic station, with totalizing output in units of kilo-pounds of steam.
 3. Heating water temperature shall be automatically reset based on the following:
 - a. As outside air temperature rises from 20 deg F (or below, adjustable) to 70 deg F (adjustable), the hot water supply temperature setpoint shall reset downwards from 160 deg F (adjustable) to 100 deg F (adjustable).
 4. Heating water system shall be enabled when all of the following are true:
 - a. Any hot water heating coil calls for heat.
 - b. Outside air temperature is below heating water reset schedule maximum outdoor temperature, and occupancy is scheduled for that day.
 5. Heating Water Circulating Pumps HWP-1 & HWP-2
 - a. Pumps operate subject to HAND-OFF-AUTO switches at VFDs.
 - b. AUTO: Pumps operate in lead-lag arrangement subject to BAS. Lead pump shall activate if there is a requirement for heating received from any portion of system served.
 - c. OFF: Pumps inoperative
 - d. HAND: Pump operates.
 - e. Lead-Lag Operation: Lead pump to alternate once per month. If lead pump fails for 15 seconds, as sensed by VFD, lag pump shall start and an alarm is sent the BAS.
- E. Input/Output Point Monitoring Summary:
1. As a minimum, the following points and features are to be monitored and alarmed. Control Contractor shall add additional points necessary to accomplish sequence of operation and interface with other control equipment.
 2. Inputs:
 - a. Pump lead-lag selection (AI)
 - b. Lead pump run status (VFD Communication)
 - c. Lag pump run status (VFD Communication)
 - d. Heating Water Supply Temperature (AI)
 - e. Heating Water Return Temperature (AI)
 - f. Steam Pressure (AI)
 - g. Steam Flow (AI)
 3. Outputs:
 - a. Lead pump start/stop (VFD Communication)
 - b. Lag pump start/stop (VFD Communication)
 - c. Lead pump VFD modulation (VFD Communication)
 - d. Lag pump VFD modulation (VFD Communication)

- e. Steam Control Valve, 1/3 (AO)
- f. Steam Control Valve, 2/3 (AO)
- 4. General Alarm:
 - a. Heating water supply high/low temperature (annunciated)
 - b. Pump failure (annunciated)
 - c. High/Low Supply Water Temperature (annunciated).
 - 1) Alarm at $\pm 5\%$ (adjustable) of supply setpoint.
- F. Condensate Return Unit (CRU-1):
 - 1. Unit controlled through integral control panel, with high water monitoring only by BAS.
 - 2. Input/Output Point Monitoring Summary:
 - a. As a minimum, the following points and features are to be monitored and alarmed. The Control Contractor shall add any additional points necessary to accomplish the sequence of operation and interface with other control equipment.
 - b. General Alarm:
 - 1) High Water Alarm (annunciated).
- G. Steam Trap Monitoring:
 - 1. Temperature sensor installed downstream of each steam trap shall monitor temperature of condensate discharge pipe. Monitor through BAS. If a temperature of 220°F is sensed for more than 30 minutes, system shall be put into alarm mode.
 - 2. Input/Output Point Monitoring Summary:
 - a. As a minimum, the following points and features are to be monitored and alarmed. Control Contractor shall add additional points necessary to accomplish sequence of operation and interface with other control equipment.
 - b. Inputs:
 - 1) Condensate Temperature (AI)
 - c. General Alarms:
 - 1) Trap Failure (annunciated)
 - 2) Indicate specific trap

3.06 CHILLED WATER SYSTEM

- A. Chilled water system utilizes campus chilled water from the campus central plant. One chilled water circulating pump CHWP-1 will be controlled as a variable flow primary only system with distribution to mechanical cooling coils in units in the building. Sequence includes freeze protection cycle for chilled water piping. Control valve on building main modulates to maintain building supply water temperature and minimize by-pass leg flow.
- B. Chilled Water Pump VFD Operation:
 - 1. Chilled water system enabled when outside temperature is 60 degrees F.
 - 2. On building call for cooling, pump is enabled to operate with a 30 minute minimum run time following a receipt of start signal.
 - 3. VFD modulates to maintain constant pressure in building chilled water piping based on differential pressure sensor, initially at 15 psi (adjustable). Determine minimum suitable pump motor speed in conjunction with Owner provided balancing agent.
 - 4. Modulate building chilled water control valve to maintain a chilled water temperature within 1 degree F above that of the incoming building supply water temperature (to prevent water flow through de-coupling by-pass).
 - a. Campus chilled water valve installed on chilled water return, closed when pump is off.
 - 5. Chilled water system freeze protection (stage 1):
 - a. Enable chilled water system freeze protection when outside air temperature is 35 deg F or below.

- b. Enable chilled water pump operation at 50% speed until chilled water temperature rises above 42 deg F (adjustable) building chilled water supply temperature sensor, minimum operating time 30 minutes (adjustable).
- C. Input/Output Point Monitoring Summary:
 1. As a minimum, the following points and features are to be monitored and alarmed. Control Contractor shall add additional points necessary to accomplish sequence of operation and interface with other control equipment.
 2. Inputs:
 - a. Chilled water differential pressure (AI)
 - b. Pump run status (VFD Communications)
 3. Outputs:
 - a. Pump start/stop (VFD Communications)
 - b. Pump VFD modulation (VFD Communications)
 - c. Campus chilled water 2-way valve (AO)
 4. General Alarms:
 - a. Building chilled Water Pump failure (annunciated)
 - b. Building chilled water supply temperature high/low
 - 1) Alarm at excess of 10% above or below set-point.

3.07 DOMESTIC WATER HEATING SYSTEM

- A. Domestic Water Heater (existing water heater):
 1. Operation of unit is controlled by integral thermostat without connection to BAS.
- B. Domestic Hot Water Recirculation, DP-1:
 1. Return Water Temperature Control:
 - a. During occupied periods:
 - 1) If flow is sensed in the makeup water pipe (incoming cold water), then allow pump to respond to immersion temperature sensor control for 15 minutes beyond the time flow was sensed.
 - 2) Immersion temperature sensor in recirculating hot water piping to operate pump to maintain setpoint. Controller set to activate HWR Pump at 115 deg F and deactivate at 120 deg F, subject to flow sensor and occupancy.
 - b. During Unoccupied periods:
 - 1) Recirculation pump: Off
 2. Operation of pump shall be monitored with a current transformer switch.
 3. Input/Output Point Monitoring Summary:
 - a. As a minimum, the following points and features are to be monitored and alarmed. The Control Contractor shall add any additional points necessary to accomplish the sequence of operation and interface with other control equipment.
 - b. Inputs:
 - 1) Water Supply Temperature (AI)
 - 2) Water Return Temperature (AI)
 - c. General Alarms (any unscheduled pump shutdown):
 - 1) Pump failure (annunciated)
 - 2) Water Supply High Temperature (annunciated)
 - a) alarm at $\pm 5\%$

3.08 UTILITY MONITORING

- A. General:
 1. The equipment necessary to monitor the following services will be provided by Section

230900. BAS shall record demand and energy usage on a continuous basis and show measured quantities listed in the “Utility Metering Category Table” below on the BAS workstation graphics.

2. Additional wiring required for monitoring equipment and the flow transducers shall be provided by Section 230900. Division 26 will terminate 120 volt power near flow stations. This Section to complete wiring.
3. Low voltage wiring and connection between monitoring equipment and the BAS system control panel/s shall be provided by Section 230900.

B. Heating Water System:

1. Heating Water Pump HWP-1 Electrical Demand, kW, from VFD (VFD Comm.)
2. Heating Water Pump HWP-1 Electrical Usage, kWh, from VFD (VFD Comm.)
3. Heating Water Pump HWP-2 Electrical Demand, kW, from VFD (VFD Comm.)
4. Heating Water Pump HWP-2 Electrical Usage, kWh, from VFD (VFD Comm.)
5. Steam usage from meter (AI)

C. Chilled Water System:

1. Chilled Water Pump CHWP-1 Electrical Demand, kW, from VFD (VFD Comm.)
2. Chilled Water Pump CHWP-1 Electrical Usage, kWh, from VFD (VFD Comm.)
3. Chilled water flow rate (AI from BTU meter)
4. Chilled water campus supply water temperature (AI from BTU meter)
5. Chilled water building supply temperature (AI)
6. Chilled water return temperature (AI)
7. Chilled water energy rate (AI from BTU meter)
8. Chilled water total energy consumed (Analog value)

D. Utility Metering Category Table:

Metering Category	Metered Loads	Reporting Units	BAS Trending Frequency	SEED Reporting Frequency	Data Collected By
<i>Electric Metering</i>					
Chilled Water System	Chilled Water Energy Use Chilled Water Pump	kW and kWh, Ton- hours	15 min	Monthly	BAS and Facilities
Heating Water System	Heating Water Pumps and Building Steam Usage	kW and kWh klbs of steam	15 min	Monthly	BAS and Facilities
Building Electrical service	1) Current 2) Voltage 3) Reactive Power 4) Apparent Power 5) Power Factor 6) Demand, kW 7) Consumption, kWh	Amps Volts kW kW PF kW kWh	15 min	Monthly	BAS and Facilities

END OF SECTION

SECTION 233100**DUCTWORK****PART 1 GENERAL****1.01 RELATED SECTIONS**

- A. Section 201000 - General Mechanical Provisions
- B. Section 202000 - Mechanical Operation and Maintenance Manuals
- C. Section 230700 - Ductwork Insulation
- D. Section 233300 - Ductwork Accessories

1.02 SHOP DRAWINGS, PRODUCT DATA, OPERATION & MAINTENANCE DATA

- A. Submittals required for the products listed in the Product Table, in accordance with Section 201000. Operation & Maintenance Information required as indicated in the Product Table in accordance with Section 202000.
- B. Operation & Maintenance Information requirements indicated by number designation as follows. Refer to Section 202000 for a description of each type of information.
 - 1. Shop Drawings (submittal data)
 - 2. Product Data (submittal data), including documentation of ORS 453.005 (7) (e) compliance.
 - 3. Manufacturer's Operation Manuals
 - 4. Manufacturer's Service and Lubrication Requirements
 - 5. Service Contracts and Field Start-up Reports
 - 6. Cleaning, Certification, and Test Reports
 - 7. System Information
 - 8. Warranties

PRODUCT TABLE	Operation & Maintenance Information							
	1	2	3	4	5	6	7	8
Round and Oval Duct, Medium Pressure	X	X				X		
Flexible Duct		X						
Duct Sealants		X						

PART 2 PRODUCTS**2.01 DUCTWORK**

- A. Fabrication and Site Delivery:
 - 1. Factory / Shop sealed by blanking or capping duct ends, bagging of small fittings, surface wrapping or shrink wrapping.
- B. Rectangular Ducts, Medium Pressure:
 - 1. Ducts Included:
 - a. Supply ducts from Air Handling Units to Air Terminal Units.
 - 2. Material: Galvanized steel.
 - 3. Fabricate and support in accordance with:
 - a. Oregon Mechanical Specialty Code, current edition.
 - b. SMACNA HVAC Duct Construction Standards, current edition.

4. Pressure Classification:
 - a. Supply Ducts: 6 inch w.g. positive static pressure.
 5. Transverse Joints: In accordance with details in SMACNA HVAC Duct Construction Standards "T-25" configuration or one of the following proprietary joint systems:
 - a. Ductmate "35" with DM 440 gasket tape.
 - b. Ductmate "45" with DM 440 gasket tape.
 - c. Ward Duct Connectors Inc. "WDCI Lite" with butyl gasket tape.
 - d. Ward Duct Connectors Inc. "WDCI Heavy" with butyl gasket tape.
 - e. "Spinfinity AccuFlange."
 6. Crossbreaking or Rollbeading:
 - a. Duct panels 16 inches wide and larger shall be rollbeaded or crossbroken, regardless of whether or not duct is lined or insulated.
 7. Material Thickness:
 - a. Duct gauges shall be determined using tables in SMACNA HVAC Duct Construction Standards, based on duct size, material, pressure class, joint type, and reinforcement spacing.
 - b. "Addendums to SMACNA" and other publications by proprietary joint manufacturers shall not be used for determining material thickness.
 - c. For determining duct gauges using SMACNA tables, proprietary joint systems shall be considered equivalent to the following SMACNA rigidity classes:
 - 1) Ductmate "35": Class "J."
 - 2) Ductmate "45": Class "K."
 - 3) Ward "WDCI Heavy": Class "J."
 - d. Ducts with proprietary joints shall be 24 gauge minimum.
 8. Sealing Requirements: Seal transverse joints and longitudinal seams with tape-and-adhesive or liquid duct sealer, specified herein. Flanged, gasketed joints that meet testing requirements need not have duct sealer applied.
 9. Fittings: Refer to details on Drawings.
- C. Round and Oval Ducts, Medium Pressure and/or Exposed:
1. Ducts Included:
 - a. Ducts from Air Handling Units to Air Terminal Units.
 2. Material: Galvanized steel.
 3. Fabricate and support in accordance with latest editions of:
 - a. Oregon Mechanical Specialty Code
 - b. SMACNA HVAC Duct Construction Standards
 4. Pressure Classification: 6 inch w.g. positive static pressure, except where noted otherwise on Drawings.
 5. Duct Joints:
 - a. Seams: Spiral lockseam.
 - b. Transverse Joints, except exposed: In accordance with details in SMACNA HVAC Duct Construction Standards "T-25" configuration or one of the following proprietary joint systems:
 - 1) Ductmate "35" with DM 440 gasket tape.
 - 2) Ductmate "45" with DM 440 gasket tape.
 - 3) Ward Duct Connectors Inc. "WDCI Lite" with butyl gasket tape.
 - 4) Ward Duct Connectors Inc. "WDCI Heavy" with butyl gasket tape.
 - 5) "Spinfinity AccuFlange."
 - c. Transverse Joints, Exposed Ducts: Flanged joints, TDC, Accu-Flange, or similar.
 6. Material Thickness: In accordance with tables in SMACNA HVAC Duct Construction Standards, based on duct diameter, duct material, and pressure class.

7. Sealing Requirements:
 - a. Medium Pressure: Seal transverse joints with tape-and-adhesive or liquid duct sealer, specified herein. Flanged, gasketed joints that meet testing requirements need not have duct sealer applied.
 - b. Exposed: Seal transverse joints with liquid duct sealer, specified herein, applied to male fittings only, so that sealer shall not be visible when joint is assembled.
 8. Fittings:
 - a. Factory-fabricated by duct manufacturer.
 - b. Elbows shall be of die-stamped, pleated, standing seam, or gored (segmented) construction. Die-stamped fittings 8" diameter and larger 22 gauge minimum. Die-stamped fittings smaller than 8" diameter 24 gauge minimum.
 - c. 90° gored elbows shall be 5 piece.
 - d. 45° gored elbows shall be 3 piece.
 - e. Gored elbows shall have continuously welded seams. Spot-welded with sealant is not acceptable.
 - f. Joints of standing seam fittings shall be fully sealed with liquid sealant.
 - g. See details on Drawings.
 9. Manufacturer: Metco, Dee's Sheet Metal, SEMCO, Arrow, Arjae Sheet Metal, Omni Duct Systems, Rolok Products, Robert Lloyd Sheet Metal, or approved.
- D. Rectangular Ducts:
1. Material: Galvanized steel.
 2. Fabricate and support in accordance with:
 - a. Oregon Mechanical Specialty Code, current edition.
 - b. SMACNA HVAC Duct Construction Standards, current edition.
 3. Pressure Classification:
 - a. Supply Ducts: 2 inch w.g. positive static pressure, except where noted otherwise on Drawings.
 - b. Return, Exhaust, and Outside Air Ducts: 2 inch w.g. negative static pressure, except where noted otherwise on Drawings.
 4. Transverse Joints: In accordance with details in SMACNA HVAC Duct Construction Standards or one of the following proprietary joint systems:
 - a. Ductmate "25" with butyl gasket tape.
 - b. Ductmate "35" with butyl gasket tape.
 - c. Lockformer "TDC" with butyl gasket tape.
 - d. Ward Duct Connectors Inc. "WDCI Lite" with butyl gasket tape.
 - e. Ward Duct Connectors Inc. "WDCI Heavy" with butyl gasket tape.
 - f. Spinfinity "AccuFlange."
 5. Crossbreaking or Rollbeading:
 - a. Duct panels 16 inches wide and larger shall be rollbeaded or crossbroken, regardless of whether or not duct is lined or insulated.
 6. Material Thickness:
 - a. Duct gauges shall be determined using tables in SMACNA HVAC Duct Construction Standards, based on duct size, material, pressure class, joint type, and reinforcement spacing.
 - b. "Addendums to SMACNA" and other publications by proprietary joint manufacturers shall not be used for determining material thickness.
 - c. For determining duct gauges using SMACNA tables, proprietary joint systems shall be considered equivalent to the following SMACNA rigidity classes:
 - 1) Lockformer "TDC," 24 gauge: Class "D."
 - 2) Lockformer "TDC," 22 gauge: Class "E."

- 3) Lockformer "TDC," 20 gauge: Class "F."
 - 4) Lockformer "TDC," 18 gauge, with tie rod(s) on each side of joint: Class "K."
 - 5) Ductmate "25": Class "F."
 - 6) Ductmate "35": Class "J."
 - 7) Ward "WDCI Lite": Class "F."
 - 8) Ward "WDCI Heavy": Class "J."
 - d. Ducts with proprietary joints shall be 24 gauge minimum.
 - e. Equivalent aluminum duct gauges shall be determined in accordance with SMACNA HVAC Duct Construction Standards.
 7. Sealing Requirements: Seal transverse joints and longitudinal seams with tape-and-adhesive or liquid duct sealer, specified herein. Not required for gasketed, flanged joints.
 8. Fittings: Refer to details on Drawings.
- E. Round Ducts, Indoors, Except Medium Pressure and Exposed:
1. Material: Galvanized steel.
 2. Fabricate and support in accordance with latest editions of:
 - a. Oregon Mechanical Specialty Code
 - b. SMACNA HVAC Duct Construction Standards
 3. Pressure Classification:
 - a. Supply Ducts: 2 inch w.g. positive static pressure, except where noted otherwise on Drawings.
 - b. Return and Exhaust Ducts: 2 inch w.g. negative static pressure, except where noted otherwise on Drawings.
 4. Duct Joints:
 - a. Seams: Longitudinal or spiral, in accordance with SMACNA HVAC Duct Construction Standards. Longitudinal seams shall be spot welded. Snaplock not acceptable.
 - b. Transverse Joints:
 - 1) Option 1: In accordance with details in SMACNA HVAC Duct Construction Standards "T-25" configuration or one of the following proprietary joint systems:
 - a) Ductmate "35" with DM 440 gasket tape.
 - b) Ductmate "45" with DM 440 gasket tape.
 - c) Ward Duct Connectors Inc. "WDCI Lite" with butyl gasket tape.
 - d) Ward Duct Connectors Inc. "WDCI Heavy" with butyl gasket tape.
 - e) "Spinfinity AccuFlange."
 - 2) Option 2: Slip joints, crimped or expanded.
 5. Material Thickness: In accordance with tables in SMACNA HVAC Duct Construction Standards, based on duct diameter, duct material, pressure class, and seam type.
 6. Sealing Requirements: Seal transverse joints with tape-and-adhesive or liquid duct sealer, specified herein. Not required for gasketed, flanged joints.
 7. Fittings: Refer to details on Drawings.
- F. Built-Up Plenums (not part of fans or air handling units):
1. Material: Galvanized steel.
 2. Fabricate and support in accordance with latest editions of:
 - a. Oregon Mechanical Specialty Code
 - b. SMACNA HVAC Duct Construction Standards
 3. Pressure Classification: 2 inch w.g. positive static pressure, 2 inch w.g. negative static pressure, except where noted otherwise on Drawings.
 4. Reinforcement: Provide standing seams and/or reinforcing angles, in accordance with SMACNA HVAC Duct Construction details.

5. Material Thickness: In accordance with tables in SMACNA HVAC Duct Construction Standards, based on panel span, pressure class, and reinforcement spacing.
 6. Sealing Requirements: Seal transverse joints with tape-and-adhesive or liquid duct sealer, specified herein. Not required for gasketed, flanged joints.
- G. Flexible Duct:
1. Pressure Rating: 6 inch w.g. positive, 1/2 inch w.g. negative.
 2. Core: Steel or aluminum helix bonded to continuous liner.
 3. Insulation: Fiberglass blanket between core and outer jacket.
 4. Thermal Conductance: 0.24 btuh/sq ft/deg. F max.
 5. Vapor Barrier Outer Jacket: Seamless polymer.
 6. Connect and support in accordance with latest editions of:
 - a. Oregon Mechanical Specialty Code
 - b. SMACNA HVAC Duct Construction Standards
 7. UL Listing: UL 181 Class 1 Air Duct.
 8. Manufacturer:
 - a. Flexmaster Type 3
 - b. ATCO UPC #070
 - c. Thermaflex G-KM
 - d. Hart & Cooley F114
- H. Liquid Duct Sealer, Indoors:
1. UL Classification: Flame spread rating not to exceed 25; smoke developed rating not to exceed 50; when applied in a 2 inch wide strip at a thickness of 0.0032 inch.
 2. Low-Emitting Material: Volatile organic compound (VOC) content less than 30 grams per liter for metal-to-metal bonding per SCAQMD Rule #1168.
 3. Application Temperature Limits: 40 to 110 deg. F.
 4. Manufacturer: United McGill Corp., Accumetric, Vulkem, Carlisle Hardcast, Alcoa, Design Polymerics, Miracle Adhesives, Ductmate, or approved. Similar to Accumetric Boss 350.
- I. Tape-and-Adhesive Duct Sealer, Indoors:
1. UL Classification: Flame spread rating not to exceed 25; smoke developed rating not to exceed 50; when applied in a 2 inch wide strip at a thickness of 0.0032 inch.
 2. Application Temperature Limits: 30 to 110 deg. F.
 3. Manufacturer:
 - a. Hardcast Inc. DT tape with FTA-20 adhesive
 - b. United McGill MDT6-300 tape with MTA-20 adhesive

PART 3 EXECUTION

3.01 GENERAL

- A. Install products in accordance with manufacturer's recommendations.
- B. Provide duct fittings and offsets not shown on Drawings, if required for coordination with the work of other sections.
- C. Install products in accordance with Manufacturer's recommendations and standards referenced herein.
- D. Duct sizes on Drawings are net inside dimensions, measured to inside face of internal liner or internal insulation.

- E. Fabricate and install ductwork to minimize gaps. Gaps in sheetmetal shall be no larger than allowed for sealant per sealant manufacturer's installation instructions.

3.02 DUCT AND FITTING HANDLING

- A. Delivery to Site:
 - 1. At site, sealed ends shall be visually examined and resealed as required.
- B. Storage:
 - 1. Store away from high dust generating processes.
 - 2. Provide pallets or blocking to keep above floor.
 - 3. Provide temporary cover to protect stored material.
- C. Installation:
 - 1. Protective coverings shall be removed immediately before installation and inspected to determine if wipe down is necessary.
 - 2. During construction, provide temporary sealing of openings into duct systems, to prevent accumulation of dust in ducts.
 - 3. Open ends of completed duct and overnight work-in-progress shall be sealed.

3.03 DUCT SEALANTS

- A. Clean duct surfaces prior to applying sealant.
- B. Prior to application, verify that ducts are dry and within specified temperature limits.
- C. Inspect after first application of sealant to identify areas where shrinkage has occurred. Fill voids with a second application.

3.04 FLEXIBLE DUCT

- A. Installation to conform to SMACNA HVAC Duct Construction Standards.
- B. Maximum Length: 6 feet, unless noted otherwise on Drawings.
- C. Limitations to Use: Flexible duct shall not be substituted for round or rectangular duct indicated on Drawings. Flexible duct is acceptable only where shown on Drawings.
- D. Connections to Collars: Secure core with stainless steel or nylon drawband under the insulation. Secure vapor barrier with an additional stainless steel or nylon drawband outside of insulation.

3.05 DUCT TESTING

- A. Testing for medium pressure ducts:
 - 1. Ducts Included:
 - a. Ducts between Air Handling Units and Air Terminal Units.
 - b. Ducts with pressure class greater than 2" w.g. noted on Drawings.
 - 2. Test Conditions:
 - a. Test pressure: 5 inches w.g.
 - b. Allowable leakage: 1% of total duct branch airflow.
 - 3. Test Apparatus:
 - a. Blower: Capable of supplying 200% of allowable duct branch leakage rate at specified test pressure. Equipped with volume control device (inlet damper, bypass damper, or variable speed controller).

- b. Flow Meter: Accurate within 7.5% at the indicated flow rate and test pressure. Certified calibration by independent testing agency or provide certificate signifying manufacture in conformance with ASME Requirements for Fluid Meters. Provide legible certified flow meter calibration curve and formula, cross-referenced to flow meter model/serial number, type, and size.
- c. Pressure Differential Sensing Instruments:
 - 1) Differential below 0.5" w.g.: Readable to 0.05" scale divisions.
 - 2) Differential above 0.5" w.g.: Readable to 0.10" scale divisions.
- 4. Test Procedure:
 - a. Test apparatus and calibration data to be approved by Engineer prior to testing.
 - b. Test after duct joints have been sealed and before ducts are concealed by ceilings and walls.
 - c. Test in accordance with SMACNA HVAC Air Duct Leakage Test Manual.
 - d. If leakage rate is exceeded in initial test, reseal ductwork and repeat test procedure until requirements are met.
 - e. Final test to be witnessed by Engineer. Notify Engineer two days in advance of final test.

END OF SECTION

SECTION 233300

DUCTWORK ACCESSORIES

PART 1 GENERAL

1.01 RELATED SECTIONS

- A. Section 201000 - General Mechanical Provisions
- B. Section 202000 - Mechanical Operation and Maintenance Manuals
- C. Section 233100 - Ductwork

1.02 SHOP DRAWINGS, PRODUCT DATA, OPERATION & MAINTENANCE DATA

- A. Submittals required for the products listed in the Product Table, in accordance with Section 201000. Operation & Maintenance Information required as indicated in the Product Table in accordance with Section 202000.
- B. Operation & Maintenance Information requirements indicated by number designation as follows. Refer to Section 202000 for a description of each type of information.
 - 1. Shop Drawings (submittal data)
 - 2. Product Data (submittal data), including documentation of ORS 453.005 (7) (e) compliance.
 - 3. Manufacturer's Operation Manuals
 - 4. Manufacturer's Service and Lubrication Requirements
 - 5. Service Contracts and Field Start-up Reports
 - 6. Cleaning, Certification, and Test Reports
 - 7. System Information
 - 8. Warranties

PRODUCT TABLE	Operation & Maintenance Information							
	1	2	3	4	5	6	7	8
Volume Dampers		X						
Concealed Volume Damper Regulators		X		X				
Turn Vanes		X						
Automatic Dampers	X	X		X				X
Flexible Duct Connectors		X						
Twist-lock Fittings		X						
Duct Access Doors		X						

PART 2 PRODUCTS

2.01 VOLUME DAMPERS

- A. Volume Dampers, up to 10 inch width:
 - 1. Blade: Minimum 22 ga. galvanized steel.
 - 2. Regulator: Quadrant type, 1/4 inch diameter shaft, wingnut, indicator dial marked "open" and "shut".
 - 3. Bearings: 1/4 inch diameter shaft, spring-lock on tail bearing.
 - 4. Regulator/Bearing Set Manufacturer: Duro-dyne KS-145; Duro-dyne SRST for externally insulated ducts, or approved.

- B. Volume Dampers, 11 inch to 20 inch width:
 - 1. Blade: Minimum 18 ga. galvanized steel. Use multiple blades for height over 12 inches.
 - 2. Regulator: Quadrant type, 3/8 inch diameter shaft, wingnut, indicator dial marked "open" and "shut".
 - 3. Bearings: 3/8 inch diameter shafts, spring-lock on tail bearing.
 - 4. Regulator/Bearing Set Manufacturer: Duro-dyne KSR-195; Duro-dyne SRST for externally insulated ducts, or approved.
- C. Volume Dampers, 21 inch to 30 inch width:
 - 1. Blade: Minimum 16 ga. galvanized steel. Use multiple blades for height over 12 inches.
 - 2. Regulator: Quadrant type, 1/2 inch diameter shaft, wingnut, indicator dial marked "open" and "shut".
 - 3. Bearings: 1/2 inch diameter shafts.
 - 4. Regulator/Bearing Set Manufacturer: Duro-dyne KS-12; Duro-dyne SRST for externally insulated ducts, or approved.
- D. Volume Dampers, over 30 inch width:
 - 1. Blade: Minimum 16 ga. galvanized steel, with stiffeners as required. Use multiple blades for height over 12 inches.
 - 2. Regulator:
 - a. Description: Quadrant type, 1/2 inch diameter shaft size, wingnut, indicator dial marked "open" and "shut".
 - b. Manufacturer: Duro-dyne K-5; or approved.
 - 3. Shaft: 1/2 inch diameter, continuous across damper width.
 - 4. End Bearing:
 - a. Description: Cast alloy, inside duct type, 1/2 inch diameter shaft size.
 - b. Manufacturer: Duro-dyne SB-112 or approved.
 - 5. Regulator/Bearing Set Manufacturer: Duro-dyne KS-12; Duro-dyne SRST for externally insulated ducts, or approved.
- E. Concealed Volume Damper Regulators:
 - 1. Where Required: Provide concealed regulators in lieu of regulators specified above for dampers located above non-accessible ceilings and as noted on Drawings.
 - 2. Description: Indicator dial, locking hex nut, cover plate flush with ceiling.
 - 3. Manufacturer:
 - a. Shaft Size 1/4 inch: Duro-dyne SRC-140 or approved.
 - b. Shaft Size 3/8 inch: Duro-dyne SRC-380 or approved.
 - c. Shaft Size 1/2 inch: Duro-dyne SRC-120 or approved.
- F. Angle Drives for Concealed Regulators:
 - 1. Where Required: Provide at concealed regulators when damper shaft is parallel to ceiling and as noted on Drawings.
 - 2. Description: Mitre gear assembly compatible with damper shaft.
 - 3. Manufacturer: Duro-dyne AD-38 or approved.
- G. Opposed Blade Volume Dampers:
 - 1. Damper Assembly:
 - a. Type: V-crimped galvanized steel.
 - b. Blade Action: Opposed blade as noted on Drawings.
 - c. Blades: 6 inches wide, v-crimped, 16 ga. galvanized steel.
 - d. Frames: 16 ga. galvanized steel or extruded aluminum.
 - e. Blade-to-blade Linkage: Concealed within frame.

- f. Blade Axles: 1/2 inch diameter hexagonal or square zinc-plated steel; or 7/8 inch diameter hexagonal extruded aluminum.
 - g. Bearings: Oil-impregnated sintered bronze or molded synthetic.
 - h. Control Shaft: 1/2 inch diameter, extends 6 inches beyond frame.
 - i. Performance Ratings: Certified in accordance with AMCA Standard 500.
 - j. Manufacturer: Ruskin, Greenheck, Cesco, or approved. Similar to Ruskin CD35.
2. Regulator:
- a. Quadrant type, 1/2 inch diameter shaft size, wingnut, indicator dial marked "open" and "shut". Duro-dyne K-5 or approved.

2.02 TURN VANES

- A. Turn Vanes:
1. Type: Non-adjustable, 90 deg. air turn.
 2. Side Rails: Minimum 24 gauge galvanized steel.
 3. Vane Spacing: 2-1/8 inch on center.
 4. Manufacturer: Aero/Dyne Co., Durodyne, or approved. Similar to Aero/Dyne Model H-E-P.

2.03 AUTOMATIC DAMPERS

- A. Automatic Dampers - Galvanized Steel Airfoil (A):
1. Description: Galvanized steel, airfoil blade, low leakage.
 2. Blade Action: Parallel blade, except where opposed blade is noted on Drawings.
 3. Blades: 6 inches wide, galvanized steel, airfoil shape.
 4. Blade Length: Not to exceed 48 inches in length. Provide multiple sections for dampers over 48 inches.
 5. Frames: 16 ga. galvanized steel or extruded aluminum.
 6. Blade-to-blade Linkage: Concealed within frame.
 7. Blade Axles: 1/2 inch diameter hexagonal or square zinc-plated steel; or 7/8 inch diameter hexagonal extruded aluminum.
 8. Bearings: Oil-impregnated sintered bronze or stainless steel.
 9. Control Shaft: 1/2 inch diameter, extends 6 inches beyond frame.
 10. Blade Edge Seals: Extruded vinyl or rubber.
 11. Jamb Seals: Flexible stainless steel.
 12. Damper Leakage Rating: AMCA Class 1A, maximum leakage rate of 3 cfm/ft² at 1.0 in w.g. when tested in accordance with AMCA Standard 500D 1998.
 13. Performance Ratings: Certified in accordance with AMCA Standard 500.
 14. Manufacturer: Ruskin, Greenheck, Cesco, or approved. Similar to Ruskin CD60.

2.04 FLEXIBLE DUCT CONNECTORS

- A. Flexible Duct Connectors:
1. Assembly: Two 3 inch wide strips of metal connected to 3 inch wide strip of fabric with continuous crimped seams.
 2. Metal Strips: 24 gauge galvanized steel.
 3. Fabric Strip:
 - a. Indoor: Glass fabric with black DuPont Neoprene coating, flame resistant, approximately 30 ounces per yard.
 - b. Outdoor: Glass fabric with white DuPont Hypalon coating, flame resistant, UV resistant, approximately 26 ounces per yard.
 4. Manufacturer: Ventfabrics, Durodyne or approved. Similar to Durodyne "Metal-Fab".

2.05 TWIST LOCK FITTINGS

- A. Twist Lock Fittings:
 - 1. Type: Straight-neck "spin-in" for round take-off from rectangular duct.
 - 2. Damper: None. Volume dampers shall be separate from twist-lock fitting. Refer to volume damper specification in this Section.
 - 3. Manufacturer: Genflex, Flexmasterwest, Gensco, Western Stats, or approved. Similar to Flexmaster FL.

2.06 DUCT ACCESS DOORS

- A. Duct Access Doors, Rectangular Ducts:
 - 1. Frame: Minimum 24 ga. galv. steel, with gasket and knock-over tabs.
 - 2. Door: Galv. steel of thickness equal or greater than that of the duct, double panel with 1 inch insulation, continuous steel hinge, cam lock, and gasket.
 - 3. Size: As required for maintenance access to equipment inside ducts. At fire dampers, coordinate door size and location with duct fittings and dampers to allow hands inside duct, sufficient to open damper and replace fusible link (for fire dampers) or to repair or replace internal components (for combination fire/smoke dampers). Minimum door size ten inches square.
 - 4. For smoke dampers provide window in access door to facilitate verifying damper position.
 - 5. Manufacturer: Ruskin, Air Balance, Safe Air, Cesco, Duro Dyne, or approved. Similar to Air Balance model FSA100.
 - 6. Products shall comply with the requirements of Oregon Revised Statute (ORS) 453.005 (7) (e), effective January 1, 2011. The referenced statute limits the use of three types of brominated fire retardant chemicals, which are defined as hazardous substances.
- B. Duct Access Doors, Round and Oval Ducts:
 - 1. Assembly: Inner and outer doors bolted together with duct sandwiched between.
 - 2. Inner Door: Double wall galvanized steel spot welded together, with fiberglass insulation between.
 - 3. Outer Door: Galvanized steel.
 - 4. Gasket: Continuous neoprene.
 - 5. Fasteners: Bolts and threaded knobs.
 - 6. Manufacturer: Ductmate "Sandwich Access Door", Cesco, or approved.
 - 7. Products shall comply with the requirements of Oregon Revised Statute (ORS) 453.005 (7) (e), effective January 1, 2011. The referenced statute limits the use of three types of brominated fire retardant chemicals, which are defined as hazardous substances.

PART 3 EXECUTION

3.01 GENERAL

- A. Install products in accordance with manufacturer's recommendations.

3.02 DUCT ACCESS DOORS

- A. Where mounting doors on ducts smaller than ten inches wide, provide duct transition for mounting access door frame, or provide transitions and larger section of duct, as needed to access components requiring maintenance.

3.03 FLEXIBLE DUCT CONNECTORS

- A. Provide flexible duct connectors where shown on Drawings and at connections to fans which are not internally spring isolated.

END OF SECTION

SECTION 233400

FANS

PART 1 GENERAL

1.01 RELATED SECTIONS

- A. Section 201000 - General Mechanical Provisions
- B. Section 202000 - Mechanical Operation and Maintenance Manuals
- C. Section 205100 - Motors

1.02 SHOP DRAWINGS, PRODUCT DATA, OPERATION & MAINTENANCE DATA

- A. Submittals required for the products listed in the Product Table, in accordance with Section 201000. Operation & Maintenance Information required as indicated in the Product Table in accordance with Section 202000.
- B. Operation & Maintenance Information requirements indicated by number designation as follows. Refer to Section 202000 for a description of each type of information.
 - 1. Shop Drawings (submittal data)
 - 2. Product Data (submittal data), including documentation of ORS 453.005 (7) (e) compliance.
 - 3. Manufacturer's Operation Manuals
 - 4. Manufacturer's Service and Lubrication Requirements
 - 5. Service Contracts and Field Start-up Reports
 - 6. Cleaning, Certification, and Test Reports
 - 7. System Information
 - 8. Warranties

PRODUCT TABLE	Operation & Maintenance Information							
	1	2	3	4	5	6	7	8
Exhaust Fans	X	X	X	X				X

PART 2 PRODUCTS

2.01 CABINET EXHAUST FANS (EF-1, EF-3)

- A. Description: Duct mounted, in-line centrifugal.
- B. Performance and Certification Ratings: Fans shall be U.L. listed and bear AMCA rating seal for air and sound performance.
- C. Construction:
 - 1. Bolted construction. 18 gauge steel with duct collars, bolted access doors on three sides with closed cell neoprene gasket.
 - 2. Finish: All steel components to have electrostatically applied, galvanized finish.
 - 3. Mounting: Housing shall be furnished with support clips for vertical suspension or platform support as shown on the drawings.
 - 4. Fan wheel: Double width, forward curved wheel constructed of painted steel, balanced in accordance with AMCA standards.
 - 5. Fan Bearings: Permanently lubricated, specified for air handling application by fan manufacturer, minimum L50 life of 200,000 hours.
 - 6. Insulation: 1 inch fiberglass internal duct liner.

7. Motor and Drive:
 - a. Motor access and mounting: Located inside cabinet.
 - b. Motor: Energy efficient, rated for use with variable frequency drives.
 - c. Drive: Adjustable belt drive. Drives sized for 150% of the installed motor horsepower. Variable pitch motor drive to be factory set to the specified RPM.
8. Vibration Isolators: Spring vibration isolators sized and furnished by the fan manufacturer for suspension mounting. Minimum 2" deflection.
9. Performance and Sound: Refer to schedule on Drawings.
10. Manufacturer: Greenheck, Loren Cook, Carnes, or approved. Similar to Greenheck BDF.

2.02 CEILING MOUNTED CABINET EXHAUST FANS (EF-2):

- A. Type: Inline cabinet exhaust fan.
- B. Performance and Certification Ratings: Fans shall be U.L. listed and bear AMCA rating seal for air and sound performance.
- C. Sound: Fan selection shall not exceed the maximum sones shown on the drawing schedule.
- D. Cabinet: Galvanized steel, insulated with fiberglass acoustic duct liner, duct collars.
- E. Fan Wheel: Galvanized steel or aluminum, forward-curved centrifugal.
- F. Discharge Arrangement: Field convertible top (vertical) or side (horizontal) discharge as shown on Drawings.
- G. Drive: Direct drive.
- H. Fan Speed Controller: Furnish with fan for field installation by Division 26.
- I. Vibration Isolators: Internal, neoprene.
- J. Electrical: Integral wiring box and receptacle.
- K. Backdraft Damper: Gravity style. Extruded aluminum frame, aluminum blades, aluminum pins and brass bushings.
- L. Grille: removable inlet grille on bottom face of fan.
- M. Performance: Refer to schedule on Drawings.
- N. Manufacturer: Loren Cook, Greenheck, Penn Ventilator, Carnes, or approved. Similar to Greenheck CSP Series.

PART 3 EXECUTION

3.01 GENERAL

- A. Install products in accordance with manufacturer's recommendations.
- B. Do not operate fans during construction.

END OF SECTION

SECTION 233600

AIR TERMINAL UNITS

PART 1 GENERAL

1.01 RELATED SECTIONS

- A. Section 201000 - General Mechanical Provisions
- B. Section 202000 - Mechanical Operation and Maintenance Manuals
- C. Section 230900 - Controls

1.02 SHOP DRAWINGS, PRODUCT DATA, OPERATION & MAINTENANCE DATA

- A. Submittals required for the products listed in the Product Table, in accordance with Section 201000. Operation & Maintenance Information required as indicated in the Product Table in accordance with Section 202000.
- B. Operation & Maintenance Information requirements indicated by number designation as follows. Refer to Section 202000 for a description of each type of information.
 - 1. Shop Drawings (submittal data)
 - 2. Product Data (submittal data), including documentation of ORS 453.005 (7) (e) compliance.
 - 3. Manufacturer's Operation Manuals
 - 4. Manufacturer's Service and Lubrication Requirements
 - 5. Service Contracts and Field Start-up Reports
 - 6. Cleaning, Certification, and Test Reports
 - 7. System Information
 - 8. Warranties

PRODUCT TABLE	Operation & Maintenance Information							
	1	2	3	4	5	6	7	8
Air Terminal Units	X	X	X	X				X

1.03 QUALITY ASSURANCE

- A. Products shall comply with the requirements of Oregon Revised Statute (ORS) 453.005 (7) (e), effective January 1, 2011. The referenced statute limits the use of three types of brominated fire retardant chemicals, which are defined as hazardous substances.

PART 2 PRODUCTS

2.01 AIR TERMINAL UNITS

- A. Terminal Units (TU):
 - 1. Type: Single duct, pressure independent, variable volume, with hot water reheat coils.
 - 2. Casing: Minimum 22 gauge galvanized steel, with access panel on bottom of unit.
 - 3. Internal Liner Insulation: Fibre-Free, 1½ lb. density, engineered polymer closed cell foam complying with UL-181 and NFPA 90A. Exposed fiberglass is not acceptable.
 - 4. Damper:
 - a. Maximum leakage rate of 1% at 3 inch w.g. inlet static pressure.
 - b. Shaft: Steel.
 - 5. Heating Coil: Factory installed, hot water, copper tubes, aluminum fins. Coils shall be tested in accordance with ARI Standard 410.

6. Air Flow Sensor: Multiple point, averaging differential pressure sensor, compatible with control system.
7. Flow Measuring Taps: External taps and calibration chart for field measurement of airflow.
8. Controls:
 - a. Refer to Section 230900 for DDC terminal unit controller and damper actuator.
 - b. Provide factory installation of DDC controller and damper actuator furnished under Section 230900.
 - c. Provide factory connection of airflow sensor to DDC controller.
 - d. Provide factory installed metal panel enclosure with hinged door for DDC controller.
 - e. Factory test assembled units before shipment.
9. Duct Outlet Connection: Slip and drive.
10. Pipe Connections and Control Panel Access: All pipe connections and control panels shall be accessible from the same side, right hand or left hand, as shown on Drawings.
11. Performance Data: Rated in accordance with ARI standard 880-94.
12. Capacity: Refer to schedule on Drawings.
13. Manufacturer: Carnes, E.H. Price, Krueger, Nailor, Tempmaster, Trane, Titus, Tuttle & Bailey, or approved. Similar to Price SDV.

PART 3 EXECUTION

3.01 GENERAL

- A. Install products in accordance with manufacturer's recommendations.

END OF SECTION

SECTION 233700**AIR OUTLETS AND INLETS****PART 1 GENERAL****1.01 RELATED SECTIONS**

- A. Section 201000 - General Mechanical Provisions
- B. Section 202000 - Mechanical Operation and Maintenance Manuals
- C. Section 209100 - Testing, Adjusting, and Balancing

1.02 SHOP DRAWINGS, PRODUCT DATA, OPERATION & MAINTENANCE DATA

- A. Submittals required for the products listed in the Product Table, in accordance with Section 201000. Operation & Maintenance Information required as indicated in the Product Table in accordance with Section 202000.
- B. Operation & Maintenance Information requirements indicated by number designation as follows. Refer to Section 202000 for a description of each type of information.
 - 1. Shop Drawings (submittal data)
 - 2. Product Data (submittal data), including documentation of ORS 453.005 (7) (e) compliance.
 - 3. Manufacturer's Operation Manuals
 - 4. Manufacturer's Service and Lubrication Requirements
 - 5. Service Contracts and Field Start-up Reports
 - 6. Cleaning, Certification, and Test Reports
 - 7. System Information
 - 8. Warranties

PRODUCT TABLE	Operation & Maintenance Information							
	1	2	3	4	5	6	7	8
Grilles	X	X						
Registers	X	X						
Diffusers	X	X						
Roof Air Intake Hoods	X	X						
Roof Air Exhaust Hoods	X	X						
Equipment Curbs for Roof Hoods	X	X						

1.03 QUALITY ASSURANCE

- A. Products shall comply with the requirements of Oregon Revised Statute (ORS) 453.005 (7) (e), effective January 1, 2011. The referenced statute limits the use of three types of brominated fire retardant chemicals, which are defined as hazardous substances.

PART 2 PRODUCTS**2.01 GRILLES, REGISTERS, AND DIFFUSERS**

- A. General:
 - 1. Refer to Drawings for types, neck sizes, and blow patterns.

- B. Supply Diffuser Ceiling (SDC-1):
1. Type: Louvered face, adjustable from horizontal to vertical.
 2. Material: Steel or aluminum.
 3. Face: Square, removable multi-louvered vane assembly.
 4. Blow Pattern: 4-way, 3-way, 2-way, or 1-way, as indicated on Drawings.
 5. Horizontal to Vertical Adjustment: By vertical movement of vane assembly or by movable deflectors in the vane assembly.
 6. Frame Type: Lay-In 24x24 module.
 7. Neck: Square or round.
 8. Finish: White.
 9. Manufacturer: Titus, Kreuger, Carnes, Tuttle & Bailey, Anemostat, E.H. Price, or approved. Similar to Titus TDCA.
- C. Supply Diffuser Ceiling (SDC-2):
1. Type: Louvered face.
 2. Material: Steel or aluminum.
 3. Face: Square, removable multi-louvered vane assembly.
 4. Blow Pattern: 4-way, 3-way, 2-way, or 1-way, as indicated on Drawings.
 5. Frame Type: Surface-mount, beveled drop face.
 6. Neck: Square or round.
 7. Finish: White.
 8. Manufacturer: Titus, Kreuger, Carnes, Tuttle & Bailey, Anemostat, E.H. Price, or approved. Similar to Titus TDC.
- D. Supply Diffuser Ceiling (SDC-3):
1. Type: Square face plaque.
 2. Material: Steel or aluminum.
 3. Face: Square, removable.
 4. Blow Pattern: 4-way.
 5. Frame Type: Surface mount, with trim ring for plaster ceiling.
 6. Neck: Round.
 7. Finish: White.
 8. Manufacturer: Titus, Kreuger, Carnes, Tuttle & Bailey, Anemostat, E.H. Price, or approved. Similar to Titus Omni.
- E. Supply Diffuser Ceiling (SDC-4):
1. Type: Adjustable linear slot, surface mount.
 2. Material: Extruded aluminum.
 3. Inlet: Field fabricated plenum.
 4. Slot: 1" wide, multiple slots as indicated on Drawings. Supply pattern adjustable through face.
 5. Finish: White face, black pattern controllers.
 6. Accessories: Mounting frame for gyp board ceiling.
 7. Manufacturer: Titus, Kreuger, Carnes, Tuttle & Bailey, Anemostat, E.H. Price, or approved. Similar to Titus ML-39 SP.
- F. Supply Grille Wall (SGW-1):
1. Type: Double deflection, individually adjustable blades.
 2. Material: Steel or aluminum.
 3. Border: 1-1/4 inch wide, countersunk screw holes, gasket.
 4. Front Blades: Maximum 3/4 inch on center, parallel to long dimension.
 5. Rear Blades: Maximum 3/4 inch on center, parallel to short dimension.
 6. Finish: White.

7. Manufacturer: Titus, Kreuger, Carnes, Tuttle & Bailey, Anemostat, E.H. Price, or approved. Similar to Titus 300RL.
- G. Supply Register Wall (SRW-1):
1. Type: Double deflection, individually adjustable blades.
 2. Material: Steel or aluminum.
 3. Border: 1-1/4 inch wide, countersunk screw holes, gasket.
 4. Front Blades: Spaced 3/4 inch on center maximum, parallel to long dimension.
 5. Rear Blades: Spaced 3/4 inch on center maximum, parallel to short dimension.
 6. Finish: White.
 7. Opposed Blade Damper: Adjustable through grille.
 8. Manufacturer: Titus, Kreuger, Carnes, Tuttle & Bailey, Anemostat, E.H. Price, or approved. Similar to Titus 300RL.
- H. Supply Grille Wall (SGW-2):
1. Type: Reversible core, narrow blade.
 2. Material: Extruded aluminum.
 3. Border: 1 inch wide.
 4. Blades: Adjustable, 3/4 inch depth, spaced 5/16 inch on center.
 5. Air Deflection: Adjustable.
 6. Fastening: Screws concealed by border and accessible by removing core.
 7. Finish: White.
 8. SRW-2: With Opposed blade damper, adjustable through grille.
 9. Manufacturer: Titus, Kreuger, Carnes, E.H. Price, or approved. Similar to Titus 1700L.
- I. Supply Grille Floor (SGF-1):
1. Type: Linear bar.
 2. Material: Extruded aluminum.
 3. Border: 3/4 inch wide.
 4. Bars: Fixed, 1/8 inch wide, spaced 1/2 inch on center, reinforced for floor mounting.
 5. Air Deflection: 0 degrees.
 6. Fastening: Secured to duct with concealed clips and screws operable through grille bars.
 7. Finish: Brushed satin aluminum.
 8. Manufacturer: Titus, Kreuger, Carnes, Tuttle & Bailey, Anemostat, E.H. Price, Air Factors, or approved. Similar to Titus CT-580.
- J. Return Grille Ceiling (RGC-1):
1. Type: Single deflection, fixed blades.
 2. Material: Steel or aluminum.
 3. Frame Type: Lay-in 24x24 inch module.
 4. Blades: Spaced 3/4 inch on center maximum, parallel to long dimension.
 5. Blade Angle: Fixed, between 35 and 45 degrees.
 6. Neck: Square.
 7. Finish: White.
 8. Manufacturer: Titus, Kreuger, Carnes, Tuttle & Bailey, Anemostat, E.H. Price, or approved. Similar to Titus 350RL.
- K. Return Grille Ceiling (RGC-2):
1. Type: Single deflection, fixed blades.
 2. Material: Steel or aluminum.
 3. Border: 1-1/4 inch wide, countersunk screw holes, gasket.
 4. Blades: Spaced 3/4 inch on center maximum, parallel to long dimension.
 5. Blade Angle: Fixed, between 35 and 45 degrees.

6. Neck: Square.
 7. Finish: White.
 8. Manufacturer: Titus, Kreuger, Carnes, Tuttle & Bailey, Anemostat, E.H. Price, or approved. Similar to Titus 350RL.
- L. Return Grille Wall (RGW-1):
1. Type: Single deflection, fixed blades.
 2. Material: Steel or aluminum.
 3. Border: 1-1/4 inch wide, countersunk screw holes, gasket.
 4. Blades: Spaced 3/4 inch on center maximum, parallel to long dimension.
 5. Blade Angle: Fixed, between 35 and 45 degrees.
 6. Finish: White.
 7. Manufacturer: Titus, Kreuger, Carnes, Tuttle & Bailey, Anemostat, E.H. Price, or approved. Similar to Titus 350RL.
- M. Return Grille Wall (RGW-2):
1. Type: Reversible core, narrow blade.
 2. Material: Extruded aluminum.
 3. Border: 1 inch wide.
 4. Blades: Adjustable, 3/4 inch depth, spaced 5/16 inch on center.
 5. Air Deflection: Adjustable.
 6. Fastening: Screws concealed by border and accessible by removing core.
 7. Finish: White.
 8. SRW-1: With Opposed blade damper, adjustable through grille.
 9. Manufacturer: Titus, Kreuger, Carnes, E.H. Price, or approved. Similar to Titus 1700L.
- N. Return Register Wall (RRW-1):
1. Type: Single deflection, fixed blades.
 2. Material: Steel or aluminum.
 3. Border: 1-1/4 inch wide, countersunk screw holes, gasket.
 4. Blades: Spaced 3/4 inch on center maximum, parallel to long dimension.
 5. Blade Angle: Fixed, between 35 and 45 degrees.
 6. Finish: White.
 7. Opposed Blade Damper: Adjustable through grille.
 8. Manufacturer: Titus, Kreuger, Carnes, Tuttle & Bailey, Anemostat, E.H. Price, or approved. Similar to Titus 350RL.
- O. Exhaust Grille Ceiling (EGC-1):
1. Type: Single deflection, fixed blades.
 2. Material: Steel or aluminum.
 3. Frame Type: Lay-in 24x24 inch module.
 4. Blades: Spaced 3/4 inch on center maximum, parallel to long dimension.
 5. Blade Angle: Fixed, between 35 and 45 degrees.
 6. Neck: Square.
 7. Finish: White.
 8. Manufacturer: Titus, Kreuger, Carnes, Tuttle & Bailey, Anemostat, E.H. Price, or approved. Similar to Titus 350RL.
- P. Exhaust Grille Ceiling (EGC-2):
1. Type: Single deflection, fixed blades.
 2. Material: Steel or aluminum.
 3. Frame Type: Lay-in 24x24 inch module.
 4. Border: 1-1/4 inch wide, countersunk screw holes, gasket.

5. Blades: Spaced 3/4 inch on center maximum, parallel to long dimension.
6. Blade Angle: Fixed, between 35 and 45 degrees.
7. Neck: Square.
8. Finish: White.
9. Manufacturer: Titus, Kreuger, Carnes, Tuttle & Bailey, Anemostat, E.H. Price, or approved. Similar to Titus 350RL.

Q. Exhaust Grille Wall (EGW-1):

1. Type: Single deflection, fixed blades.
2. Material: Steel or aluminum.
3. Border: 1-1/4 inch wide, countersunk screw holes, gasket.
4. Blades: Spaced 3/4 inch on center maximum, parallel to long dimension.
5. Blade Angle: Fixed, between 35 and 45 degrees.
6. Finish: White.
7. Manufacturer: Titus, Kreuger, Carnes, Tuttle & Bailey, Anemostat, E.H. Price, or approved. Similar to Titus 350RL.

2.02 ROOF AIR INTAKES AND EXHAUSTS

A. Louvered Penthouse (LP-1 through LP-4):

1. Description: Prefabricated, louver blade penthouse with curb cap. Extruded aluminum construction with mitered corners. Sound deadening insulation applied to underside of removable roof. Internal structural angles and removable 1/2"-mesh screen inside louver blades. Louvers with 4-inch spacing. Louver blades 4-inches deep, with rain hook. Custom color of baked enamel as selected by Architect.
2. Design Airflow, Hood and Throat Size: As scheduled on Drawings.
3. Maximum Pressure Drop: 0.05 inch w.g. at 500 fpm face velocity.
4. Manufacturer and Model: Manufacturer: Carnes, Greenheck, Penn, Loren Cook, or approved. Similar to Greenheck WIH.

B. Equipment Curbs for Roof Hoods:

1. Type: Factory-fabricated to match roof-mounted intake and exhaust hoods.
2. Body Construction: Minimum 18 gauge galvanized steel, continuous welded seams, no cant, pressure-treated nailer.
3. Insulation: 1-1/2 inch thick, 3 pound density fiberglass on interior of curb wall with full sheet metal liner.
4. Height: 18 inches.
5. Pitched: To provide level base on sloped roof. Verify roof slope at each unit.
6. Manufacturer: Roof Products & Systems, Loren Cook, Custom Curbs, Inc., ThyCurb, Greenheck, Carnes, or approved.

PART 3 EXECUTION

3.01 GENERAL

- A. Install products in accordance with manufacturer's recommendations.
- B. Secure grilles and registers with flat head, countersunk screws, flush with borders, painted to match borders. Hex head and/or bright finish screws are not acceptable.
- C. Install outlets and inlets tight to mounting surfaces.
- D. Center outlets and inlets between lights and in ceiling tiles, as shown on Architectural reflected ceiling plans.
- E. Install outlets and inlets plumb and square with walls and ceilings.

- F. Install return air grilles so that blades block vision through grille.
- G. Paint ductwork visible behind outlets and inlets matte black.
- H. Secure roof hoods to curbs with corrosion resistant fasteners.

END OF SECTION

SECTION 235700

HEAT EXCHANGERS

PART 1 GENERAL

1.01 RELATED SECTIONS

- A. Section 201000 - General Mechanical Provisions
- B. Section 202000 - Mechanical Operation and Maintenance Manuals

1.02 SHOP DRAWINGS, PRODUCT DATA, OPERATION & MAINTENANCE DATA

- A. Submittals required for the products listed in the Product Table, in accordance with Section 201000. Operation & Maintenance Information required as indicated in the Product Table in accordance with Section 202000.
- B. Operation & Maintenance Information requirements indicated by number designation as follows. Refer to Section 202000 for a description of each type of information.
 - 1. Shop Drawings (submittal data)
 - 2. Product Data (submittal data), including documentation of ORS 453.005 (7) (e) compliance.
 - 3. Manufacturer's Operation Manuals
 - 4. Manufacturer's Service and Lubrication Requirements
 - 5. Service Contracts and Field Start-up Reports
 - 6. Cleaning, Certification, and Test Reports
 - 7. System Information
 - 8. Warranties

PRODUCT TABLE	Operation & Maintenance Information							
	1	2	3	4	5	6	7	8
Heat Exchangers	X	X	X		X			X

PART 2 PRODUCTS

2.01 HEAT EXCHANGERS

- A. Heat Exchanger (HE-1):
 - 1. Type: Shell and tube, steam-to-water.
 - 2. Tube Bundle: U-bend, removable.
 - 3. Shell: steel.
 - 4. Tubes: 3/4 inch O.D. copper.
 - 5. Heads: Cast iron.
 - 6. Tube Sheets and Supports Steel.
 - 7. Supports: Provide cradles and cradle straps.
 - 8. Minimum Working Pressure: 125 psig, ASME coded.
 - 9. Capacity: As scheduled on drawings.
 - 10. Minimum Fouling Factor: 0.0005.
 - 11. Manufacturer: Bell & Gossett, Taco, Armstrong, Thrush, Wheatley, Adamson, Ketema (Whitlock), or approved.

PART 3 EXECUTION**3.01 GENERAL**

- A. Install products in accordance with manufacturer's recommendations.
- B. Provide access clearance for removal of tube bundles and/or plates with minimum disassembly of adjacent piping.
- C. Support shell and tube heat exchangers on welded steel pipe and angle floor stand, as detailed on Drawings.
- D. Pitch shell and tube heat exchangers slightly to completely drain condensate.

END OF SECTION

SECTION 237200

HEAT RECOVERY UNITS

PART 1 GENERAL

1.01 RELATED SECTIONS

- A. Section 201000 - General Mechanical Provisions
- B. Section 202000 - Mechanical Operation and Maintenance Manuals
- C. Section 205100 - Motors
- D. Section 205200 - Variable Frequency Drives

1.02 SHOP DRAWINGS, PRODUCT DATA, OPERATION & MAINTENANCE DATA

- A. Submittals required for the products listed in the Product Table, in accordance with Section 201000. Operation & Maintenance Information required as indicated in the Product Table in accordance with Section 202000.
- B. Operation & Maintenance Information requirements indicated by number designation as follows. Refer to Section 202000 for a description of each type of information.
 - 1. Shop Drawings (submittal data)
 - 2. Product Data (submittal data), including documentation of ORS 453.005 (7) (e) compliance.
 - 3. Manufacturer's Operation Manuals
 - 4. Manufacturer's Service and Lubrication Requirements
 - 5. Service Contracts and Field Start-up Reports
 - 6. Cleaning, Certification, and Test Reports
 - 7. System Information
 - 8. Warranties

PRODUCT TABLE	Operation & Maintenance Information							
	1	2	3	4	5	6	7	8
Heat Recovery Units	X	X	X	X	X		X	X

- C. Shop drawing and Product Data shall include:
 - 1. Overall dimensions and weights of units.
 - 2. Casing materials, gauges, and finishes.
 - 3. Fan curves and performance data.
 - 4. Fan bearing types and specifications.
 - 5. Coil selection worksheet and performance data.
 - 6. Dimensions and arrangement of demountable sections.
 - 7. Fan vibration isolator types and ratings.
 - 8. Fan base seismic restraint details and calculations.
 - 9. Details and locations of lifting lugs / seismic anchor brackets.
 - 10. Damper specifications and sizes.
 - 11. Louver specifications and sizes.
 - 12. Sound data.
 - 13. Heat recovery section performance data.
 - 14. Additional information as required to confirm compliance with specifications and drawings.

1.03 QUALITY ASSURANCE

- A. Products shall comply with the requirements of Oregon Revised Statute (ORS) 453.005 (7) (e), effective January 1, 2011. The referenced statute limits the use of three types of brominated fire retardant chemicals, which are defined as hazardous substances.

PART 2 PRODUCTS

2.01 HEAT RECOVERY UNITS (HRU-1)

- A. General:
1. Units shall be indoor, internally spring-isolated, double wall construction.
 2. Units shall include fans, coils, fan motors, filters, plenums, dampers, and additional components shown on Drawings and specified herein.
 3. Refer to Drawings for required sections, arrangement, and dimensional limitations.
 4. Refer to schedule on Drawings for performance data, fan types, filter areas, and unit weights.
 5. Units shall consist of a number of demountable sections, as required to fit through existing wall openings. Provide hardware, gaskets, caulking and instructions for field assembly.
 6. Units shipped in multiple sections due to shipping size or building opening limitations: Provide hardware, gaskets, caulking and instructions for field assembly, and final inspection of the unit following assembly. Any form of field assembly required shall be brought to the attention of the installing contractors by bid date and shall be identified in the shop drawings. Unit manufacturer or authorized representative shall provide complete wiring of the electrical components in the field following final assembly of the sections.
 7. Construction requirements specified herein shall be typical for all sections of the units, including filter sections and plenums.
 8. Provide external unit and curb seismic restraints in accordance with Section 204200. Submit seismic bracing details for review.
- B. Quality Assurance:
1. Certify air volume, static pressure, fan speed, brake horsepower and selection procedures in accordance with ARI 430. If air handling units are not certified in accordance with ARI 430, contractor shall be responsible for expenses associated with testing of units after installation to verify performance of fan(s). Any costs incurred to adjust fans to meet scheduled capacities shall be the sole responsibility of the contractor.
- C. Air Coils: Certify capacities, pressure drops and selection procedures in accordance with ARI 410-91.
- D. Casing and Frame Construction:
1. Unit shall be constructed of a complete frame with removable panels. Removal of panels shall not affect the structural integrity of the unit.
 2. Double wall, bolted panel construction. Casing constructed to withstand 6 inches positive and 4 inches negative pressure, and a maximum 0.005 inch deflection per inch of panel.
 3. Frame: Bolted or welded.
 4. Finishes:
 - a. Base Rails: Rust-inhibiting prime coat, enamel finish.
 - b. Framework, Fan Base, Safety Guards, Fan Wheel: Rust-inhibiting prime coat.
 - c. Floors: Unpainted, galvanized.
 - d. Inner Liner: Unpainted, galvanized.
 - e. Wall and Roof Outer Panels: Manufacturer's standard finish. G-90 galvanizing as a minimum.

5. Double-Wall Panel Assembly:
 - a. Type 1 Fiberglass:
 - 1) Each surface of each section to receive double wall construction.
 - 2) Construction: Two Inch thick double wall assembly.
 - 3) Outer wall panels: 18 gauge, G-90 galvanized steel secured with cadmium plated screw fasteners.
 - 4) Inner Liner: 22 gauge minimum solid G-90 galvanized steel.
 - 5) Insulation: 3 lb/cu. ft density fiberglass. Two (2") inch thick.
 - b. Type 2 Foam:
 - 1) Each surface of each section to receive double wall construction.
 - 2) Construction: Two Inch thick double wall assembly.
 - 3) Inner Liner: 24 gauge minimum G-90 galvanized steel.
 - 4) Outer wall panels: 18 gauge G-90 galvanized steel.
 - 5) Perforated Liner: Where specified herein, G90 galvanized perforated steel filled with 3 lb. per cu ft. density, neoprene coated, glass fiber insulation secured to the inner liner.
 - 6) Insulation: Injected with polyurethane foam insulation with thermal breaks providing an R-value of not less than R-13.
 - 7) Panel deflection: Not to exceed L/240 ratio at 125% of design static pressure, maximum 6 inches of negative static pressure or 5 inches of positive static pressure. Deflection shall be measured at the midpoint of the panel height.
 6. Supply fan section shall have a perforated liner.
 7. An integral shipping skid shall be provided. Provide support cross members under internal components. Lifting Lugs: Minimum of (4) on each separate demountable section. Lifting lugs shall include brackets suitable for seismically anchoring the assembled unit to the building structure. Brackets to withstand seismic forces in accordance with Section 204200.
 8. Cabinet width and height shall be sufficient to accommodate the minimum filter and coil face areas specified herein or shown in the drawing schedule. Filter banks shall not be overlapped. Width and height shall remain the same along the length of the unit.
- E. Access Doors:
1. Construction: Double wall insulated construction to match section where it is installed. Door shall be hinged and removable, with a minimum of two hinges per door.
 2. Minimum Size: Manufacturer's maximum height available for the size of cabinet selected. Door width for fan, filter and plenums to be the manufacturer's largest door size available for the size of cabinet selected. Door width for coil access to be 6 inches minimum.
 3. Frame: 16 gauge galvanized steel or extruded aluminum, mounted in exterior wall and flush with the outside of the unit.
 4. Latches: Ventlock style non-corrosive alloy latches configured to be operable from inside or outside the unit.
 5. Gasket: Continuous 1/2 inch min. closed cell neoprene gasket with metal encapsulated reinforced backing mechanically fastened to the door frame.
 6. Inspection Window: Window: Provide a window in each access door.
 7. Door swing: Regardless of pressure, doors shall open outwards, unless directed otherwise on Drawings for clearance purposes.
 8. Finish: To match casing finish.
 9. Quantity: As shown on Drawings and as required for access to fans, coils, dampers, and controls.

F. Fans, Bases and Motors:

1. Fans: Refer to Drawings for fan types, arrangement, and capacity.
2. Fan Class: Provide AMCA pressure class which will permit increasing the rpm 5% over specified operating conditions without exceeding the pressure class rpm limits.
3. Fan Rating and Testing: In accordance with AMCA Standard 210 and shall bear the AMCA label.
4. Balancing: Fan assembly shall be statically and dynamically balanced to maximum 1.5 mil amplitude using an IRD 245, or equal, vibration balancer. Furnish balance test reports upon request.
5. Shaft: Solid, ground and polished, carbon steel keyed to wheel, coated with rust inhibitor after machining.
6. Bearings: Self aligning pillow block, grease lubricated ball. Selected for an L-50 average life of 200,000 hrs.
7. Extended Lubrication Lines: High pressure plastic tubing extending from bearings to grease fittings near access door.
8. Fan Base: Structural steel, continuously-welded joints, prime-coated, on spring vibration isolators. Motor shall be installed on a slide rail to allow belt tension adjustments.
9. Vibration Isolators:
 - a. Description: Free standing spring with sound deadening pads and leveling bolts.
 - b. Spring isolator manufacturer shall select a suitable spring deflection for the specific equipment and type of building structure supporting the unit.
 - c. Vibration Isolator Manufacturer: Mason Industries, Cal-Dyne, Kinetics, Amber Booth or approved.
 - d. Seismic Restraints: Provide seismic restraints to fan/motor base in accordance with Section 204200.
10. Flexible Connectors: Flexible fabric between casing and housed fan outlets.
11. V-Belt Drive: Cast iron sheaves, dynamically balanced, bored to fit shafts, and keyed. Adjustable pitch sheaves for motors up to 10 hp, selected so required rpm is obtained with sheaves set at mid-position; fixed sheave for larger than 10 hp. Matched belts, and drive rated as recommended by manufacturer or minimum 1.5 times nameplate rating of motor.
12. Motor and Drive Location: On the access door side of the unit.
13. Fan Motors: Open drip proof, premium efficiency. Refer to Section 205100 for motor requirements.

G. Moving Equipment Safety Devices:

1. Provide one of the following methods to meet UL 1995 and provide UL label with unit:
 - a. Safety Guards:
 - 1) OSHA-approved belt guards.
 - 2) Housed Fans: Prime or epoxy coated steel. Secure to fan or fan supports without short circuiting vibration isolation, with provision for adjustment of belt tension, lubrication, and use of tachometer with guard in place.
 - 3) Plug Fans: Galvanized expanded metal enclosure around plug fan wheel, motor, and drive. Enclosure shall include removable section(s), as required for easy access to motor, drive, and bearings. Secure to fan or fan supports without short circuiting vibration isolation, with provision for adjustment of belt tension, lubrication, and use of tachometer with guard in place.
 - b. Tooled access door on cabinet housing moving equipment.
 - c. Interlocking door mechanism to de-energize electrical power to moving equipment when access door is opened.

- H. Automatic Dampers (Outside Air, Exhaust Air):
1. Blades shall be galvanized steel or aluminum, low leakage, parallel or opposed airfoil blade, as shown on the Drawings, housed in a galvanized steel or aluminum frame and factory mounted on air handling unit.
 2. Blades: Maximum width 6 inches, maximum length 48 inches. Provide multiple sections where necessary. Linkage concealed within frame.
 3. Leakage Rate: Maximum of 4 cfm per sq ft at 1 inch w.g. and 9 cfm per sq ft at 4 inch w.g.
 4. Performance Ratings: Certified in accordance with AMCA Standard 500.
 5. Blade Axles: 1/2 inch diameter hexagonal or square zinc-plated steel.
 6. Bearings: Oil-impregnated sintered bronze or molded synthetic.
 7. Control Shaft: 1/2 inch diameter, extends 6 inches beyond frame.
 8. Blade Edge Seals: Extruded vinyl or rubber.
 9. Jamb Seals: Flexible stainless steel.
 10. Damper Actuators: Provided by Section 230900, Controls. Contractor to coordinate damper control shaft location for best access to actuators.
 11. Manufacturer: T.A. Morrison, Ruskin, Greenheck, or approved. Similar to Ruskin CD60, or equal.
- I. Hot Water Heating and Chilled Water Cooling Coils:
1. Tubes: 5/8-inch diameter seamless copper with 0.024 inch minimum tube thickness or 1/2-inch diameter with 0.025 inch minimum tube wall thickness.
 2. Return Bends: Not less than tube thickness.
 3. Header: Seamless copper, die-form collars, brazed tube connections.
 4. Fins: Aluminum, 0.008 inch minimum thickness, mechanically bonded to tubes.
 5. Casing: 16 gauge galvanized steel.
 6. Connections: Male pipe thread, supply and return on same end, extended through casing with seals at penetrations.
 7. Supports: Stacked coils shall be supported independently, to allow either coil to be removed with the other left in place.
 8. Vent and Drain Connections.
 9. Water Velocity: Not to exceed 8 fps.
 10. Fin Spacing: Not to exceed 10 fins per inch.
 11. Face area, Pressure Drop, Capacity: Refer to schedule on Drawings.
 12. Performance Ratings: Certified in accordance with ARI 410.
- J. Heat-Pipe Heat Recovery Coils:
1. Description: "Heat pipe" counterflow, air-to-air heat recovery unit, consisting of refrigerant-charged sealed tubes, secondary heat transfer fins, and a sealed partition separating the two airstreams.
 2. Tubes: 5/8 or 1" diameter, aluminum, 0.049" wall thickness, with internal knurled surface.
 3. Fins: Aluminum, 0.015" thickness.
 4. Refrigerant: HFC-134a, or approved.
 5. Casing: 16 gauge galvanized steel.
 6. Partition: 18 galvanized steel.
 7. Tilt: None.
 8. Face area, Pressure Drop, Capacity: Refer to schedule on Drawings.
- K. Condensate and Frost Drain Pans:
1. Where Required: Under each cooling coil and under each heat recovery coil.
 2. Size and Quantity: Drain pans shall extend a minimum of 12 inch downstream of the coil face. Provide intermediate drain pans for stacked coils.
 3. Pan: 16 gauge stainless steel, welded corners, double sloped for complete drainage.

4. Insulation: One inch rigid fiberglass insulation with vapor barrier.
 5. Drain Connection: Stainless steel or copper, male pipe thread, extended through casing, with seal at penetration. Refer to Drawings for connection side.
- L. Pre-Filter Section:
1. Filter Rack: Galvanized steel, side access upstream filter access.
 2. Filter Access Door: Same as specified for casing access doors.
 3. Filter Media: See Air Cleaning Devices Section 234000 for filters to be provided with the unit.
 4. Filter Media Type/Thickness: See Air Handling Unit or Filter Schedule on Drawings.
 5. Filter Gauge:
 - a. Filter gauge shall be field mounted on the filter access side piped with copper tubing around filter bank.
 - b. Type: Magnehelic.
 - c. Manufacturer: Dwyer, Cleveland Draft Gauge, Farr, or approved. Similar to Dwyer series 2001-ASF (adjustable signal flag).
- M. Electrical Components and Wiring:
1. Mounting and wiring of electrical components, including but not limited to: fan motors, starters, variable frequency drives, internal lighting, outlets, airflow station transmitters (where specified), shall be the responsibility of the unit manufacturer. Wiring shall terminate at the fan variable frequency drive, a disconnect switch or junction box as applicable, ready for connection by Division 26 contractor.
 2. Electrical components shall be UL listed and wiring shall conform to requirements of the National Electrical Code, applicable local codes and Division 26.
 3. Combination Starter / Disconnect switches:
 - a. Provide starter as specified in Section 262419 Motor Controls.
 - b. Starter shall be properly sized, mounted, wired to the fan motor and commissioned by the air handling unit manufacturer. Package shall include the disconnect switch for each circuit, fuses, 120 volt control transformer, Hands-Off-Auto (H-O-A) switch and electronic overloads (factory-set for the specific motor).
 4. Starters shall be wired to fan motors per NEC, UL, and NFPA 90 requirements.
 5. Fuses and overload heaters shall be selected individually for the voltage, horsepower, and full load amps of the actual motor being supplied. Testing shall include a "Hypot" test of unit wiring to insure that no weaknesses exist in the starter, wiring or motor. "Hand" and "Auto" positions shall be verified to insure starter is operational.
 6. Provide 120 volt convenience GFCI receptacles with separate disconnect on AHU-1
- N. Sound Data:
1. Unit air and sound performance data shall be based on test data generated in an AMCA certified test facility, in accordance with procedures listed in AMCA 210 for air and AMCA 330 for sound. Furnish test performance data upon request.
- O. Capacity and Performance Requirements: Refer to Schedule shown on Drawings.
- P. Manufacturer: Trane Modular Climate Changer, McQuay Vision, York AirPak, Temtrol ITF or WF, Carrier Modular Series, or approved.

PART 3 EXECUTION

3.01 GENERAL

- A. Install products in accordance with manufacturer's recommendations.

END OF SECTION

SECTION 237300**AIR HANDLING UNITS****PART 1 GENERAL****1.01 RELATED SECTIONS**

- A. Section 201000 - General Mechanical Provisions
- B. Section 202000 - Mechanical Operation and Maintenance Manuals
- C. Section 205100 - Motors
- D. Section 205200 - Variable Frequency Drives

1.02 SHOP DRAWINGS, PRODUCT DATA, OPERATION & MAINTENANCE DATA

- A. Submittals required for the products listed in the Product Table, in accordance with Section 201000. Operation & Maintenance Information required as indicated in the Product Table in accordance with Section 202000.
- B. Operation & Maintenance Information requirements indicated by number designation as follows. Refer to Section 202000 for a description of each type of information.
 - 1. Shop Drawings (submittal data)
 - 2. Product Data (submittal data), including documentation of ORS 453.005 (7) (e) compliance.
 - 3. Manufacturer's Operation Manuals
 - 4. Manufacturer's Service and Lubrication Requirements
 - 5. Service Contracts and Field Start-up Reports
 - 6. Cleaning, Certification, and Test Reports
 - 7. System Information
 - 8. Warranties

PRODUCT TABLE	Operation & Maintenance Information							
	1	2	3	4	5	6	7	8
Air handling units	X	X	X	X	X	X		X
Overall dimensions and weights of units	X	X						
Casing materials, gauges, and finishes	X	X						
Fan curves, performance and sound data		X				X		
Fan bearing types and specifications		X		X				
Motor data, Starters and Variable Frequency Drives		X	X	X		X		
Coil selection worksheet and performance data		X		X		X		
Filter performance data and Filter Gauge		X		X				
Dimensions and arrangement of demountable sections	X	X						
Fan vibration isolator types and ratings		X						
Seismic restraint details and calculations	X	X				X		
Details and locations of lifting lugs / seismic anchor brackets	X	X						
Damper specifications, sizes and design pressure drop data	X	X						

PRODUCT TABLE	Operation & Maintenance Information							
	1	2	3	4	5	6	7	8
Sound data, including radiated, inlets and outlets		X				X		
Additional information as required to confirm compliance with specifications and drawings	X	X						

1.03 REFERENCES

A. References:

1. ARI 430 - Standard for Central Station Air Handling Units.
2. ARI 410 - Standard for Forced Circulation Air-Cooling and Air-Heating Coils.
3. NFPA 90A - Installation of Air Conditioning and Ventilation Systems.
4. UL 1995 - Heating and Cooling Equipment.
5. ANSI/AFBMA 9 - Load Ratings and Fatigue Life for Ball Bearings.
6. SMACNA - HVAC Duct Construction Standards.
7. ANSI/UL 900 - Test Performance of Air Filter Units.
8. AMCA 300 - Reverberant Method for Sound Testing of Fans.
9. ARI 260 - Standard for Sound Rating of Ducted Air Moving and Conditioning Equipment
10. AMCA 301 - Method for Publishing Sound Ratings for Air Moving Devices.
11. ASHRAE 68 - Laboratory Method of Testing In-Duct Sound Power Measurement Procedure for Fans.

1.04 QUALITY ASSURANCE

- A. Products shall comply with the requirements of Oregon Revised Statute (ORS) 453.005 (7) (e), effective January 1, 2011. The referenced statute limits the use of three types of brominated fire retardant chemicals, which are defined as hazardous substances.

PART 2 PRODUCTS

2.01 AIR HANDLING UNITS, SEMI-CUSTOM/ MODULAR INDOOR (AHU-1 THROUGH AHU-4)

A. General:

1. Units shall be indoor, internally spring-isolated, double wall construction.
2. Units shall include fans, coils, fan motors, filters, plenums, dampers, and additional components shown on Drawings and specified herein.
3. Refer to Drawings for required sections, arrangement, and dimensional limitations.
4. Refer to schedule on Drawings for performance data, fan types, filter areas, and unit weights.
5. Units shall consist of a number of demountable sections, as required to fit through existing wall openings. Provide hardware, gaskets, caulking and instructions for field assembly.
6. Units shipped in multiple sections due to shipping size or building opening limitations: Provide hardware, gaskets, caulking and instructions for field assembly, and final inspection of the unit following assembly. Any form of field assembly required shall be brought to the attention of the installing contractors by bid date and shall be identified in the shop drawings. Unit manufacturer or authorized representative shall provide complete wiring of the electrical components in the field following final assembly of the sections.
7. Construction requirements specified herein shall be typical for all sections of the units, including filter sections and plenums.
8. Provide external unit and curb seismic restraints in accordance with Section 204200. Submit seismic bracing details for review.

- B. Quality Assurance:
1. Certify air volume, static pressure, fan speed, brake horsepower and selection procedures in accordance with ARI 430. If air handling units are not certified in accordance with ARI 430, contractor shall be responsible for expenses associated with testing of units after installation to verify performance of fan(s). Any costs incurred to adjust fans to meet scheduled capacities shall be the sole responsibility of the contractor.
- C. Air Coils: Certify capacities, pressure drops and selection procedures in accordance with ARI 410-91.
- D. Casing and Frame Construction:
1. Unit shall be constructed of a complete frame with removable panels. Removal of panels shall not affect the structural integrity of the unit.
 2. Double wall, bolted panel construction. Casing constructed to withstand 6 inches positive and 4 inches negative pressure, and a maximum 0.005 inch deflection per inch of panel.
 3. Frame: Bolted or welded.
 4. Finishes:
 - a. Base Rails: Rust-inhibiting prime coat, enamel finish.
 - b. Framework, Fan Base, Safety Guards, Fan Wheel: Rust-inhibiting prime coat.
 - c. Floors: Unpainted, galvanized.
 - d. Inner Liner: Unpainted, galvanized.
 - e. Wall and Roof Outer Panels: Manufacturer's standard finish. G-90 galvanizing as a minimum.
 5. Double-Wall Panel Assembly:
 - a. (Type 1 Fiberglass):
 - 1) Each surface of each section to receive double wall construction.
 - 2) Construction: Two Inch thick double wall assembly.
 - 3) Outer wall panels: 18 gauge, G-90 galvanized steel secured with cadmium plated screw fasteners.
 - 4) Inner Liner: 22 gauge minimum perforated G-90 galvanized steel.
 - 5) Insulation: 3 lb/cu. ft density fiberglass. Two (2") inch thick.
 - b. (Type 2 Foam):
 - 1) Each surface of each section to receive double wall construction.
 - 2) Construction: Two Inch thick double wall assembly.
 - 3) Inner Liner: 24 gauge minimum G-90 galvanized steel.
 - 4) Outer wall panels: 18 gauge G-90 galvanized steel.
 - 5) Perforated Liner: Where specified herein, G90 galvanized perforated steel filled with 3 lb. per cu ft. density, neoprene coated, glass fiber insulation secured to the inner liner.
 - 6) Insulation: Injected with polyurethane foam insulation with thermal breaks providing an R-value of not less than R-13.
 - 7) Panel deflection: Not to exceed L/240 ratio at 125% of design static pressure, maximum 6 inches of negative static pressure or 5 inches of positive static pressure. Deflection shall be measured at the midpoint of the panel height.
 6. Supply fan and Return Fan sections shall have a perforated liner.
 7. An integral shipping skid shall be provided. Provide support cross members under internal components. Lifting Lugs: Minimum of (4) on each separate demountable section. Lifting lugs shall include brackets suitable for seismically anchoring the assembled unit to the building structure. Brackets to withstand seismic forces in accordance with Section 204200.

8. Cabinet width and height shall be sufficient to accommodate the minimum filter and coil face areas specified herein or shown in the drawing schedule. Filter banks shall not be overlapped. Width and height shall remain the same along the length of the unit.
- E. Access Doors:
1. Construction: Double wall insulated construction to match section where it is installed. Door shall be hinged and removable, with a minimum of two hinges per door.
 2. Minimum Size: Manufacturer's maximum height available for the size of cabinet selected. Door width for fan, filter and plenums to be the manufacturer's largest door size available for the size of cabinet selected. Door width for coil access to be 6 inches minimum.
 3. Frame: 16 gauge galvanized steel or extruded aluminum, mounted in exterior wall and flush with the outside of the unit.
 4. Latches: Ventlock style non-corrosive alloy latches configured to be operable from inside or outside the unit.
 5. Gasket: Continuous 1/2 inch min. closed cell neoprene gasket with metal encapsulated reinforced backing mechanically fastened to the door frame.
 6. Door swing: Regardless of pressure, doors shall open outwards, unless directed otherwise on Drawings for clearance purposes.
 7. Finish: To match casing finish.
 8. Quantity: As shown on Drawings and as required for access to fans, coils, dampers, and controls.
- F. Fans, Bases and Motors:
1. Fans: Refer to Drawings for fan types, arrangement, and capacity.
 2. Fan Class: Provide AMCA pressure class which will permit increasing the rpm 5% over specified operating conditions without exceeding the pressure class rpm limits.
 3. Fan Rating and Testing: In accordance with AMCA Standard 210 and shall bear the AMCA label.
 4. Balancing: Fan assembly shall be statically and dynamically balanced to maximum 1.5 mil amplitude using an IRD 245, or equal, vibration balancer. Furnish balance test reports upon request.
 5. Shaft: Solid, ground and polished, carbon steel keyed to wheel, coated with rust inhibitor after machining.
 6. Bearings: Self aligning pillow block, grease lubricated ball. Selected for an L-50 average life of 200,000 hrs.
 7. Extended Lubrication Lines: High pressure plastic tubing extending from bearings to grease fittings near access door.
 8. Fan Base: Structural steel, continuously-welded joints, prime-coated, on spring vibration isolators. Motor shall be installed on a slide rail to allow belt tension adjustments.
 9. Vibration Isolators:
 - a. Description: Free standing spring with sound deadening pads and leveling bolts.
 - b. Spring isolator manufacturer shall select a suitable spring deflection for the specific equipment and type of building structure supporting the unit.
 - c. Vibration Isolator Manufacturer: Mason Industries, Cal-Dyne, Kinetics, Amber Booth or approved.
 - d. Seismic Restraints: Provide seismic restraints to fan/motor base in accordance with Section 204200.
 10. Flexible Connectors: Flexible fabric between casing and housed fan outlets.

11. Direct Drive Fans:
 - a. Plug fans with airfoil extruded aluminum blades.
 - b. Variable Speed Fans: Fans shall be selected with a wheel width and synchronous speed to provide airflow and static pressure within 0% to 5% of the design values scheduled on the drawings. Variable frequency drives shall be used to adjust to design conditions. Fans specified to have variable frequency drives with manual bypass starters shall be selected with synchronous speeds that will not exceed the specified pressure classification of the connecting ductwork or air handling unit casing when set in manual operation mode.
 12. Motor and Drive Location: On the access door side of the unit.
 13. Fan Motors: Open drip proof, premium efficiency. Refer to Section 205100 for motor requirements.
- G. Moving Equipment Safety Devices:
1. Provide one of the following methods to meet UL 1995 and provide UL label with unit:
 - a. Safety Guards:
 - 1) OSHA-approved belt guards. Alternatively, the door to the fan assembly may act as belt protection for certain smaller size air handling units provided the manufacturer has obtained prior approval from the governing agency.
 - 2) Housed Fans: Prime or epoxy coated steel. Secure to fan or fan supports without short circuiting vibration isolation, with provision for adjustment of belt tension, lubrication, and use of tachometer with guard in place.
 - 3) Plug Fans: Galvanized expanded metal enclosure around plug fan wheel, motor, and drive. Enclosure shall include removable section(s), as required for easy access to motor, drive, and bearings. Secure to fan or fan supports without short circuiting vibration isolation, with provision for adjustment of belt tension, lubrication, and use of tachometer with guard in place.
 - b. Tooled access door on cabinet housing moving equipment.
 - c. Interlocking door mechanism to de-energize electrical power to moving equipment when access door is opened.
- H. Automatic Dampers (Outside Air, Return Air and Relief/Exhaust Air):
1. Blades shall be galvanized steel or aluminum, low leakage, parallel airfoil blade, housed in a galvanized steel or aluminum frame and factory mounted on air handling unit.
 2. Blades: Maximum width 6 inches, maximum length 48 inches. Provide multiple sections where necessary. Linkage concealed within frame.
 3. Leakage Rate: Maximum of 5 cfm per sq ft at 1 inch w.g. and 9 cfm per sq ft at 4 inch w.g.
 4. Performance Ratings: Certified in accordance with AMCA Standard 500.
 5. Blade Axles: 1/2 inch diameter hexagonal or square zinc-plated steel.
 6. Bearings: Oil-impregnated sintered bronze or molded synthetic.
 7. Control Shaft: 1/2 inch diameter, extends 6 inches beyond frame.
 8. Blade Edge Seals: Extruded vinyl or rubber.
 9. Jamb Seals: Flexible stainless steel.
 10. Damper Actuators: Provided by Section 230900, Controls. Contractor to coordinate damper control shaft location for best access to actuators.
 11. Basis: Similar to Ruskin CD60, or equal.
- I. Chilled Water Cooling Coils and Hot Water Heating Coils:
1. Tubes: 5/8-inch diameter seamless copper with 0.024 inch minimum tube thickness or 1/2-inch diameter with 0.025 inch minimum tube wall thickness.
 2. Return Bends: Not less than tube thickness.
 3. Header: Seamless copper, die-form collars, brazed tube connections.

4. Fins: Aluminum, 0.008 inch minimum thickness, mechanically bonded to tubes.
 5. Casing: 16 gauge galvanized steel.
 6. Connections: Male pipe thread, supply and return on same end, extended through casing with seals at penetrations.
 7. Supports: Stacked coils shall be supported independently, to allow either coil to be removed with the other left in place.
 8. Vent and Drain Connections.
 9. Water Velocity: Not to exceed 8 fps.
 10. Fin Spacing: Not to exceed 12 fins per inch.
 11. Face area, Pressure Drop, Capacity: Refer to schedule on Drawings.
 12. Performance Ratings: Certified in accordance with ARI 410.
- J. Condensate Drain Pans:
1. Required under each cooling coil.
 2. Size and Quantity: Drain pans shall extend a minimum of 6 inches downstream of the coil face without water carry over from the coil. Unit manufacturer shall guarantee that water carryover will not occur for the size and type of coil selected when passing 115% of the fan design airflow, otherwise provide a drain pan extending 12 inches from coil. Provide intermediate drain pans for stacked coils.
 3. Pan: 16 gauge stainless steel, welded corners, double sloped for complete drainage.
 4. Insulation: One inch rigid fiberglass insulation with vapor barrier.
 5. Drain Connection: Stainless steel or copper, male pipe thread, extended through casing, with seal at penetration.
- K. Airflow Monitoring Station:
1. Provide in the outdoor air intake opening to measure airflow.
 2. Output signal shall be proportional to velocity.
 3. Measurement accuracy shall be "plus or minus" five percent over the range of air flow measurement. System shall automatically compensate for temperature variations.
 4. Manufacturer: Ebtron, Paragon, Traq Dampers, Air Monitor Corporation, or approved. Similar to Paragon OAFE-1500 series .
 5. Provide input, output signals and interface with Building Automation System described in Section 230900.
 6. Manufacturer to provide field set up, calibrate and commission airflow station in concert with Section 230900 contractor.
- L. Pre-Filter Section:
1. Filter Rack: Galvanized steel, side access filter access.
 2. Filter Access Door: Same as specified for casing access doors.
 3. Filter Media Type/Thickness:
 - a. Maximum Pressure Drop:
 - 1) 2 inch Thickness: 0.08 inch w.g. at 250 fpm face velocity when clean.
 - b. Quantity: Provide three sets of filters as follows; one set furnished with rack assembly, one set to be installed before final air balance, and one set delivered to the owner.
 - c. Manufacturer: Farr, Cambridge, Fram, Flanders, Filtration Group, or approved. Similar to Farr Type 30/30.
 4. Filter Gauge:
 - a. Filter gauge shall be field mounted on the filter access side piped with copper tubing around filter bank.
 - b. Type: Magnehelic.

- c. Manufacturer: Dwyer, Cleveland Draft Gauge, Farr, or approved. Similar to Dwyer series 2001-ASF (adjustable signal flag).
- M. Electrical Components and Wiring:
1. Mounting and wiring of electrical components, including but not limited to: fan motors, starters, variable frequency drives, internal lighting, outlets, airflow station transmitters (including power), shall be the responsibility of the unit manufacturer. Wiring shall terminate at the fan variable frequency drive, a disconnect switch or junction box as applicable, ready for connection by Division 26 contractor.
 2. Electrical components shall be UL listed and wiring shall conform to requirements of the National Electrical Code, applicable local codes and Division 26.
 3. Combination Variable Frequency Drive (VFD) / Disconnect switches:
 - a. Provide VFD as specified in Section 205200.
 - b. VFD shall be properly sized, mounted, wired to the fan motor and commissioned by the air handling unit manufacturer. Package shall include the disconnect switch for each circuit, fuses, 120 volt control transformer, Hands-Off-Auto (H-O-A) switch and electronic overloads (factory-set for the specific motor).
 4. Variable Frequency Drives shall be wired to fan motor per NEC, UL, and NFPA 90 requirements.
 5. Fuses and overload heaters shall be selected individually for the voltage, horsepower, and full load amps of the actual motor being supplied. Testing shall include a "Hypot" test of unit wiring to insure that no weaknesses exist in the starter, VFD, wiring or motor. "Hand" and "Auto" positions shall be verified to insure starter is operational.
 6. Provide 120 volt convenience GFCI receptacles with separate disconnect on AHU-1, AHU-2, AHU-3, & AHU-4.
- N. Sound Data:
1. Unit air and sound performance data shall be based on test data generated in an AMCA certified test facility, in accordance with procedures listed in AMCA 210 for air and AMCA 330 for sound. Furnish test performance data upon request.
- O. Capacity and Performance Requirements: Refer to Schedule shown on Drawings.
- P. Manufacturer: Trane Modular Climate Changer, McQuay Vision, York Solution, Temtrol ITF or WF, Carrier Modular Series, Innovent, or approved.

PART 3 EXECUTION

3.01 GENERAL

- A. Install products in accordance with manufacturer's recommendations.
- B. Do not operate units until ductwork is clean, filters are in place, bearings have been lubricated, shipping restraints have been removed, and fan has been test run under observation.
- C. Anchor equipment to floor in accordance with seismic requirements indicated in Section 204200.

END OF SECTION

SECTION 238110

SPLIT SYSTEM AIR CONDITIONING UNITS

PART 1 GENERAL

1.01 RELATED SECTIONS

- A. Section 201000 - General Mechanical Provisions
- B. Section 202000 - Mechanical Operation and Maintenance Manuals
- C. Section 230900 - Controls
- D. Section 231000 - Controls Sequence of Operations

1.02 SHOP DRAWINGS, PRODUCT DATA, OPERATION & MAINTENANCE DATA

- A. Submittals required for the products listed in the Product Table, in accordance with Section 201000. Operation & Maintenance Information required as indicated in the Product Table in accordance with Section 202000.
- B. Operation & Maintenance Information requirements indicated by number designation as follows. Refer to Section 202000 for a description of each type of information.
 - 1. Shop Drawings (submittal data)
 - 2. Product Data (submittal data), including documentation of ORS 453.005 (7) (e) compliance.
 - 3. Manufacturer's Operation Manuals
 - 4. Manufacturer's Service and Lubrication Requirements
 - 5. Service Contracts and Field Start-up Reports
 - 6. Cleaning, Certification, and Test Reports
 - 7. System Information
 - 8. Warranties

PRODUCT TABLE	Operation & Maintenance Information							
	1	2	3	4	5	6	7	8
Air Conditioning Units	X	X	X	X	X		X	X
Thermostats		X	X					X

1.03 QUALITY ASSURANCE

- A. Products shall comply with the requirements of Oregon Revised Statute (ORS) 453.005 (7) (e), effective January 1, 2011. The referenced statute limits the use of three types of brominated fire retardant chemicals, which are defined as hazardous substances.

PART 2 PRODUCTS

2.01 AIR CONDITIONING UNITS (AC-1/CU-1)

- A. General: Five year minimum compressor warranty.
- B. Outdoor Units:
 - 1. Cabinet: Galvanized steel, painted, with coil guards.
 - 2. Compressor: Direct drive, hermetic, reciprocating or scroll, internally isolated, overload protection.
 - 3. Condenser Fan: Direct drive, overload protection.

4. Condenser Coil: Aluminum or copper tubes bonded to aluminum fins. Wind baffle for low ambient operation.
 5. Refrigeration Components: Liquid line filter-drier, R-410A or refrigerant charge, service valves.
 6. Refrigerant Line Sets: Brazed connections, length as required, or provide refrigerant piping under Section 221100.
 7. Electrical: Refer to schedule on Drawings.
 8. Capacity: Refer to schedule on Drawings.
- C. Indoor Units:
1. Cabinet: Horizontal unit for wall mounting, steel, enamel finish, fiberglass insulation.
 2. Evaporator Coil: Copper tubes, aluminum fins, condensate drain pan, expansion device.
 3. Blower: Direct drive, overload protection.
 4. Capacity: Refer to schedule on Drawings.
 5. Electrical: Refer to schedule on Drawings. Single point connection.
 6. Optional Equipment:
 - a. Manufacturer provided condensate pump with built-in sensor to shut off unit if drain clogs or pump fails.
- D. Controls: Factory installed transformer and terminal board with microprocessor controls. Condenser fan control for cooling operation down to zero degrees F. Space temperature sensor for field mounting or factory mounted in Indoor Unit.
- E. Manufacturer: Mitsubishi, Carrier, Daiken, Trane, or approved. Similar to manufacturer and model indicated in schedule on Drawings.

PART 3 EXECUTION

3.01 GENERAL

- A. Install products in accordance with manufacturer's recommendations.
- B. Charge refrigerant system as recommended by manufacturer. Verify that system is holding refrigerant charge and that no leakage is detectable from service valves or mechanical connections.
- C. Provide unit controller programming and initial operational scheduling. Set thermostats to prevent users from making adjustments.
 1. Initial operational settings:
 - a. Space setpoints:
 - 1) Cooling, 77 deg F.
 - b. AC-1, intermittent indoor unit fan operation.
 - c. AC-2, continuous indoor unit fan operation.
 2. Set controller to resume previous mode of operation in event of a power failure.
- D. Cooling coil condensate routing as directed on drawings.
- E. Thermostat, control wiring between outdoor and indoor units installation under Section 230900.

END OF SECTION

SECTION 238220**TERMINAL HEAT TRANSFER UNITS****PART 1 GENERAL****1.01 RELATED SECTIONS**

- A. Section 201000 - General Mechanical Provisions
- B. Section 202000 - Mechanical Operation and Maintenance Manuals

1.02 SHOP DRAWINGS, PRODUCT DATA, OPERATION & MAINTENANCE DATA

- A. Submittals required for the products listed in the Product Table, in accordance with Section 201000. Operation & Maintenance Information required as indicated in the Product Table in accordance with Section 202000.
- B. Operation & Maintenance Information requirements indicated by number designation as follows. Refer to Section 202000 for a description of each type of information.
 - 1. Shop Drawings (submittal data)
 - 2. Product Data (submittal data), including documentation of ORS 453.005 (7) (e) compliance.
 - 3. Manufacturer's Operation Manuals
 - 4. Manufacturer's Service and Lubrication Requirements
 - 5. Service Contracts and Field Start-up Reports
 - 6. Cleaning, Certification, and Test Reports
 - 7. System Information
 - 8. Warranties

PRODUCT TABLE	Operation & Maintenance Information							
	1	2	3	4	5	6	7	8
Panel Radiation	X	X		X				
Unit Heaters		X	X	X				X

1.03 QUALITY ASSURANCE

- A. Products shall comply with the requirements of Oregon Revised Statute (ORS) 453.005 (7) (e), effective January 1, 2011. The referenced statute limits the use of three types of brominated fire retardant chemicals, which are defined as hazardous substances.

PART 2 PRODUCTS**2.01 PANEL RADIATION**

- A. Panel Radiator (PR):
 - 1. Material: Cold rolled carbon steel, fully welded.
 - 2. Tubes: Flat oval.
 - 3. Minimum Wall Thickness: 0.078 inches.
 - 4. Pressure:
 - a. 125 psi minimum operating pressure.
 - b. 180 psi minimum testing pressure.
 - 5. Water Connections: 1/2-inch NPT supply and return, with manual air vent.
 - 6. Maximum Radiator Expansion: 0.018 inch per linear foot at 215 deg. F.

7. Finish:
 - a. Baked enamel paint after cleaning with phosphate solution.
 - b. Color: Runtal Cream White 9001, or as selected by architect.
8. Accessories: Supports and brackets with nylon expansion silencers.
9. Trim: As detailed on drawings.
10. Minimum Capacity: As scheduled on drawings.
11. Manufacturer: Runtal, Panel Radiator, Inc., or approved.

2.02 UNIT HEATERS

- A. Hot Water (UH-1 & UH-2):
 1. Air delivery: Horizontal.
 2. Fan: Direct driven, propeller, guard.
 3. Coil Tubes: Seamless copper.
 4. Coil Fins: Aluminum, mechanically bonded to tubes.
 5. Motor Overload Protection: Built-in.
 6. Casing: Phosphated.
 7. Finish: Baked enamel.
 8. Louvers: Horizontal, adjustable.
 9. Capacity: As scheduled on Drawings.
 10. Manufacturer: Trane, Carrier, McQuay, Resnor, Modine, Airtherm, Dunham-Bush, or approved. Similar to Trane Model S.

PART 3 EXECUTION

3.01 GENERAL

- A. Install products in accordance with manufacturer's recommendations.

END OF SECTION