DIVISION 23: HEATING, VENTILATING, AND AIR-CONDITIONING

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SECTION 23 0501 – COMMON HVAC REQUIREMENTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and General Provisions of Contract, including General and Supplementary Conditions and other Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Furnish labor, materials, and equipment necessary for completion of work as described in Contract Documents.

B. It is the intent of these specifications that the systems specified herein are to be complete and operational before being turned over to the owner. During the bidding process, the contractor is to ask questions or call to the engineer's attention any items that are not shown or may be required to make the system complete and operational. Once the project is bid and the contractor has accepted the contract, it is his responsibility to furnish and install all equipment and parts necessary to provide a complete and operational system without additional cost to the owner.

C. Furnish and install fire stopping materials to seal penetrations through fire rated structures and draft stops.

D. Includes But Not Limited To:
   1. General procedures and requirements for HVAC.

E. Related Sections:
   1. Section 23 0593: Testing, Adjusting, and Balancing for HVAC.

1.3 SUBMITTALS

A. Substitutions: By specific designation and description, standards are established for specialties and equipment. Other makes of specialties and equipment of equal quality will be considered provided such proposed substitutions are submitted to the Architect for his approval, complete with specification data showing how it meets the specifications, at least 5 working days prior to bid opening. A list of approved substitutions will be published as an addendum.
   1. Submit a single copy of Manufacturer's catalog data including Manufacturer's complete specification for each proposed substitution.
   2. The Architect or Engineer is to be the sole judge as to the quality of any material offered as an equal.

B. Product Data, Shop Drawings: Within 30 days after award of contract, submit 10 sets of Manufacturer's catalog data for each manufactured item.
   1. Literature shall include enough information to show complete compliance with Contract Document requirements.
   2. Mark literature to indicate specific item with applicable data underlined.
   3. Information shall include but not be limited to capacities, ratings, type of material used, guarantee, and such dimensions as are necessary to check space requirements.
   4. When accepted, submittal shall be an addition to Contract Documents and shall be in equal force. No variation shall be permitted.
   5. Even though the submittals have been accepted by the Engineer, it does not relieve the contractor from meeting all of the requirements of the plans and specifications and providing a complete and operational system.

C. Drawings of Record: One complete sets of blue line mechanical drawings shall be provided for the purpose of showing a complete picture of the work as actually installed.
   1. These drawings shall serve as work progress report sheets. Contractor shall make notations neat and legible therein daily as the work proceeds.
   2. The drawings shall be kept at the job at a location designated by the Mechanical Engineer.

3. At completion of the project these "as-built" drawings shall be signed by the Contractor, dated, and returned to the Architect.

D. Operating Instructions and Service Manual: The Mechanical Contractor shall prepare 2 copies of an Operation and Maintenance Manual for all mechanical systems and equipment used in this project. Manuals shall be bound in hard-backed binders and the front cover and spine of each binder shall indicate the name and location of the project. Use plastic tab indexes for all sections. Provide a section for each different type of equipment item. The following items shall be included in the manual, together with any other pertinent data. This list is not complete and is to be used as a guide.
   1. Provide a master index at the beginning of the manual showing all items included.
   2. The first section of the manual shall contain:
      a. Names, addresses, and telephone numbers of Architect, Mechanical Engineer, Electrical Engineer, General Contractor, Plumbing Contractor, Sheet Metal Contractor, and Temperature Control Contractor.
      b. List of Suppliers which shall include a complete list of each piece of equipment used with the name, address, and telephone number of vendor.
      c. General Description of Systems including –
         1) Location of all major equipment
         2) Description of the various mechanical systems
         3) Description of operation and control of the mechanical systems
         4) Suggested maintenance schedule
      d. Copy of contractor's written warranty
   3. Provide a copy of approved submittal literature for each piece of equipment.
   4. Provide maintenance and operation literature published by the manufacturer for each piece of equipment which includes: oiling, lubrication and greasing data; belt sizes, types and lengths; wiring diagrams; step-by-step procedure to follow in putting each piece of mechanical equipment in operation.
   5. Include parts numbers of all replaceable items.
   6. Provide control diagram and operation sequence, along with labeling of control piping and instruments to match diagram.
   7. Include a valve chart indicating valve locations.

E. Include air balance and/or water balance reports.

1.4 SUBMITTALS FOR COMMON HVAC REQUIREMENTS

A. Samples: Sealer and gauze proposed for sealing ductwork.

B. Quality Assurance / Control:
   1. Manufacturer’s installation manuals providing detailed instructions on assembly, joint sealing, and system pressure testing for leaks.
   2. Specification data on sealer and gauze proposed for sealing ductwork.

C. Quality Assurance
   1. Requirements: Construction details not specifically called out in Contract Documents shall conform to applicable requirements of SMACNA HVAC Duct Construction Standards.
   2. Pre-Installation Conference: Schedule conference immediately before installation of ductwork.

1.5 QUALITY ASSURANCE

A. Requirements of Regulatory Agencies:
   1. Perform work in accordance with applicable provisions of local and state Plumbing Code, Gas Ordinances, and adoptions thereof. Provide materials and labor necessary to comply with rules, regulations, and ordinances.
   2. In case of differences between building codes, state laws, local ordinances, utility company regulations, and Contract Documents, the most stringent shall govern. Promptly notify Architect in writing of such differences.

B. Applicable Specifications: Referenced specifications, standards, and publications shall be of the issues in effect on date of Advertisement for Bid.

1. "Heating, Ventilating and Air Conditioning Guide" published by the American Society of Heating and Air Conditioning Engineers.
2. "Engineering Standards" published by the Heating, Piping, and Air Conditioning Contractors National Association.
3. "2015 International Building Code", "2015 International Mechanical Code", “2015 International Plumbing Code” and "2015 International Fire Code" as published by the International Conference of Building Officials.
4. "National Electrical Code" as published by the National Fire Protection Association.
5. "2015 International Energy Conservation Code ".

C. Identification: Motor and equipment name plates as well as applicable UL and AGA labels shall be in place when Project is turned over to Owner.

1.6 INSPECTIONS AND PERMITS

A. Pay for permits, fees, or charges for inspection or other services. Local and state codes and ordinances must be properly executed without expense to Owner and are considered as minimum requirements. Local and state codes and ordinances do not relieve the Contractor from work shown that exceeds minimum requirements.

1.7 ADDITIONAL WORK:

A. Design is based on equipment as described in the drawing equipment schedule. Any change in foundation bases, electrical wiring, conduit connections, piping, controls and openings required by alternate equipment submitted and approved shall be paid for by this division. All work shall be in accordance with the requirements of the applicable sections.

PART 2 - PRODUCTS FOR COMMON HVAC REQUIREMENTS

A. Finishes, Where Applicable: Colors as selected by Architect.

B. Duct Hangers:
1. One inch 25 mm by 18 ga 1.27 mm galvanized steel straps or steel rods as shown on Drawings, and spaced not more than 96 inches 2 400 mm apart. Do not use wire hangers.
2. Attaching screws at trusses shall be 2 inch 50 mm No. 10 round head wood screws. Nails not allowed.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Site Inspection:
1. Examine premises and understand the conditions which may affect performance of work of this Division before submitting proposals for this work.
2. No subsequent allowance for time or money will be considered for any consequence related to failure to examine site conditions.

B. Drawings:
1. Mechanical drawings show general arrangement of piping, ductwork, equipment, etc, and do not attempt to show complete details of building construction which affect installation. This Contractor shall refer to architectural, structural, and electrical drawings for additional building detail which affect installation of his work.
    a. Follow mechanical drawings as closely as actual building construction and work of other trades will permit.
    b. No extra payments will be allowed where piping and/or ductwork must be offset to avoid other work or where minor changes are necessary to facilitate installation.
    c. Everything shown on the mechanical drawings shall be the responsibility of Mechanical Contractor unless specifically noted otherwise.

2. Consider architectural and structural drawings part of this work insofar as these drawings furnish information relating to design and construction of building. These drawings take precedence over mechanical drawings.
3. Because of small scale of mechanical drawings, it is not possible to indicate all offsets, fittings, and accessories which may be required. Investigate structural and finish conditions affecting this work and arrange work accordingly, providing such fittings, valves, and accessories required to meet conditions. Do not scale drawings for locations of equipment or piping. Refer to large scale dimensioned drawings for exact locations.

C. Insure that items to be furnished fit space available. Make necessary field measurements to ascertain space requirements including those for connections and furnish and install equipment of size and shape so final installation shall suit true intent and meaning of Contract Documents.
1. If approval is received to use other than specified items, responsibility for specified capacities and insuring that items to be furnished will fit space available lies with this Division.
2. If non-specified equipment is used and it will not fit job site conditions, this Contractor assumes responsibility for replacement with items named in Contract Documents.

3.2 PREPARATION

A. Cut carefully to minimize necessity for repairs to existing work. Do not cut beams, columns, or trusses.
1. Patch and repair walls, floors, ceilings, and roofs with materials of same quality and appearance as adjacent surfaces unless otherwise shown. Surface finishes shall exactly match existing finishes of same materials.
2. Each Section of this Division shall bear expense of cutting, patching, repairing, and replacing of work of other Sections required because of its fault, error, tardiness, or because of damage done by it.
3. Cutting, patching, repairing, and replacing pavements, sidewalks, roads, and curbs to permit installation of work of this Division is responsibility of Section installing work.

3.3 INSTALLATION

A. Arrange pipes, ducts, and equipment to permit ready access to valves, unions, traps, starters, motors, control components, and to clear openings of doors and access panels.

3.4 STORAGE AND PROTECTION OF MATERIALS:

A. Provide storage space for storage of materials and assume complete responsibility for losses due to any cause whatsoever. Storage shall not interfere with traffic conditions in any public thoroughfare.

B. Protect completed work, work underway, and materials against loss or damage.

C. Close pipe openings with caps or plugs during installation. Cover fixtures and equipment and protect against dirt, or injury caused by water, chemical, or mechanical accident.

3.5 EXCAVATION AND BACKFILL

A. Perform necessary excavation of whatever substance encountered for proper laying of all pipes and underground ducts.
1. Excavated materials not required for fill shall be removed from site as directed by Engineer.
2. Excavation shall be carried low enough to allow a minimum coverage over underground piping of 5'-0" or to be below local frost level.
3. Excess excavation below required level shall be backfilled at Contractor's expense with earth, sand, or gravel as directed by Engineer. Tamp ground thoroughly.
4. Ground adjacent to all excavations shall be graded to prevent water running into excavated areas.

B. Backfill pipe trenches and allow for settlement.
1. Backfill shall be mechanically compacted to same density as surrounding undisturbed earth.
2. Cinders shall not be used in backfilling where steel or iron pipe is used.
3. No backfilling shall be done until installation has been approved by the Engineer.

3.6 COOPERATION

A. Cooperate with other crafts in coordination of work. Promptly respond when notified that construction is ready for installation of work under Division 23000. Contractor will be held responsible for any delays which might be caused by his negligence or failure to cooperate with the other Contractors or crafts.

3.7 SUPERVISION

A. Provide a competent superintendent in charge of the work at all times. Anyone found incompetent shall be removed at once and replaced by someone satisfactory, when requested by the Architect.

3.8 INSTALLATION CHECK:

A. An experienced, competent, and authorized representative of the manufacturer or supplier of each item of equipment indicated in the equipment schedule shall visit the project to inspect, check, adjust if necessary, and approve the equipment installation. In each case, the equipment supplier's representative shall be present when the equipment is placed in operation. The equipment supplier's representative shall revisit the project as often as necessary until all trouble is corrected and the equipment installation and operation is satisfactory to the Engineer.

B. Each equipment supplier's representative shall furnish to the Owner, through the Engineer, a written report certifying the following:
   1. Equipment has been properly installed and lubricated.
   2. Equipment is in accurate alignment.
   3. Equipment is free from any undue stress imposed by connecting piping or anchor bolts.
   4. Equipment has been operated under full load conditions.
   5. Equipment operated satisfactorily.

C. All costs for this installation check shall be included in the prices quoted by equipment suppliers.

3.9 CLEANING EQUIPMENT AND PREMISES

A. Properly lubricate equipment before Owner's acceptance.

B. Clean exposed piping, ductwork, equipment, and fixtures. Repair damaged finishes and leave everything in working order.

C. Remove stickers from fixtures and adjust flush valves.

D. At date of Substantial Completion, air filters shall be new, clean, and approved by Owner's representative.

E. Trap elements shall be removed during cleaning and flushing period. Replace trap elements and adjust after cleaning and flushing period.

3.10 TESTS

A. No piping work, fixtures, or equipment shall be concealed or covered until they have been inspected and approved by the inspector. Notify inspector when the work is ready for inspection.

B. All work shall be completely installed, tested as required by Contract Documents and the city and county ordinances and shall be leak-tight before the inspection is requested.

C. Tests shall be repeated to the satisfaction of those making the inspections.

D. Water piping shall be flushed out, tested at 100 psi and left under pressure of supply main or a minimum of 40 psi for the balance of the construction period.

3.11 WARRANTEE

A. Contractor shall guarantee work under Division 23 to be free from inherent defects for a period of one year from acceptance.
   1. Contractor shall repair, revise or replace any and all such leaks, failure or inoperativeness due to defective work, materials, or parts free of charge for a period of one year from final acceptance, provided such defect is not due to carelessness in operation or maintenance.
   2. In addition, the Contractor shall furnish all refrigeration emergency repairs, emergency service and all refrigerant required due to defective workmanship, materials, or parts for a period of one year from final acceptance at no cost to the Owner, provided such repairs, service and refrigerant are not caused by lack of proper operation and maintenance.

B. In addition to warrantee specified in General Conditions, heating, cooling, and plumbing systems are to be free from noise in operation that may develop from failure to construct system in accordance with Contract Documents.

3.12 SYSTEM START-UP, OWNER'S INSTRUCTIONS

A. Off-Season Start-up
   1. If Substantial Completion inspection occurs during heating season, schedule spring start-up of cooling systems. If inspection occurs during cooling season, schedule autumn start-up for heating systems.
   2. Notify Owner 7 days minimum before scheduled start-up.
   3. Time will be allowed to completely service, test, check, and off-season start systems. During allowed time, train Owner's representatives in operation and maintenance of system.
   4. At end of off-season start-up, furnish Owner with letter confirming that above work has been satisfactorily completed.

B. Owner's Instructions
   1. Instruct building maintenance personnel and Owner Representative in operation and maintenance of mechanical systems utilizing Operation & Maintenance Manual when so doing.
   2. Minimum instruction periods shall be as follows –
      a. Mechanical - Four hours.
      b. Temperature Control - Four hours.
      c. Refrigeration - Two hours.
   3. Instruction periods shall occur after Substantial Completion inspection when systems are properly working and before final payment is made.
   4. None of these instructional periods shall overlap another.

3.13 PROTECTION

A. Do not run heat pump, air handling units, fan coil units, or other pieces of equipment used for moving supply air without proper air filters installed properly in system.

B. The mechanical systems are not designed to be used for temporary construction heat. If any equipment is to be started prior to testing and substantial completion, such equipment will be returned to new condition with full one year warranties, from date of substantial completion after any construction use. This includes, but is not necessarily limited to: Equipment, filters, ductwork, fixtures, etc.

3.14 COMMON HVAC REQUIREMENTS:

A. INSTALLATION
   1. During installation, protect open ends of ducts by covering with plastic sheet tied in place to prevent entrance of debris and dirt.
   2. Make necessary allowances and provisions in installation of sheet metal ducts for structural conditions of building. Revisions in layout and configuration may be allowed, with prior written approval of Architect. Maintain required airflows in suggesting revisions.
   3. Hangers And Supports:
      a. Install pair of hangers close to each transverse joint and elsewhere as required by spacing indicated in table on Drawings.

b. Install upper ends of hanger securely to floor or roof construction above by method shown on Drawings.
c. Attach strap hangers to ducts with cadmium-plated screws. Use of pop rivets or other means will not be accepted.
d. Where hangers are secured to forms before concrete slabs are poured, cut off flush all nails, strap ends, and other projections after forms are removed.
e. Secure vertical ducts passing through floors by extending bracing angles to rest firmly on floors without loose blocking or shimming. Support vertical ducts, which do not pass through floors, by using bands bolted to walls, columns, etc. Size, spacing, and method of attachment to vertical ducts shall be same as specified for hanger bands on horizontal ducts.

B. CLEANING
1. Clean interior of duct systems before final completion.

END OF SECTION 23 0501

SECTION 23 0548 – SEISMIC AND VIBRATION CONTROL

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings, General Provisions of Contract, including General and Supplementary Conditions and Section 23 05 01 apply to this Section.

1.2 SUMMARY

A. Furnish and install engineering, labor, material, and equipment necessary for a complete anchorage and seismic restraint system and vibration isolation system as described in Contract Documents.
   1. The system design and installation shall be based on Seismic Zone D or above of the International Building Code and other standards listed below.
   2. The work shall include all mechanical isolated and non- isolated equipment, ducts and piping systems which shall include:
      a. Air handling units.
      b. Utility and inline exhaust fans.
      c. Expansion tanks.
      d. Ceiling and roof fans.
      e. Air compressors.
      f. Pumps.
      g. Round ductwork 24” round and larger.
      h. Rectangular ductwork 4 sq. ft. in cross-sectioned area and larger.
      i. All piping 2-1/2” and larger except waste, vent and roof drainage piping.

1.3 REFERENCE STANDARDS

A. International Building Code, Current Edition

B. NFPA Bulletin 90A, Current Edition

C. UL Standard 181

D. Tri-Services Manual, Fagel Et Al

E. MACNA Guidelines for Seismic Restraints of Mechanical Systems

1.4 SEISMIC REQUIREMENTS & QUALIFICATIONS

A. The Mechanical Contractor shall be responsible for supplying and installing equipment, vibration isolators, flexible connections, rigid steel frames, anchors, inserts, hangers and attachments, supports, seismic snubbers and bracing to comply with the current code. All supports, hangers, bases, braces and anchorage for all non-isolated equipment, ductwork and piping shall be installed as detailed and specified in the contract documents. Specific requirements on equipment anchorage and restraints, locations and sizes shall be furnished to the contractor after shop drawings for mechanical equipment have been reviewed and approved. All supports, hangers, bases, anchorage and bracing for all isolated equipment shall be designed by a professional engineer employed by the restraint manufacturer, qualified with seismic experience in bracing for mechanical equipment. Shop drawings submitted for earthquake bracing and anchors shall bear the Engineer’s signed professional seal.

B. The Contractor shall require all equipment suppliers to furnish equipment that meets the seismic code, with bases designed to receive seismic bracing and/or anchorage. All isolated mechanical equipment bracing to be used in the project shall be designed from the Equipment Shop Drawings certified correct by the equipment manufacturer for Seismic Zone III with direct anchorage capability.

1.5 SUBMITTALS

A. Submittal data prior to fabrication, shall include but not be limited to the following:
   1. Complete engineering calculations and shop drawings for all vibration and seismic requirements for all equipment to be isolated and restrained.
   2. The professional stamp of the engineer who is responsible for the design of the Vibration and Seismic Restraint System for isolated equipment.
   3. Details for all the isolators and seismic bracing with snubbers proposed for items in this specification and on the drawings.
   4. Details for steel frames, concrete inertia bases, and anchors to be used in conjunction with the isolation of the items in this specification and drawings.
   5. Clearly outlined procedures for installing and adjusting the isolators, seismic bracing anchors and snubbers.
   6. The proposed location of pipe and duct restraints.

PART 2 - PRODUCTS

2.1 RESTRAINT EQUIPMENT

A. Manufacturer of restraint equipment for isolated equipment shall be the manufacturer of the vibration isolators furnished for the equipment. Design of restraints and anchors for isolated equipment shall also be by the manufacturer.

B. Approved Manufacturers and Suppliers:
   1. Manufacturers and suppliers of restraint equipment and systems approved for use by the Contractor, for isolated and non-isolated systems, are Mason Industries. Inc., Korfund, Amber/Booth Company, Vibration Mountings & Control Co. or prior approved equal.

2.2 INERTIA PADS

A. Reinforced concrete inertia bases, the steel members of which are designed and supplied by the isolator manufacturer. The concrete shall be poured into a welded steel frame, incorporating prelocated equipment anchor bolts, ½" diameter reinforcing bars on nominal 8" centers each way, and recessed isolator mounting brackets to reduce the mounting height of the equipment, but yet remain within the confines of the base. The thickness of the base shall be 6 inches, or as indicated on the drawings. Where inertia bases are used to mount pumps, the bases shall be wide enough to support piping elbows. Provide with 1 inch minimum deflection springs.

B. Approved Manufacturers:
   1. Mason
   2. Peabody
   3. Vibration Mountings

PART 3 - EXECUTION

3.1 SEISMIC REQUIREMENTS

A. All mechanical equipment, piping and ductwork shall be braced, snubbed or supported to withstand seismic disturbances and remain operational. Furnish all engineering, labor, materials and equipment to provide protection against seismic disturbances as specified herein.

B. Isolated Equipment:
   1. All vibration isolated equipment shall be mounted on rigid steel frames or concrete bases as described in the vibration control specifications unless the equipment manufacturer certified direct attachment capability. Each spring mounted base shall have a minimum of four all-directional seismic snubbers that are double acting and located as close to the vibration isolators as possible to facilitate attachment both to the base and the structure. The snubbers shall consist of interlocking steel members restrained by shock absorbent rubber materials.
   2. Elastomeric material shall be replaceable and a minimum of ¾" thick. Snubbers shall be manufactured with an air gap between hard and resilient material of not less than 1/8" nor more

than ¼". Snubbers shall be installed with factory set clearances. Snubbers shall be equal to Mason Z-1011.

3. A one "g" minimum vertical and lateral level shall be used in the design of all snubbers restraining isolated equipment.

C. Piping:

1. All isolated and non-isolated piping 2-1/2" I.D. and larger shall be protected in all planes by restraints to accommodate thermal movement as well as restrain seismic motion. Locations shall be as scheduled and shall include but not be limited to:
   a. At all drops to equipment and at flexible connections.
   b. At all 45° or greater changes in direction of pipe.
   c. At horizontal runs of pipe, not to exceed 30 feet O.C. spacing.
   d. Piping shall be restrained by a cable restraining system using a minimum of two cables at all restraint points.
   e. Shop drawings shall be submitted with the locations of all restraints shown on a floor plan and noting the size and type of restraint to be used.
   f. Gas piping shall have additional restraints as scheduled.

D. Non Isolated Equipment:

1. The restraint systems for all non isolated equipment shall be designed according to Table 23J, sec. 2312 of the Uniform Building Code with an importance factor of 1.5, a site factor Z = 0.75 and a Cp = 0.3. Horizontal force factor for elements of structures. In addition, the vertical forces restraint requirement shall be computed as ½ the value of the horizontal forces. All equipment not anchored directly to floors shall be restrained by cables as designed and furnished by the Restraint Manufacturer.

E. Ductwork:

1. All isolated and non isolated rectangular ductwork 4 sq. feet in cross-sectional area and larger and all isolated and not isolated round ductwork 24" round and larger shall be protected in all planes by restraints to accommodate thermal movement as well as restrain seismic motion. Locations shall be as determined by the Seismic Restraint Manufacturer and shall include but not be limited to:
   a. All horizontal runs of ductwork, not to exceed 30 feet O.C. spacing.
   b. At all 45° or greater changes in direction of ductwork.
   c. At each end of duct runs and drops to equipment.
   d. At each flexible connection.
   e. Ducts shall be restrained by a cable restraining system using a minimum of two cables at all restraint points.
   f. Shop drawings shall be submitted with the size and type of all restraints to be used. A floor plan shall be provided to show the locations of all restraints.

3.2 VIBRATION ISOLATION REQUIREMENTS

A. All mechanical equipment 1 horsepower and over, unless otherwise noted, shall be isolated from the structure by means of resilient vibration and noise isolators designed and supplied by the manufacturer supplying seismic design and equipment. All piping and ductwork shall be isolated from the structure. Isolation equipment, hangers, connections, and other isolating devices shall be designed and installed to prevent transmission of vibration to the structure from the mechanical equipment or any associated piping and ductwork. All isolation systems shall be designed and installed to provide isolation efficiency of 98 percent.

B. All spring supports shall be designed to have an additional travel of 50 percent between the design height and the solid height.

C. All heating, hot water piping in the mechanical equipment room and piping three supports away from other mechanical equipment shall be isolated from the structure by means of vibration and noise isolators. Suspended piping shall be isolated with combination spring and fiberglass hangers in the supporting rods. Floor-mounted piping shall be supported directly on spring mounts.

D. Vertical pipe risers shall be isolated from the structure by means of vibration and noise isolating expansion hangers. The hangers shall have a minimum rated deflection of four times the anticipated pipe movement and shall be enclosed in a housing for fail-safe equipment.

E. Flexible members shall be incorporated in the piping adjacent to all reciprocating equipment.

F. Flexible connections shall be incorporated in the ductwork adjacent to all air-moving units.

END OF SECTION 23 0548

SECTION 23 0553 – IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings, General Provisions of Contract, including General and Supplementary Conditions and Section 23 0501 apply to this Section.

1.2 SUMMARY

A. Furnish and install identification of equipment and piping as described in Contract Documents.

B. Mechanical Contractor shall touch-up equipment where factory paint has been damaged. Repaint entire item where more than 20 percent of the surface is involved.

C. Primary painting of walls, ceilings, ductwork, piping and plenums is covered in the general painting section of these Contract Documents.

PART 2 - PRODUCTS

2.1 PAINT

A. Benjamin Moore Impervo or equivalent by Paint Manufacturer approved in Section 09 900.

B. Use appropriate primer.

2.2 LABELS

A. Black Formica with white reveal on engraving.

2.3 CODED BANDS

A. Using colored bands and arrows to indicate supply and return, with colored reflective tape, color code all piping installed in this contract at not more than 20-foot intervals, at equipment, at walls, etc., in accordance with ANSI Standards.

B. Approved Manufacturers:
1. Seton
2. Craftmark

2.4 PIPE IDENTIFICATION

A. In addition to the colored bands, stencil with black paint in ½ inch high letters a symbol and directional arrow for all fluids handled or use Seaton coded and colored pipe markers and arrows to meet ANSI Standards.

2.5 EQUIPMENT IDENTIFICATION

A. Provide an engraved plastic plate for each piece of equipment stating the name of the item, symbol number, area served, and capacity. Label all control components with plastic embossed mechanically attached labels. Sample:
1. Supply Fan SF-1 – North Classrooms
2. 10,000 CFM @ 2.5”

2.6 VALVE IDENTIFICATION

A. Make a list of and tag all valves installed in this work.
   1. Valve tags shall be of brass, not less than 1”x2” size, hung with brass chains.
   2. Tag shall indicate plumbing or heating service.

PART 3 - EXECUTION

3.1 APPLICATION

A. Engraved Plates:
   1. Identify thermostats and control panels in mechanical rooms, furnaces, boilers and hot water heating specialties, duct furnaces, air handling units, electric duct heaters, and condensing units with following data engraved and fastened to equipment with screws –
      a. Equipment mark noted on Drawings (i.e., SF-1)
      b. Area served (i.e., North Classrooms)
      c. Capacity (10,000 CFM @ 2.5)

B. Stenciling:
   1. Locate identifying legends and directional arrows at following points on each piping system –
      a. Adjacent to each item of equipment and special fitting.
      b. At point of entry and exit where piping goes through wall.
      c. On each riser and junction.
      d. Every 50 feet on long continuous lines.
   2. Steam Pipe, Hot Water Heating, Chilled Water, Gas, & Valve Identification –
      a. Identify specific pipe contents by stenciling pipe with written legend and placing of arrows to indicate direction of flow.

C. Painting:
   1. Background Color - Provide by continuous painting of piping.

Symbol	Name	Color
STM	Steam Lines	Orange
COND	Steam Condensate Return Line	Lt Orange
HWH	Hot Water Heating	Green
CHW	Chilled Water	Blue
NG	Natural Gas	Yellow
FS	Fire Sprinkler	Red
AIR	Air	Blue

   2. Identification stenciling and flow arrows shall be following colors for proper contrast:

Arrows & ID Stenciling	Color Shade of Pipe
White	Red, Grays, & black
Black	Yellows, Oranges, Greens, & White

END OF SECTION 23 0553

SECTION 23 0593 – TESTING, ADJUSTING, AND BALANCING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Division 23 0501 – Common HVAC Requirements and Basic Mechanical Materials and Methods Sections apply to work of this section.

1.2 SUMMARY SCOPE

A. This Section includes TAB to produce design objectives for the following:
   1. Air Systems.
      a. Fan Coil Units.
      b. Exhaust Fans.
   2. Hydronic Piping Systems.
      a. Primary – Secondary Systems
      b. Coils
      c. Pumps
      d. Heat Exchangers

1.3 SUBMITTALS

A. Agency Data:
   1. Submit proof that the proposed testing, adjusting, and balancing agency meets the qualifications specified below. The firm or individuals performing the work herein specified may not be the installing firm.

B. Engineer and Technicians Data:
   1. Submit proof that the Test and Balance Engineer assigned to supervise the procedures, and the technicians proposed to perform the procedures meet the qualifications specified below.

C. Procedures and Agenda: Submit a synopsis of the testing, adjusting, and balancing procedures and agenda proposed to be used for this project.

D. Sample Forms: Submit sample forms, if other than those standard forms prepared by the AABC or NEBB are proposed.

E. Certified Reports: Submit testing, adjusting, and balancing reports bearing the seal and signature of the Test and Balance Engineer. The reports shall be certified proof that the systems have been tested, adjusted, and balanced in accordance with the referenced standards; are an accurate representation of how the systems have been installed; are a true representation of how the systems are operating at the completion of the testing, adjusting, and balancing procedures; and are an accurate record of all final quantities measured, to establish normal operating values of the systems. Follow the procedures and format specified below.
   1. Draft Reports: Upon completion of testing, adjusting, and balancing procedures, prepare draft reports on the approved forms. Draft reports may be hand written, but must be complete, factual, accurate, and legible. Organize and format draft reports in the same manner specified for the final reports. Submit 2 complete sets of draft reports. Only 1 complete set of draft reports will be returned.
   2. Final Report: Upon verification and approval of draft reports, prepare final reports, type written, and organized and formatted as specified below. Submit 4 complete sets of final reports.
   3. Report Format: Report forms shall be those standard forms prepared by the referenced standard for each respective item and system to be tested, adjusted, and balanced. Bind report forms complete with schematic systems diagrams and other data. Divide the contents of the binder into the below listed divisions, separated by divider tabs:
      a. General Information and Summary
      b. Air Systems
      c. Temperature Control System Verification.

F. Report Contents: Provide the following minimum information, forms, and data:
   1. General information and Summary: Inside cover sheet to identify testing, adjusting, balancing agency, Contractor, Owner, Engineer, and Project. Include addresses and contact names and telephone numbers. Also include a certification sheet containing the seal and name, address, telephone number, and signature of the Certified Test and Balance Engineer. Include in this division a listing of the instrumentation used for the procedures along with the instrument calibration sheet.
   2. The remainder of the report shall contain the appropriate forms containing as a minimum, the information indicated on the standard report forms prepared by the AABC or NEBB, for each respective item and system. Prepare a schematic diagram for each item of equipment and system to accompany each respective report form. The report shall contain the following information, and all other data resulting from the testing, adjusting, and balancing work:
      a. All nameplate and specification data for all air handling equipment and motors.
      b. Actual metered running amperage for each phase of each motor on all pumps and air handling equipment.
      c. Actual metered voltage at air handling equipment (phase-to-phase for all phases).
      d. Fan RPM for each piece of air handling equipment.
      e. Total actual CFM being handled by each piece of air handling equipment.
      f. Actual CFM of systems by rooms.
   3. Certify that all smoke and fire dampers operate properly and can be reset under actual system operating conditions.

G. Calibration Reports:
   1. Submit proof that all required instrumentation has been calibrated to tolerances specified in the referenced standards, within a period of six months prior to starting the project.

1.4 CERTIFICATION

A. Agency Qualifications:
   1. Employ the services of a certified testing, adjusting, and balancing agency meeting the qualifications specified below, to be the single source of responsibility to test, adjust, and balance the building mechanical systems identified above, to produce the design objectives. Services shall include checking installations for conformity to design, measurement, and establishment of the fluid quantities of the mechanical systems as required to meet design specifications, recording and reporting the results, and operation of all systems to demonstrate satisfactory performance to the owner.
   2. The testing, adjusting, and balancing agency certified by National Environmental Balancing Bureau (NEBB) or Associated Air Balance Council (AABC) in those testing and balancing disciplines required for this project, and having at least one person certified by NEBB or AABC as a Test and Balance supervisor, and a registered professional mechanical engineer, licensed in the state where the work will be performed.

B. Codes and Standard:
   1. NEBB: “Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems.”
   2. AABC: “National Standards for Total System Balance.”
   3. ASHRAE: ASHRAE Handbook, 1984 Systems Volume, Chapter 37, Testing, Adjusting, and Balancing.

1.5 PROJECT CONDITIONS

A. Systems Operation: Systems shall be fully operation and clean prior to beginning procedures.

1.6 SEQUENCING AND SCHEDULING

A. Test, adjust, and balance the air systems before hydronic, steam, and refrigerant systems within +10% to -5% of contract requirements.

B. The report shall be approved by the Engineer. Test and balance shall be performed prior to substantial completion.

PART 2 - NOT USED

PART 3 - EXECUTION

3.1 PRELIMINARY PROCEDURES FOR AIR SYSTEM BALANCING

A. Before operating the system, perform these steps.
   1. Obtain design drawings and specifications and become thoroughly acquainted with the design intent.
   2. Obtain copies of approved shop drawings of all air handling equipment, outlets (supply, return, and exhaust) and temperature control diagrams.
   3. Compare design to installed equipment and field installations.
   4. Walk the system from the system air handling equipment to terminal units to determine variations of installation from design.
   5. Check filters for cleanliness and to determine if they are the type specified.
   6. Check dampers (both volume and fire) for correct and locked position. Check automatic operating and safety controls and devices to determine that they are properly connected, functioning, and at proper operating setpoint.
   7. Prepare report test sheets for both fans and outlets. Obtain manufacturer's outlet factors and recommended procedures for testing. Prepare a summation of required outlet volumes to permit a cross-check with required fan volumes.
   8. Determine best locations in main and branch ductwork for most accurate duct traverses.
   9. Place outlet dampers in the full open position.
   10. Prepare schematic diagrams of system "As-Built" ductwork and piping layouts to facilitate reporting.
   11. Lubricate all motors and bearings.
   12. Check fan belt tension.
   13. Check fan rotation.

3.2 PROCEDURES FOR HYDRONIC SYSTEMS

B. Measure water flow at pumps. Use the following procedures, except for positive-displacement pumps:
   1. Verify impeller size by operating the pump with the discharge valve closed. Read pressure differential across the pump. Convert pressure to head and correct for differences in gage heights. Note the point on manufacturer's pump curve at zero flow and verify that the pump has the intended impeller size.
   2. Check system resistance. With all valves open, read pressure differential across the pump and mark pump manufacturer's head-capacity curve. Adjust pump discharge valve until indicated water flow is achieved.
   3. Verify pump-motor brake horsepower. Calculate the intended brake horsepower for the system based on pump manufacturer's performance data. Compare calculated brake horsepower with nameplate data on the pump motor. Report conditions where actual amperage exceeds motor nameplate amperage.
   4. Report flow rates that are not within plus or minus 5 percent of design.

C. Set calibrated balancing valves, if installed, at calculated presettings.

D. Measure flow at all stations and adjust, where necessary, to obtain first balance.
   1. System components that have Cv rating or an accurately cataloged flow-pressure-drop relationship may be used as a flow-indicating device.

E. Measure flow at main balancing station and set main balancing device to achieve flow that is 5 percent greater than indicated flow.

F. Adjust balancing stations to within specified tolerances of indicated flow rate as follows:
   1. Determine the balancing station with the highest percentage over indicated flow.
   2. Adjust each station in turn, beginning with the station with the highest percentage over indicated flow and proceeding to the station with the lowest percentage over indicated flow.
   3. Record settings and mark balancing devices.

G. Measure pump flow rate and make final measurements of pump amperage, voltage, rpm, pump heads, and systems' pressures and temperatures including outdoor-air temperature.

H. Measure the differential-pressure control valve settings existing at the conclusions of balancing.

3.3 MEASUREMENTS

A. Provide all required instrumentation to obtain proper measurements, calibrated to the tolerances specified in the referenced standards. Instruments shall be properly maintained and protected against damage.

B. Provide instruments meeting the specifications of the referenced standards.

C. Use only those instruments which have the maximum field measuring accuracy and are best suited to the function being measured.

D. Apply instrument as recommended by the manufacturer.

E. Use instruments with minimum scale and maximum subdivisions and with scale ranges proper for the value being measured.

F. When averaging values, take a sufficient quantity of readings which will result in a repeatability error of less than 5%. When measuring a single point, repeat readings until 2 consecutive identical values are obtained.

G. Take all readings with the eye at the level of the indicated value to prevent parallax.

H. Use pulsation dampeners where necessary to eliminate error involved in estimating average of rapidly fluctuation readings.

I. Take measurements in the system where best suited to the task.

3.4 PERFORMING TESTING, ADJUSTING, AND BALANCING

A. Perform testing and balancing procedures on each system identified, in accordance with the detailed procedures outlined in the referenced standards. Balancing of the air systems and hydronic systems shall be achieved by adjusting the automatic controls, balancing valves, dampers, air terminal devices, and the fan/motor drives within each system.

B. Cut insulation, ductwork, and piping for installation of test probes to the minimum extent necessary to allow adequate performance of procedures.

C. Patch insulation, ductwork, and housings, using materials identical to those removed.

D. Seal ducts and piping, and test for and repair leaks.

E. Seal insulation to re-establish integrity of the vapor barrier.

F. Adjust timing relays of environmental equipment motor reduced voltage starters to the optimum time period for the motor to come up to the maximum reduced voltage speed and then transition to the full voltage speed to prevent damage to motor, and to limit starting current spike to the lowest possible and practical.

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

H. Retest, adjust, and balance systems subsequent to significant system modifications, and resubmit test results.

3.5 RECORD AND REPORT DATA

A. Record all data obtained during testing, adjusting, and balancing in accordance with, and on the forms

recommended by the referenced standards, and as approved on the sample report forms.

B. Prepare report of recommendations for correcting unsatisfactory mechanical performances when system cannot be successfully balanced.

C. Report shall be certified and stamped by a registered professional mechanical engineer employed by the agency and licensed in the state where the work will be performed.

D. Engineer is to provide a floor plan and test and balance contractor to include the plan in test and balance report and identify actual cfm on drawing or number the diffusers to match report.

3.6 DEMONSTRATION

A. If requested, testing, adjusting, and balancing agency shall conduct any or all of the field tests in the presence of the engineer.

B. Agency shall include a maximum of one (1) call back to the project within the one year warranty period to make additional adjustments if requested by the engineer.

END OF SECTION 23 0593

SECTION 23 0710 - MECHANICAL INSULATION AND FIRE STOPPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings, General Provisions of Contract, including General and Supplementary Conditions and Section 23 0501 apply to this Section.

1.2 SUMMARY

A. Furnish and install mechanical insulation and fire stopping as described in Contract Documents including but not limited to the following:
   1. Ductwork Insulation
   2. Heating and Chilled Piping Insulation
   3. Underground Thermally Activated Pipe Insulation
   4. Steam and Condensate Piping Insulation
   5. Refrigerant Piping
   6. Fire Stopping

1.3 QUALITY ASSURANCE

A. Insulation shall have composite (insulation, jacket or facing and adhesive used to adhere facing or jacket to insulation) fire and smoke hazard ratings as tested by Procedure ASTM E-84, NFPA 255 and UL 723 not exceeding: Flame Spread of 25 and Smoke Developed of 50.

B. Insulation Contractor shall certify in writing, prior to installation, that all products to be used will meet the above criteria.

C. Accessories, such as adhesives, mastics, cements, and tapes, for fittings shall have the same component ratings as listed above.

D. Products, or their shipping cartons, shall bear a label indicating that flame and smoke ratings do not exceed above requirements.

E. Any treatment of jacket or facings to impart flame and smoke safety shall be permanent.

F. The use of water-soluble treatments is prohibited.

END OF SECTION 23 0710

SECTION 23 0712- CHILLED WATER SUPPLY & RETURN PIPING INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings, General Provisions of Contract, including General and Supplementary Conditions and Section 23 0501 apply to this section.

1.2 SUMMARY

A. Furnish and install insulation on piping mains, branches, risers, fittings, and valves, pump bodies and flanges as described in Contract Documents.

PART 2 - PRODUCTS

2.1 MATERIAL

A. 6 lb./cu.ft. heavy density fiberglass with fire retardant vapor barrier jacket with self sealing laps. Thickness shall be 1-1/2 inches on heating supply and return lines.

B. Approved Manufacturers:
1. Owens-Corning Fiberglass heavy density with ASJ-SSL jacket.
2. Equals by Johns-Mansville or CTM.
3. Zeston covers for valves and fittings.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Pipes:
1. Install in accordance with manufacturer's directions on clean dry pipes.
2. Butt joints firmly together.
3. Seal vapor barrier longitudinal seam overlap with vapor barrier adhesive.
4. Wrap butt joints with four inch strip of vapor barrier jacket material cemented with vapor barrier adhesive.
5. Finish with bands applied as mid-section and at each end of insulation.

B. Valves & Fittings:
1. Insulate and finish by one of the following methods:
   a. With hydraulic setting insulating cement, or equal, to thickness equal to adjoining pipe insulation.
   b. With segments of molded insulation securely wired in place.
   c. With prefabricated covers made from molded pipe insulation finished with vapor barrier adhesive.
   d. Zeston covers and factory applied insulation diapers.
2. Finish fittings and valves with four ounce canvas and coat with vapor barrier adhesive or Zeston covers.

C. Piping located outdoors and exposes to the weather shall be insulated as indicated above except the thickness shall be determined according to the worst weather extremes expected. The insulation shall then by protected with one of the following weatherproof finishes as indicated on contract drawings:
1. Metal jacketing shall be 0.016" (0.4mm) minimum aluminum or stainless steel with moisture barrier, secured in accordance with the jacket manufacturer's recommendations. Joints shall be applied to they will shed water and shall be sealed completely.
2. UV resistant PVC jacketing may be applied in lieu of metal jacketing provided jacketing manufacturer's limitations with regard to pipe size, surface temperature, and thermal expansion and contraction are followed.

3. Fittings shall be insulated as prescribed above, jacketed with preformed fitting covers matching outer jacketing used on straight pipe sections, with all joints together sealed.

4. On outdoor child water and refrigerant lines, the insulation system shall be completely vapor sealed before the weather-resistant jacket is applied. The outer jacket shall not compromise the vapor barrier by penetration of fasteners, etc. Vapor stops at butt joints shall be applied at ever forth pipe section joint and at each fitting to provide isolation of water incursion.

END OF SECTION 23 0712

SECTION 23 0713 – UNDERGROUND THERMALLY ACTIVATED PIPE INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of contract, including general and supplementary conditions and division. Specification sections, insulation manufacturers shop/installation drawings Design & Installation manual apply to work of this section.

1.2 DESCRIPTION OF WORK

A. Extent of underground piping insulation required by this section is indicated on drawings and schedules and by requirement of this section.

B. Types of underground piping insulation specified in this section include the following: Inorganic, engineered granular, underground pipe insulation.

1.3 SECTION INCLUDES

A. Controlled Density Thermal Insulation & Corrosion Protection Pipes & Tanks

B. Miscellaneous incidental to complete installation of field applied exterior insulation to raw carrier pipe

1.4 CODE AND STANDARDS American Society for Testing and Materials (ASTM)

A. ASTM C-177-04 Steady-State Heat Flux Measurement and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus

1. Thermal Conductivity – material ASTM testing at installed/use density

B. ASTM D-1895 Apparent Density, Bulk Factor and Pourability of Plastic Materials

1. Method A: Apparent Density (Bulk Density)
2. Method C: (Applied 400 lbs.) Compaction & Corresponding Density Under Static Load
3. Method C: (Applied 400 lbs.) Percent of compaction of installed density under static load
4. Method C: (Applied 12,000 lbs.) Material Bearing Under Applied Static Loading

1.5 SUBMITTALS

A. Submit product testing of product properties in accordance and compliance of ASTM Industry Codes and Standards for items in Section 1.4 “Codes and Standards” and Section 2.4 “Physical Properties”

B. Long Term Water Retardancy Test: Submit passage of 3rd party conducted laboratory testing for minimum of 30 days withstanding moisture penetration.

C. Submit manufacturer entire warranty, per manufacturer’s current design/installation manual.

D. Current Published Manufacturer's Design & Installation Manual and Instructions

E. Manufacturer Statement: Indicating if the material is sold based on bulk density or installed/use density.

1.6 QUALITY ASSURANCE

A. Manufacturer’s Qualifications: Firm regularly engaged in the manufacture of granular insulation products of size and type required, whose product has been in satisfactory use in similar service for not less than 10 years.

B. Installers Qualifications: Firm with at least 3 years of successful installation experience on projects with elevated temperature mechanical insulation systems.

C. On site supervision of direct buried insulation installation: Provide services of a manufacturer trained representative of the insulation manufacturer for a minimum of 2 trip(s), to include pre-installation/start-up training and continued installation supervision. Provide a written report following each site trip. Advise manufacturer of minimum 7-10 days in advance for scheduling.

1.7 SUBSTITUTIONS

A. Request for alternative must be made within 10 days prior to bid. Proposed alternative must be a viable direct-buried product. Substitutions will be included in addendum prior to bid and all deviations from requirements of this specification noted.

1.8 DELIVERY, STORAGE AND HANDLING

A. Deliver insulation, associated adhesives, form work and supplementary steel to site in manufacturer's containers with manufacturer's stamp or label clearly shown.

B. Protect insulation packaging and associated components against sun, dirt, water and chemical damage.

PART 2 - PRODUCTS

2.1 MANUFACTURER & PROPRIETER OF PATENT

Gilsulate International, Incorporated
26000 Springbrook Ave 201
Santa Clarita, Ca 91350
800-833-3881 – www.gilsulate.com

2.2 PATENTED PRODUCT

A. Gilsulate®500XR (Patent 4,231,884)

1. Exact Match Only –this necessary item is not available under any other product name.
2. There is NO equal alternative to or replacement for Gilsulate®500XR.

2.3 INSULATION & CORROSION PROTECTION

A. Provide a system meeting Unified Facilities Guide Specifications UFGS-33.61.13 (2.4) including manufacturer requirements, ASTM Codes & Standards and installed guidelines.

B. Product must consist of insulating minerals (sodium potassium aluminum silicate) and dielectric mineral filler (coated calcium carbonate). Material shall be dry, free-flowing, inert, inorganic, non-toxic, non-flammable, and completely free of asbestos and fibers. Material to be chemically treated to render it hydrophobic. Product is NOT to rely upon polyethylene barrier to prevent: foreign object/soil intrusion, material protection or direct contact of water. Unified Soil Classification System (USCS) recognizes well-graded and poorly graded materials. Underground fill product must consist of well-graded, multi-sized and shaped particles and raw material must be dimensionally stable. Insulation material must be able to be mechanically compacted.

2.4 PHYSICAL PROPERTIES

1. ASTM C177-04 Thermal Conductivity (tested @ use density):
2. K = 0.53 Btu/hr.ft2 °F/in. @ 100 °F Mean Temp
3. K = 0.60 Btu/hr.ft2 °F/in. @ 175 °F Mean Temp
4. K = 0.65 Btu/hr.ft2 °F/in. @ 300 °F Mean Temp

5. ASTM D1895A – Bulk Density
6. 30-34 lbs./ft3
7. ASTM D1895C (400 lbs.) – Consolidated Cubic Foot Installed/Use Density (CFUD)
8. 40-42 lbs./ft3 CFUD
9. ASTM D1895C (400 lbs.) – Percent of compaction of installed density under static load
10. Shall not exceed more than 1% compaction
11. ASTM D1895C (12,000 lbs.) – Material Bearing Under Applied Static Loading
12. 12,000 PSF
13. Particle Sizing Range: “Well-graded” diameter ranging from 1mm to sub-micron sizes
14. Material Stability: Material for direct-buried application must support weight of a man prior to backfill placement.
15. Temperature Range: 35°F to 800°F
16. Electrical Resistivity: Greater than 10 to the 12th Ohm-cm

2.5 ACCESSORIES

A. Protective Coatings: provide a bitumastic self-priming, heavy duty, cold-applied, waterproof coating made from pitch derived from tar and solvents. Approved product: Carboline® “Bitumastic 50” or equal.

B. Structural Steel Components: provide steel anchors and guides as required by the contract documents and insulation manufacturer's drawings and Design and Installation Manual.

C. Expansion Cushions: provide 3 to 5 pound density mineral fiber cushion to accommodate thermal expansion at expansion loops and elbows as required by the contract documents and insulation manufacturer's drawings and Design and Installation Manual.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine area and conditions under which engineered controlled density insulating fill & corrosion protection system is to be installed. Do not proceed with work until unsatisfactory conditions have been corrected. All standing water shall be removed from trench prior to installing insulation.

B. Pile dirt from trenching on one side of trench and work from opposite side. Insure bottom of trench is free of debris and large stones.

C. Bottom of trench shall be undisturbed soil.

3.2 INSTALLATION

A. Install and test carrier pipe: Install and test prior to installing insulation. Inspect welds and pressure test pipe as required by other sections of this specification. Clean pipe of all dirt, scale and foreign materials.

B. Installation of anchors: Install structural steel and concrete of the size and quantity shown on the contract documents. Pour 2000 psi concrete at 28 days around rebar and anchor post and against undisturbed soil. Insure anchor post and support channel (if required) are at the proper elevation for installation of piping. Insure the rebar and the bottom of the anchor post is within the concrete envelope. Just prior to pouring the insulation coat all exposed steel (anchor post, support channel and knee brace) with bitumastic. Bitumastic must be tacky during insulation.

C. Installation of guides: Install structural steel and concrete of the size and quantity shown on the contract documents. Pour 2000 psi concrete at 28 days around lower portion of guide brackets and against undisturbed soil. Weld the horizontal guide brackets at the proper pipe elevation. Just prior to pouring the insulation coat all exposed steel guide brackets and spacer angles with bitumastic. Bitumastic must be tacky during insulation installation.

D. Installation of expansion loop support: Pour concrete support pad of the size indicated on the contract documents. Insure pad elevation is correct for proper pipe elevation when the concrete pipe support is installed. Coat pipe support with bitumastic. Bitumastic must be tacky during insulation installation.

E. Installation of temporary pipe supports: Provide temporary pipe support wires suspended from lumber bridging the trench. Temporary wood blocks located under the pipe may also be used. These supports must be removed as the insulation is poured and consolidated. No object should be allowed to bridge the gap between the soil and the pipe except the insulation.

F. Installation of expansion cushions: Wrap mineral fiber cushions around pipe elbows on expansion elbows and expansion loops as indicated on the contract documents. Insure there is sufficient space or flexibility between cushions to allow insulation to pour and be consolidated under piping. Secure cushion to pipe with fiber reinforced tape. Specified Insulation thicknesses need to be maintained around fiber cushion areas.

G. Installation of forms: Provide gypsum board forms with support posts as shown in Gilsulate International, Inc.'s Design and Installation Manual. Posts must be located on the outside of the forms and spaced to prevent bowing of the gypsum board. After forms are in place, partially backfill outside of form to height of pipe.

H. Pouring of insulation: Pour insulation in short sections along the pipe axis. Apply bitumastic to structural steel surfaces and fill trench to centerline of pipe. Consolidate insulation using a rod-type concrete vibrator pulled along the sides and between the pipes. Pour and consolidate additional layers of insulation until the design coverage has been achieved. Proper consolidation is achieved when the insulation can be walked on with foot prints less than 1" deep. No wood is to remain in contact with pipe(s) or left in insulation envelope. This could affect overall system efficiency (heat gain/loss) of non-metallic pipe(s) and/or cause corrosion to metallic pipe(s).

I. Inspector must physically be capable of confirming specified installed/compacted insulation thicknesses prior to placement of any backfill.

J. Backfill first 6" of soil (no stones) by hand. Complete backfilling and mechanically compact in uniform layers with suitable excavated soil to grade level.

K. Refer to Gilsulate International Inc. “Design & Installation Manual for Installation Procedures.

END OF SECTION 23 0713

SECTION 23 0714 – PREMOLDED ONE PIECE PVC FITTINGS INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and General Provisions of Contract, including General and Supplementary Conditions and Section 23 0501 apply to this Section.

1.2 SUMMARY

A. Furnish and install premolded one piece PVC fittings insulation as described in Contract Documents.

1.3 QUALITY ASSURANCE

A. Fittings shall be UL rated 25/50 PVC.

PART 2 - PRODUCTS

2.1 MANUFACTURED UNITS

A. Approved Manufacturers:
   1. Zeston

PART 3 - EXECUTION

3.1 INSTALLATION

A. Where factory premolded one piece PVC insulating fitting covers are to be used, proper factory precut Hi-Lo Temp insula tion shall be applied to the fitting. Ends of Hi-Lo Temp insulation shall be tucked snugly into throat of fitting and edges adjacent to pipe covering tufted and tucked in. Fully insulate pipe fittings. One piece PVC fitting cover is then secured by stapling, tack fastening, banding or taping ends to adjacent pipe covering.

B. Cold:
   1. Chilled water systems shall be insulated as "A" above and have all seam edges of cover sealed with Zeston's vapor barrier adhesive or equal.
   2. Circumferential edges of cover shall be wrapped with Zeston's vapor barrier pressure sensitive color matched Z tape.
   3. Tape shall extend over adjacent pipe insulation and have an overlap on itself at least 2" on downward side.

C. Hot:
   1. On fittings where temperature exceeds 250 degrees F., two layers of factory precut Hi-Lo Temp insulation inserts shall be applied with a few wrappings of twine on first layer, to be sure there are no voids or hot spots. Fitting cover shall then be applied over Hi-Lo Temp insulation as described above in "A."

END OF SECTION 23 0714

SECTION 23 0715 – HOT WATER HEATING & RETURN PIPING INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings, General Provisions of Contract, including General and Supplementary Conditions and Section 23 0501 apply to this Section.

1.2 SUMMARY

A. Furnish and install insulation on piping mains, branches, risers, fittings, and valves, pump bodies and flanges as described in Contract Documents.

PART 2 - PRODUCTS

2.1 MATERIAL

A. 3 lb./cu.ft. heavy density fiberglass with fire retardant vapor barrier jacket with self sealing laps. Thickness shall be 1-1/2 inches on heating supply and return lines.

B. Approved Manufacturers:
1. Owens-Corning Fiberglass heavy density with ASJ-SSL jacket
2. Equals by Johns-Manville or CTM.
3. Zeston covers for valves and fittings.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Pipes:
1. Install in accordance with manufacturer's directions on clean dry pipes.
2. Butt joints firmly together.
3. Seal vapor barrier longitudinal seam overlap with vapor barrier adhesive.
4. Wrap butt joints with four inch strip of vapor barrier jacket material cemented with vapor barrier adhesive.
5. Finish with bands applied at mid-section and at each end of insulation.

B. Valves & Fittings:
1. Insulate and finish by one of following methods:
   a. With hydraulic setting insulating cement, or equal, to thickness equal to adjoining pipe insulation.
   b. With segments of molded insulation securely wired in place.
   c. With prefabricated covers made from molded pipe insulation finished with vapor barrier adhesive.
   d. Zeston covers and factory applied insulation diapers.
2. Finish fittings and valves with four ounce canvas and coat with vapor barrier adhesive or Zeston covers.

C. Piping located outdoors and exposed to the weather shall be insulated as indicated above except the thickness shall be determined according to the worst weather extremes expected. The insulation shall then be protected with one of the following weatherproof finishes as indicated on contract drawings:

1. Metal jacketing shall be 0.016" (0.4 mm) minimum aluminum or stainless steel with moisture barrier, secured in accordance with the jacket manufacturer's recommendations. Joints shall be applied so they will shed water and shall be sealed completely.
2. UV resistant PVC jacketing may be applied in lieu of metal jacketing provided jacketing manufacturer's limitations with regard to pipe size, surface temperature, and thermal expansion

and contraction are followed.

3. Fittings shall be insulated as prescribed above, jacketed with preformed fitting covers matching outer jacketing used on straight pipe sections, with all joints weather sealed.
4. On outdoor chilled water and refrigerant lines, the insulation system shall be completely vapor sealed before the weather-resistant jacket is applied. The outer jacket shall not compromise the vapor barrier by penetration of fasteners, etc. Vapor stops at butt joints shall be applied at every fourth pipe section joint and at each fitting to provide isolation of water incursion.

END OF SECTION 23 0715

SECTION 23 0716 - DUCTWORK INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings, General Provisions of Contract, including General and Supplementary Conditions and other Division 1 Specification Sections, and Section 23 0501 apply to this Section.

1.2 SUMMARY

A. Furnish and install insulation on air ducts outside building insulation envelope as described in Contract Documents.

B. Furnish and install insulation on fresh air ducts and combustion air ducts within building insulation envelope as described in Contract Documents.

C. Furnish and install insulation on other air ducts where indicated on Drawings.

PART 2 - PRODUCTS

2.1 INSULATION

A. 1-1/2 inch thick fiberglass with aluminum foil scrim kraft facing and have a density of one lb/cu ft.

B. Approved Manufacturers:
1. Manville Microlite FSK
2. CSG Type IV standard duct insulation
3. Owens-Corning FRK
4. Knauf (Duct Wrap FSK)

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install duct wrap in accordance with Manufacturer's recommendations.

B. Do not compress insulation except in areas of structural interference.

C. Completely seal joints.

END OF SECTION 23 0716

SECTION 23 0717 – ROUND SUPPLY DUCT INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings, General Provisions of Contract, including General and Supplementary Conditions and Section 23 0501 apply to this Section.

1.2 SUMMARY

A. Furnish and install round supply duct insulation as described in Contract Documents.

1.3 QUALITY ASSURANCE

A. Insulation shall be UL rated with FSK (foil-skrim-kraft) facing.

PART 2 - PRODUCTS

2.1 MANUFACTURED UNITS

A. Fiberglass blanket insulation

B. Approved Manufacturers:
1. Johns-Manville R-4 Microlite (R-4 does not include the vapor barrier material).
2. Owens-Corning faced duct wrap insulation FRK-25 ED-150
3. Certainteed Standard Duct Wrap.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Insulate round air supply ducts.

B. Facing shall overlap 2" at joints and shall be secured with outward clinch staples on 4" centers.

C. Ducts over 30" in width shall have spot application of adhesive, weld pins or metal screws and caps on not more than 18" centers applied to underside.

D. 3" wide vapor barrier paper shall be applied over seams and sealed with vapor barrier adhesive.

E. Insulate attenuators.

F. Insulate high and low pressure flex ducts.

END OF SECTION 23 0717

SECTION 23 0718 - DUCT LINING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings, General Provisions of Contract, including General and Supplementary Conditions and other Division 1 Specification Sections, and Section 23 0501 apply to this Section.

1.2 SUMMARY

A. Furnish and install acoustic lining in following above ground metal ductwork as described in Contract Documents unless detailed otherwise:
   1. Outside air
   2. Supply air
   3. Return air
   4. Mixed air
   5. Transfer air
   6. Relief air
   7. Elbows, fittings, and diffuser drops greater than 12 inches in length.

1.3 SYSTEM DESCRIPTION

A. Duct dimensions shown on Drawings are for free area inside insulation. Allowance must be made for insulation, where applicable.

1.4 RATINGS:

A. Material shall have maximum air friction correction factor of 1.10 at 1000 FPM velocity and have a minimum sound absorption coefficient NRC of .60.

PART 2 - PRODUCTS

2.1 DUCT LINER

A. One inch thick, 1-1**/**2 lb density fiberglass, factory edge coated.

B. Duct lining materials are to meet the requirements of UL 181 for mold, humidity, and erosion resistance.

C. Approved Manufacturers:
   1. Certainteed Ultralite 150 Certa Edge Coat
   2. Knauf - Type M
   3. Manville - Lina-Coustic
   4. Owen Corning Fiberglas - Aeroflex

2.2 ADHESIVE

A. Water Base Type:
   1. Cain - Hydrotak
   2. Duro Dyne - WSA
   3. Kingco - 10-568
   4. Miracle - PF-101
   5. Mon-Eco - 22-67
   6. Techno Adhesive - 133

B. Solvent Base (non-flammable) Type:
   1. Cain - Safetak
   2. Duro Dyne - FPG

3. Kingco - 15-137
4. Miracle - PF-91
5. Mon-Eco - 22-24
6. Techno Adhesive - 'Non-Flam' 106

C. Solvent Base (flammable) Type:
1. Cain - HV200
2. Duro Dyne - MPG
3. Kingco - 15-146
4. Miracle - PF-96
5. Mon-Eco - 22-22
6. Techno Adhesive - 'Flammable' 106

2.3 FASTENERS

A. Adhesively secured fasteners not allowed.

B. Approved Manufacturers:
1. AGM Industries Inc - "DynaPoint" Series DD-9 pin
2. Cain
3. Duro Dyne
4. Omark dished head "Insul-Pins"
5. Grip nails may be used if each nail is installed by "Grip Nail Air Hammer" or by "Automatic Fastener Equipment" in accordance with Manufacturer's recommendations.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install mat finish surface on air stream side. Secure insulation to cleaned sheet metal duct with continuous 100% coat of adhesive and with 3/4 inch long mechanical fasteners 12 inches on center maximum unless detailed otherwise on Drawings. Pin all duct liner.

B. Accurately cut liner and thoroughly coat ends with adhesive. Butt joints tightly. Top and bottom sections of insulation shall overlap sides. If liner is all one piece, folded corners shall be tight against metal. Ends shall butt tightly together.

C. In casings and plenums further contain insulation with wire mesh.

3.2 FIELD QUALITY CONTROL

A. If insulation is installed without longitudinal and end joints butted together, installation will be rejected and work removed and replaced with work that conforms to this Specification.

B. Insulation shall be installed in accordance with Duct Liner Application Standard SMACNA Manual 15.

3.3 ADJUSTING, CLEANING

A. Keep duct liner clean and free from dust. At completion of project, vacuum duct liner if it is dirty or dusty.

END OF SECTION 23 0718

SECTION 23 0720 - REFRIGERANT PIPING INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings, General Provisions of Contract, including General and Supplementary Conditions and Section 23 0501 apply to this Section.

1.2 SUMMARY

A. Furnish and install insulation on above ground refrigerant suction piping and fittings, including thermal bulb, from thermal expansion valve as described in Contract Documents.

1.3 QUALITY ASSURANCE

A. Insulation shall have flame-spread rating of 25 or less and a smoke density rating of 50 or less as tested by ASTM E-84 method.

B. Ratings:
1. Upper rating of =210 deg. F.
2. Lower rating of -110 deg. F.
3. UV stabilized for ten year life.
4. Thermal conductivity of 0.24.
5. Water vapor transmission of .03 perms per inch.
6. Material to be polyolefin food grade.

PART 2 - PRODUCTS

2.1 FLEXIBLE FOAMED PIPE INSULATION

A. Thickness:
1. 1/2 inch for one inch outside diameter and smaller pipe.
2. 3/4 inch for 1-1/8 through 2 inch outside diameter pipe.
3. One inch for 2-1/8 inches outside diameter and larger pipe (two layers of 1/2 inch).
4. One inch sheet for fittings as recommended by Manufacturer.

B. Approved Manufacturers:
1. Armaflex
2. Halstead "Insul-tube"
3. Rubatex
4. Therma-Cel

2.2 JOINT SEALER

A. Approved Manufacturers:
1. Armaflex 520
2. BFG Construction Adhesive #105
3. Therma-Cel 950.

2.3 MANUFACTURED UNITS

A. Nominal 3/4" wall thickness

B. Approved Manufacturers:
1. ImcoLock Pipe Insulation
2. or approved equal

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install insulation in snug contact with pipe and in accordance with Manufacturer's recommendations.

B. Insulation shall be slipped onto pipe prior to connection or applied after pipe is installed, at contractor's option.

C. Close butt joints and miter joints.
   1. Approved Manufacturers:
      a. IMCOA's Fuse-Seal joining system
      b. or factory approved contact adhesive

D. Insulation shall be installed according to manufacturer's recommended procedures.

E. Exterior exposed Insulation shall be finished with two coats of factory approved finish. Color shall be selected by the Owner's representative.

F. Stagger joints on layered insulation.

G. Slip insulation on tubing before tubing sections and fittings are assembled keeping slitting of insulation to a minimum.

H. Seal joints in insulation.

I. Insulate flexible pipe connectors.

J. Insulate thermal expansion valves with insulating tape.

K. Insulation exposed outside building shall have "slit" joint seams placed on bottom of pipe.

L. Insulate fittings with sheet insulation and as recommended by Manufacturer.

END OF SECTION 23 0720

SECTION 23 0768 - STEAM SUPPLY AND CONDENSATE RETURN PIPING INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings, General Provisions of Contract, including General and Supplementary Conditions and other Division 1 Specification Sections, and Section 15055 apply to this Section.

1.2 SUMMARY

A. Furnish and install insulation on piping mains, branches, risers, fittings, and valves, pump bodies and flanges as described in Contract Documents.

PART 2 - PRODUCTS

2.1 MATERIAL

A. 6 lb./cu.ft. heavy density fiberglass with fire retardant vapor barrier jacket with self sealing laps. Thickness shall be 1-1/2 inches on heating supply and return lines.

B. Approved Manufacturers:
1. Owens-Corning Fiberglass heavy density with ASJ-SSL jacket
2. Equals by Johns-Manville or CTM.
3. Zeston covers for valves and fittings.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Pipes:
1. Install in accordance with manufacturer's directions on clean dry pipes.
2. Butt joints firmly together.
3. Seal vapor barrier longitudinal seam overlap with vapor barrier adhesive.
4. Wrap butt joints with four inch strip of vapor barrier jacket material cemented with vapor barrier adhesive.
5. Finish with bands applied at mid-section and at each end of insulation.

B. Valves & Fittings:
1. Insulate and finish by one of following methods -
2. With hydraulic setting insulating cement, or equal, to thickness equal to adjoining pipe insulation.
3. With segments of molded insulation securely wired in place.
4. With prefabricated covers made from molded pipe insulation finished with vapor barrier adhesive.
5. With Zeston covers and factory supplied insulation diapers.
6. Finish fittings and valves with four ounce canvas and coat with vapor barrier adhesive or Zeston covers.

END OF SECTION 23 0768

SECTION 23 0800 – FIRE STOPPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings, General Provisions of Contract, including General and Supplementary Conditions and Section 23 0501 apply to this Section.

1.2 SUMMARY

A. Furnish and install fire stopping as described in Contract Documents.

1.3 QUALITY ASSURANCE

A. Fire stopping material shall meet ASTM E814, E84 and be UL listed.

PART 2 - PRODUCTS

2.1 MANUFACTURED UNITS

A. Material shall be flexible, long lasting, intumescent acrylic seal to accommodate vibration and building movement.

B. Caulk simple penetrations with gaps of 1/4" or less with:
1. Dow Corning Fire Stop Sealant
2. Pensil 300

C. Caulk multiple penetrations and/or penetrations with gaps in excess of 1/4" with:
1. Dow Corning Fire Stop Foam
2. Pensil 200
3. IPC flame safe FS-1900
4. Tremco “Tremstop 1A”

PART 3 - EXECUTION

3.1 INSTALLATION

A. Follow manufacturer's installation instructions explicitly.

B. Seal penetrations of ductwork, piping, and other mechanical equipment through one-hour and two-hour rated partitions as shown on Architectural and Mechanical Drawings.

C. Install fire stopping material on clean surfaces to assure adherence.

END OF SECTION 23 0800

SECTION 23 0953 – TEMPERATURE CONTROLS (DDC)

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings, General Provisions of Contract, including General and Supplementary Conditions and Section 23 0501 apply to this Section.

1.2 SCOPE

A. The scope of work shall include all labor, material, and equipment necessary to complete the automatic temperature control work and the DDC Control System as described herein. The Contractor under this heading shall furnish and install a complete direct digital temperature control system as specified for all items indicated on the drawings and described hereinafter including sensors, switches, relays, thermostats, control panels for instruments and central control software.

PART 2 - PERFORMANCE

2.1 PERFORMANCE

A. Control system manufacturer shall have had a complete engineering, sales, installation and service operation within the area for a period of not less than five years prior to bid date of this project. Both electrical and mechanical installation shall be by manufacturer-trained mechanics.

B. The temperature controls shall be checked and certified by a factory trained representative of the ATC manufacturer. Any deviations from the specifications shall be listed and submitted to the design engineer for review, prior to bid date. Should no list be submitted to the engineer, it will be assumed all aspects of this specification will be complied with and furnished accordingly.

C. Qualified Contractors: Johnson Controls, Inc., ATS.

PART 3 - EXECUTION

3.1 SUBMITTAL

A. The following shall be submitted for approval:
   1. Data sheets for all control systems and components.
   2. Valve, damper, well and tap schedules, showing sizes, configuration capacity and location of all equipment.
   3. Control system drawings containing pertinent data to provide a functional operating system, including a sequence of operation. Detailed shop drawings may be submitted in as-built form upon project completion.

3.2 INSPECTION OF CONDITIONS

A. Examine related work and surface before starting work of this section. Report to Mechanical Engineer, in writing, conditions which will prevent proper provision of this work. Beginning work of this section without reporting unsuitable conditions to Mechanical Engineer constitutes acceptance of conditions by Contractor. Perform any required removal, repair or replacement of this work caused by unsuitable conditions at no additional cost to Owner.

3.3 WIRING

A. Electric wiring and wiring connections required for the installation of the temperature control system as herein specified shall be provided by the Temperature Control Contractor unless specifically shown on the drawings or called for in the specifications to be by the Electrical Contractor. All conduit and wiring shall comply with the requirements of local and national electrical codes. Plenum rated cable shall be allowed

in return air openings. All connections to vibrating equipment such as fans, pumps, chillers, etc. shall be by flexible conduit. Plenum rated cable shall be permitted without EMT, in accessible ceiling spaces, being used as a supply or return air duct. All conduit and wire for thermostats shall be by the control contractor.

B. Wiring from the building fire alarm panel to smoke detectors shall be furnished and installed by Electrical Contractor.

C. All power wiring of heating and ventilating equipment shall be furnished and installed by Electrical Contractor.

D. All power wiring (120 VAC) to each local ATC panel location shall be furnished and installed by Electrical Contractor in accordance with Division 16.

3.4 INSTRUCTION AND ADJUSTMENT

A. Upon completion of the project, the Temperature Control Contractor shall adjust and validate all thermostats, controllers, valves, damper operators, relays, etc. provided under this section.

B. Instruction manuals shall be furnished covering function and operation of control system on the project for use by the owner's operating personnel. An instruction period lasting not less than 32 hours shall be provided to completely familiarize operating personnel with the temperature control system and direct digital controller on the project.

3.5 EQUIPMENT

A. Direct Digital System Controllers (DDC):
   1. Overview:
      a. The Direct Digital Control System shall be a personal computer system with local microprocessor-based control panel networked together for information sharing and operating convenience.
      b. It is the intent of these specifications to create a direct digital control system. All "system" type control functions, such as those used for fan systems, boilers, chillers, central plant and pumps, building pressurization, etc. shall be accomplished by using software algorithms in the respective DDC. Final control devices (valve operators, damper actuators, etc.) shall be electric/electronic.
      c. All safety devices such as fire alarm shutdown, smoke detectors, low limit thermostats, etc., shall be hard wired to accomplish their critical functions completely independent of the DDC and shall have additional outputs as required to service as inputs to the DDC for secondary control and reporting functions.

B. Facility Management System:
   1. The Facility Management System shall be capable of integrating multiple building functions including equipment supervision and control, alarm management, energy management, and historical data collection, including 24 hour continuous Point History of all points, and archiving.
   2. The facility management system shall consist of the following:
      a. Standalone Network Control Units (NCUs)
      b. Standalone application specific controllers (ASCs) with HVAC System sequence pre-configured software applications programs. (This application software program shall be demonstrated to the Mechanical Engineer prior to bid). HVAC pre-configured software shall be included in bid as specified herein.
      c. Portable Operator's Terminals
      d. Personal Computer Operator Workstation Software.
      e. Direct connection and communication capability to Standalone Intelligent Lighting, Fire and Security Controller on the same HVAC ASC communications trunk without use of a separate communication trunk to the Central Processing Unit.
      f. The system shall be modular in nature, and shall permit expansion of both capacity and functionality through the addition of sensors, actuators, standalone NCU panels, and Standalone Application Specification Controller (i.e., HVAC, Lighting, Fire, Security).
   3. System architectural design shall eliminate dependence upon any single device for alarm reporting and control execution. Each NCU panel shall operate independently by performing its own

specified control, alarm management, operator I/O, and historical data collection. The failure of any single component or network connection shall not interrupt the execution of control strategies at other operational devices.

4. Standalone NCU panels shall be able to access any data from, or send control commands and alarm reports directly to any other NCU panel or combination of panels on the network without dependence upon a central processing device. Standalone NCU panels shall also be able to send alarm reports to multiple operator work stations without dependence upon a central processing device.

3.6 NETWORKING/COMMUNICATIONS (LOCAL AREA NETWORK)

A. Workstation/NCU Panel Support:
   1. Operator work stations and NCU panels shall directly reside on an Arcnet local area network such that communications may be executed directly between controllers, directly between work stations, and between controllers and work stations on a total Dynamic Data Access basis.

B. Dynamic Data Access:
   1. All operator devices, and NCUs resident on the LAN network, shall be able to access all point status and application report data, or execute control functions for any and all other devices on the local area network. Access to data shall be based upon logical identification of building equipment. Access to system data shall not be restricted by the hardware configuration of the facility management system. The hardware configuration of the FMS network shall be totally transparent to the user when accessing data or developing control programs.

3.7 STANDALONE NCU PANELS

A. General:
   1. Standalone NCU panels shall be microprocessor based, multi-tasking, multi-user, real-time digital control processors. Each standalone NCU panel shall consist of modular hardware with plug-in enclosed processors, communication controllers, power supplies, and input/output modules. A sufficient number of controllers shall be supplied to fully meet the requirements of this specification.

B. Capability:
   1. Each NCU panel shall have 1 Meg of DRAM memory, an 80186 processor, 64K EPROM and 5 communication ports. Each NCU panel shall support its own operating system and databases including:
      a. Control processes
      b. Energy Management Applications
      c. Alarm Management
      d. Historical/Trend Data for all points
      e. Maintenance Support Applications
      f. Custom Processes
      g. Operator I/O
      h. Dial-Up Communications
      i. Manual Override Monitoring

C. Point types:
   1. Each NCU panel shall support the following types of point inputs and outputs:
      a. Digital Inputs for status/alarm contacts
      b. Digital Outputs for on/off equipment control
      c. Analog Inputs for temperature, pressure, humidity, flow, and position measurements either electric or pneumatic
      d. Analog Outputs for valve and damper position control, and capacity control of primary equipment either electric or pneumatic
      e. Pulse Inputs for pulsed contact monitoring

D. Continuous 24 Hour Point Histories:
   1. Each NCU panel without software programming by the operator shall store Point History Files for every analog and binary input and output points. The Point History routine shall continuously and automatically sample the value of all analog inputs at half hour intervals. Samples for all points shall be stored for the past 24 hours to allow the user to immediately analyze equipment

performance and all problem-related events for the past day. Point History Files for binary input or output points and analog output points shall include a continuous record of the last ten status changes of commands for each point.

E. Serial Communication Ports:
1. Standalone NCU panels shall provide at least two RS-232C serial data communication ports for simultaneous operation of multiple operator I/O devices such as industry standard printers, laptop work stations, PC work stations, and panel mounted or portable NCU panel Operator's Terminals. Standalone NCU panels shall allow temporary use of portable devices without interrupting the normal operation of permanently connected modems, printers, or network terminals.

F. Hardware Override Switches:
1. The operator at the NCU panel shall have the ability to manually override the NCU Panel terminated points via local, point discrete, onboard hand/auto operator override switches for binary control points and gradual switches for electronic or pneumatic analog control type points. These override switches shall be operable whether the panel is powered or not.

G. Hardware Override Monitoring:
1. NCU panels shall monitor the status or position of all overrides, and include this information in logs and summaries to inform the operator that automatic control has been placed in hardware override. NCU panels shall also collect override activity information for daily and monthly reports.

H. Local Status Indicator Lamps:
1. The NCU panel with terminated points shall provide local status indication for each binary input and output for constant, up-to-date verification of all point conditions without the need for an operator I/O device.

I. Integrated On-Line Diagnostics:
1. Each NCU panel shall continuously perform self-diagnostics, communication diagnosis and diagnosis of all subsidiary equipment. The NCU panel shall provide both local and remote annunciation of any detected component failures, or repeated failure to establish communication. Indication of the diagnostic results shall be provided at each NCU panel, and shall not require the connection of an operator I/O device.

J. Surge and Transient Protection:
1. Isolation shall be provided at all network terminations, as well as all field point terminations to suppress induced voltage transients consistent with IEEE Standard 587-1980. Isolation levels shall be sufficiently high as to allow all signal wiring to be run in the same conduit as high voltage wiring where acceptable by electrical code.

K. Powerfail Restart:
1. In the event of the loss of normal power, there shall be an orderly shutdown of all standalone NCU panels to prevent the loss of database or operating system software. Non-Volatile memory shall be incorporated for all critical controller configuration data, and battery back-up shall be provided to support the real-time clock and all volatile memory for a minimum of 72 hours.
   a. Upon restoration of normal power, the NCU panel shall automatically resume full operation without manual intervention.
   b. Should NCU panel memory be lost for any reason, the user shall have the capability of reloading the NCU panel via the local area network, via the local RS-232C port, or via telephone line dial-in.

L. Each Control Module within an NCU shall have separate independent power supplies with OFF/ON switches to allow operator to remove individual control modules without powering down the entire NCU panel.

M. Each NCU panel shall have a built-in duplex power outlet for operator use.

3.8 NCU SOFTWARE FEATURES

A. Control Software Description:

1. Pre-Tested Control Algorithms: The NCU panels shall have the ability to perform the following pre-tested control algorithms:
   a. Two Position Control
   b. Proportional Control
   c. Proportional plus Integral Control
   d. Proportional, Integral, plus Derivative Control
   e. Automatic Control Loop Tuning
2. Equipment Cycling Protection: Control software shall include a provision for limiting the number of times each piece of equipment may be cycled within any one-hour period.
3. Heavy Equipment Delays: The system shall provide protection against excessive demand situations during start-up periods by automatically introducing time delays between successive start commands to heavy electrical loads.
4. Powerfail Motor Restart: Upon the resumption of normal power, the NCU panel shall analyze the status of all controlled equipment, compare it with normal occupancy scheduling, and turn equipment on or off as necessary to resume normal operation.

B. Energy Management Applications:
1. NCU Panels shall have the ability to perform any or all of the following energy management routines. All programs shall be executed automatically without the need for operator intervention, and shall be flexible enough to allow user customization.
   a. Time of Day Scheduling
   b. Calendar Based Scheduling
   c. Holiday Scheduling
   d. Temporary Schedule Overrides
   e. Optimal Start
   f. Optimal Stop
   g. Night Setback Control
   h. Enthalpy Switchover (Economizer)
   i. Peak Demand Limiting
   j. Temperature Compensated Load Rolling
   k. Fan Speed/CFM Control
   l. Heating/Cooling Interlock
   m. Hot Water Reset

C. Custom Process Programming Capability:
1. NCU panels shall be able to execute custom, job-specific processes defined by the user, to automatically perform calculations and special control routines.

D. Alarm Management:
1. Alarm management shall be provided to monitor, buffer, and direct alarm reports to operator devices and memory files. Each NCU panel shall perform distributed, independent alarm analysis and filtering to minimize operator interruptions due to non-critical alarms, minimize network traffic, and prevent alarms from being lost. At no time shall the NCU panel's ability to report alarms be affected by either operator activity at a PC Workstation or local I/O device, or communications with other panels on the network.

E. Historical Data and Trend Analysis:
1. A variety of Historical data collection utilities shall be provided to automatically sample, store, and display system data in all of the following ways.
   a. Continuous Point Histories: Standalone NCU panels shall store Point History Files for all analog and binary inputs and outputs. The Point History routine shall continuously and automatically sample the value of all analog inputs at half hour intervals. Samples for all points shall be stored for the past 24 hours to allow the user to immediately analyze equipment performance and all problem-related events for the past day. Point History Files for binary input or output points and analog output points shall include a continuous record of the last ten status changes or commands for each point.
   b. Control Loop Performance Trends: Standalone NCU panels shall also provide high resolution sampling capability with an operator-adjustable resolution of 10-300 seconds in one-second increments for verification of control loop performance.
   c. Extended Sample Period Trends: Measured and calculated analog and binary data shall also be assignable to user-definable trends for the purpose of collecting operator-specified

performance data over extended periods of time. Sample intervals of 1 minute to 2 hours, in one-minute intervals, shall be provided. Each standalone NCU panel shall have a dedicated buffer for trend data, and shall be capable of storing a minimum of 5000 data samples.

d. Data Storage and Archiving: Trend data shall be stored at the Standalone NCU panels, and uploaded to hard disk storage when archival is desired. Upload shall occur based upon either user-defined interval, manual command, or when the trend buffers become full. All trend data shall be available in disk file form for use in 3rd Party personal computer applications.

F. Runtime Totalization:
1. Standalone NCU panels shall automatically accumulate and store runtime hours for binary input and output points.
   a. The Totalization routine shall have a sampling resolution of one minute or less.
   b. The user shall have the ability to define a warning limit for Runtime Totalization. Unique, user-specified messages shall be generated when the limit is reached.

G. Analog/Pulse Totalization:
1. Standalone NCU panels shall automatically sample, calculate and store consumption totals on a daily, weekly, or monthly basis for user-selected analog and binary pulse input-type points.
   a. Totalization shall provide calculation and storage of accumulations of up to 99,999.9 units (e.g. KWH, gallons, KBTU, tons. etc.).
   b. The Totalization routine shall have a sampling resolution of one minute or less.
   c. The user shall have the ability to define a warning limit. Unique, user-specified messages shall be generated when the limit is reached.

H. Event Totalization:
1. Standalone NCU panels shall have the ability to count events such as the number of times a pump or fan system is cycled on and off. Event totalization shall be performed on a daily, weekly, or monthly basis.
   a. The Event Totalization feature shall be able to store the records associated with a minimum of 9,999,999 events before reset.
   b. The user shall have the ability to define a warning limit. Unique, user-specified messages shall be generated when the limit is reached.

3.9 APPLICATION SPECIFIC CONTROLLERS - HVAC APPLICATIONS

A. Each Standalone NCU Controller shall be able to extend its performance and capacity through the use of remote Application Specific Controllers (ASCs).

B. Each ASC shall operate as a standalone controller capable of performing its specified control responsibilities independently of other controllers in the network. Each ASC shall be a microprocessor-based, multi-tasking, real-time digital control processor.

C. Each ASC shall have sufficient memory to support its own operating system and data bases including:
1. Generic Input/Output Monitor & Control
2. Control Processes
3. Energy Management Applications
4. Operator I/O (Portable Service Terminal)

D. Powerfail Protection:
1. All system setpoints, proportional bands, control algorithms, and any other programmable parameters shall be stored such that a power failure of any duration does not necessitate reprogramming the controller.

E. Application Specific Software:
1. A pre-written ASC HVAC software program shall be provided to the owner with common ASHRAE HVAC sequences of operations for single zone, multizone, VAV units. This software program shall have pre-written sequences of operations where the owner can select system designs, with prompted default values or configure HVAC ASC for generic input/output for monitor and control. Software program shall be capable of printing out owner selected sequence of operation, setpoints, and ASC predetermined wire termination guide for each input/output point. Prior to putting Application Specific Controller on-line in an HVAC operating environment, the application specific

software shall have a commissioning mode, so the owner can simulate the control sequence through assigning default values or by actual, connecting hardware to the ASC Controller at the owner's lab or test bench.

3.10 ZONE SENSOR: (Room Thermostat)

A. The Zone sensor shall be a Johnson Controls TE-6000 with programming jack series or equal. Sensor cover shall be a beige high impact plastic cover with brushed aluminum face. Sensor dimensions shall not exceed 3" x 4" and shall not protrude from the wall more than 2".
   1. Sensors with no external controls shall be installed in all transient areas.
   2. Sensors with override switches shall be installed in all open work areas and multiple private office zones.
   3. Sensors with override switches and setpoints shall be installed in all single zone private offices and conference rooms.

B. Provide a mechanism for adjusting setpoint within a limited range at the sensor. For example, a setpoint adjustment potentiometer with scale and stops. Provide legend indicating the potentiometer position on the unit face. The legend color shall be the same neutral color as the molded case.

C. Provide an override switch to signal the controller when the zone is occupied. The switch shall be a momentary type rocker switch. The switch bezel shall be mounted below the surface of the face plate allowing only the rocker to protrude.
   1. The temperature sensor shall be a high quality, high output, wire wound nickel resistant sensor. The temperature sensing element shall be mounted under the aluminum face plate allowing the sensor appropriate response to the zone's thermal elements. Installed accuracy shall be ±1°F over a 32°F to 86°F range.

D. The zone sensor shall include a jack for connection of the service tool. To prevent unauthorized tampering and vandalism, the jack shall be mounted under the sensor's cover. The cover shall be held in place by a recessed socket head set screw requiring an Allen wrench for removal. Sensors having the service tool jack exposed shall not be accepted.

E. Occupancy Switch:
   1. Operation of a momentary switch on the room sensor shall cause an internal override to be set. When the override is set and the zone controller is in the standby or unoccupied mode, the controller shall control as if in the occupied mode. When the override expires, the controller shall revert to the commanded mode unless the commanded mode is standby. If the commanded mode is standby, the mode shall change to occupied.

3.11 AIR CONTROL BOX ACTUATOR

A. The air valve shall be positioned by a dual synchronous 3-point floating motor provided by Johnson Controls, Inc. series EDP-2040. The motor shall operate the damper from full closed to full open no faster than 4 minutes and no slower than 8 minutes. Motor gears and housing shall be metallic to insure long motor life.

B. The motor assembly shall slip over the damper shaft and lock into position using knurled set screws. Rotation shall be adjustable from 45° to 90°. The motor frame shall be mounted to the box with no more than three screws. To minimize maintenance costs over the life of the installation, the gear motor shall be a separate component. Motors which are an integral part of the controller shall not be accepted.

3.12 INPUT/OUTPUT HARDWARE

A. Information transmitted shall include status, space temperature, entering air temperature, heating setpoint, cooling setpoint, unoccupied setpoint, enter air velocity and CFM, percentage heating demand and percentage cooling demand, velocity control points, and ventilation setpoint. The controller shall accept the following commands: New heating, cooling setpoint, night setback command, new heating or cooling space coefficients. The controller shall incorporate inherent input isolation such that it may be connected to other controllers sharing the same power source without isolating transformers. The controller shall incorporate multiple scans of the analog and digital inputs to verify change of state before control outputs

are varied.

B. Each controller shall have at least six digital outputs capable of driving a 24 VAV, 400 mv load or pilot relay. Outputs shall be electrically isolated from the inputs and communications line.

3.13 OTHER APPLICATION SPECIFIC CONTROLLERS - LIGHTING, FIRE, SECURITY APPLICATIONS:

A. Each Standalone NCU Controller, for project or future applications, shall be able to directly extend its performance and capacity through the use of remote Application Specific Controllers (ASCs) dedicated to controlling standalone VAV boxes, lighting, fire and security.

B. Each NCU shall be capable of directly monitoring and controlling a standalone heat pump, lighting, fire and security panel without the use of an operator's workstation, installation of a secondary communication trunk or gateway interface panels. Information from these panels can be shared anywhere on the network through Dynamic Data Access for multiple building control and overrides.

3.14 CENTRAL OPERATOR WORKSTATION (OWS)

A. The OWS shall be an existing Owner provided Personal Computer. The Personal Computer shall directly connect to the network of ASCs.

B. The contractor shall install all necessary software on the Owner's computer which will also be used for the hospital nurse call system.

3.15 CENTRAL OPERATOR WORKSTATION SOFTWARE (OWSS)

A. Basic Interface Description:
   1. Command Entry/Menu Selection Process:
      a. Operator Workstation interface software shall minimize operator training through the use of English language prompting, English language point identification, and industry standard PC application software. For ease of operator's use, the entire facility being monitored and controlled shall be laid out in a network map similar to a "family tree". The operator interface shall minimize the use of a typewriter style keyboard through the use of a mouse or similar pointing device, and "point and click" approach to menu selection. Users shall be able to start and stop equipment or change setpoints from graphical displays through the use of a mouse or similar pointing device.
   2. Graphical and Text-Based Displays:
      a. At the option of the user, Operator work stations shall provide consistent graphical or text-based displays of all system point and application data described in this specification. Point identification, engineering units, status indication, and application naming conventions shall be the same at all work stations.
   3. Multiple, Concurrent Displays:
      a. The Operator Interface shall provide the ability to simultaneously view several different types of system displays in overlapping windows to speed building analysis. For example, the interface shall provide the ability to simultaneously display a graphic depicting an air handling unit, while displaying the trend graph of several associated space temperatures to allow the user to analyze system performance. If the interface is unable to display several different types of displays at the same time, the FMS contractor shall provide at least two operator stations.
   4. Password Protection: Multiple-level password access protection shall be provided to allow the user/manager to limit workstation control, display and data base manipulation capabilities as he deems appropriate for each user, based upon an assigned password.
      a. Passwords shall be exactly the same for all operator devices, including portable or panel-mounted network terminals. Any additions or changes made to password definition shall automatically cause passwords at all NCU panels on a network to be updated and downloaded to minimize the task of maintaining system security. Users shall not be required to update passwords for NCU panels individually.
      b. A minimum of five levels of access shall be supported:
         1) Level 1 = Data Access and Display
         2) Level 2 = Level 1 + Operator Overrides
         3) Level 3 = Level 2 + Database Modification

4) Level 4 = Level 3 + Database Generation
5) Level 5 = Level 4 + Password Add/Modification

c. A minimum of 50 passwords shall be supported at each NCU panel.
d. Operators will be able to perform only those commands available for their respective passwords. Menu selections displayed at any operator device, including portable or panel mounted devices, shall be limited to only those items defined for the access level of the password used to log-on.
e. User-definable, automatic log-off timers of from 1 to 60 minutes shall be provided to prevent operators from inadvertently leaving devices on-line.

5. Operator Commands: The operator interface shall allow the operator to perform commands including, but not limited to, the following:
   a. Start-up or shutdown selected equipment
   b. Adjust setpoints
   c. Add/Modify/Delete time programming
   d. Enable/Disable process execution
   e. Lock/Unlock alarm reporting for each point
   f. Enable/Disable Totalization for each point
   g. Enable/Disable Trending for each point
   h. Override PID Loop setpoints
   i. Enter temporary override schedules
   j. Define Holiday Schedules
   k. Change time/date
   l. Enter/Modify analog alarm limits
   m. Enter/Modify analog warning limits
   n. View limits
   o. Enable/Disable Demand Limiting for each meter
   p. Enable/Disable Duty Cycle for each load.
6. Logs and Summaries: Reports shall be generated automatically or manually, and directed to either CRT displays, printers, or disk files. Summaries shall be provided for specific points, for a logical point group, for a user-selected group of groups, or for the entire facility without restriction due to the hardware configuration of the facility management system. Under no conditions shall the operator need to specify the address of hardware controller to obtain system information. As a minimum, the system shall allow the user to easily obtain the following types of reports:
   a. A general listing of all points in the network
   b. List all points currently in alarm
   c. List of all off-line points
   d. List all points currently in override status
   e. List of all disabled points
   f. List all points currently locked out
   g. List of all items defined in a "Follow-Up" file
   h. List all Weekly Schedules
   i. List all Holiday Programming
   j. List of Limits and Dead bands

B. Dynamic Color Graphic Displays: Color graphic floor plan displays, and system schematics for each piece of mechanical equipment, including air handling units, chilled water systems, and hot water boiler systems, shall be provided.
   1. System Selection/Penetration: The operator interface shall allow users to access the various system schematics and floor plans via a graphical penetration scheme, menu selection, or text-based commands.
   2. Dynamic Data Displays: Dynamic temperature values, humidity values, flow values, and status indication shall be shown in their actual respective locations, and shall automatically update to represent current conditions without operator intervention.
   3. Windowing: The windowing environment of the PC Operator Workstation shall allow the user to simultaneously view several graphics at the same time to analyze total building operation, or to allow the display of a graphic associated with an alarm to be viewed without interrupting work in progress.
   4. Graphics Definition Package: Graphic generation software shall be provided to allow the user to add, modify, or delete system graphic displays.
      a. The FMS contractor shall provide libraries of pre-engineered screens and symbols depicting standard air handling unit components (e.g. fans, cooling coils, filters, dampers, etc.),

complete mechanical systems (e.g. constant volume-terminal reheat, VAV, etc.) and electrical symbols.

b. The graphic development package shall use a mouse or similar pointing device in conjunction with a drawing program.

5. The works station software shall have a separate graph showing current and past 24 hour Point History with all attributes listed below the graph about the selected point being viewed. With a drag bar, the operator can pinpoint exact time and temperature a variance occurred during the 24 hour period.

C. System Configuration and Definition: All temperature and equipment control strategies and energy management routines shall be definable by the operator. System definition and modification procedures shall not interfere with normal system operation and control.

1. The system shall be provided complete with all equipment and documentation necessary to allow an operator to independently perform the following functions:
   a. Add/Delete/Modify Standalone NCU Panels
   b. Add/Delete/Modify Operator Work stations
   c. Add/Delete Application Specific Controllers
   d. Add/Delete/Modify points of any type, and all associated point parameters, and tuning constants
   e. Add/Delete/Modify alarm reporting definition for each point
   f. Add/Delete/Modify energy management applications
   g. Add/Delete/Modify time- and calendar-based programming
   h. Add/Delete/Modify Totalization for every point
   i. Add/Delete/Modify Historical Data Trending for every point
   j. Add/Delete/Modify any and all graphic displays, symbols, and cross-references to point data
   k. Add/Delete/Modify dial-up telecommunication definition
   l. Add/Delete/Modify all operator passwords
   m. Add/Delete/Modify Alarm Messages

D. While still monitoring the network, the operator shall be capable of running concurrent DOS based programs without interruption of the Facility Management system reporting at the operator's workstation. While operator is using concurrent software and an alarm is generated, the operator will have the option to look at alarm later, now, or discard. Separate alarm printers used for printing alarms while operator is using concurrent software will not be allowed.

1. Database Save/Restore/Back-Up: Back-up copies of all standalone NCU panel databases shall be stored in at least one personal computer operator workstation. Continuous supervision of the integrity of all NCU panel data bases shall be provided. In the event that any NCU panel on the network experiences a loss of its data base for any reason, the system shall automatically download a new copy of the respective data base to restore proper operation. Data base back-up/Download shall occur over the local area network without operator intervention. Users shall also have the ability to manually execute downloads of any or all portions of a NCU panels data base.
2. Graphics Programming Language (GPL):
   a. With Operator's Workstation Software, ATC contractor shall provide GPL software, to enable owner to modify or add sequences through utilization of graphics as discussed herein.
   b. Programming Description: Definition of operator device characteristics, DDC panels, individual points, applications and control sequences shall be performed through fill-in-the-blank templates and graphical programming approach.
   c. Graphical programming shall allow the user to define the software configuration of DDC control logic for HVAC system control sequences, fan interlocks, pump interlocks, PID control loops, and other control relationships through the creation of graphical logic flow diagrams.
   d. Graphical Programming: Control sequences are created by using a mouse input device to draw interconnecting lines between symbols depicting inputs, operators (comparisons and mathematical calculations), and outputs of a control sequence. As a minimum, graphic symbols shall be used to represent:
      1) Process Inputs, such as temperature, humidity, or pressure values, status, time, date, or any other measured or calculated system data.
      2) Mathematical Process Operators, such as addition, subtraction, multiplication, or greater than, equal to, less than, etc.
      3) Logical Process Operators such as AND, OR, Exclusive OR, NOT, etc.
      4) Time Delays
      5) Process Control Outputs such start/stop control points, analog adjust points, etc.
      6) Process Calculation Outputs

7) Text file Outputs and Advisories

e. Network-Wide Strategy Development: Inputs and outputs for any process shall not be restricted to a single DDC panel, but shall be able to include data from any and all other DDC panels to allow the development of network-wide control strategies. Processes shall also allow the operator to use the results of one process as the input to any number of other processes (cascading).

f. Sequence Testing and Simulation: A software tool shall be provided, which allows a user to simulate control sequence execution to test strategies before they are actually applied to mechanical systems. Users shall be able to enter hypothetical input data, and verify desired control response and calculation results via graphical displays and hard copy printouts.

3. System Definition/Control Sequence Documentation: All portions of system definition shall be self-documenting to provide hard copy printouts of all configuration and application data. Control process and DDC control loop documentation shall be provided in logical, graphical flow diagram format to allow control sequences to be easily interpreted and modified at any time in the future.

3.16 WARRANTY

A. Upon completion of the project as defined either by acceptance of the building by the Owner or by beneficial use of the equipment by the Owner, a warranty period of one year shall commence. The warranty shall consist of a commitment by the Automatic Temperature Control Contractor to provide at no cost to the Owner, parts and labor as required to repair or replace such parts of the temperature control system that prove inoperative due to defective materials or installation practices. This warranty expressly excludes routine service such as filter cartridge replacement, compressor lubrication or instrument calibration.

END OF SECTION 23 0953

SECTION 23 2111 - SNOWMELT PIPING

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Hydronic Piping and Fittings (PEX-a) for the Following Applications:

1. Snow-melt heating piping, above ground.
2. Snow-Melt heating piping installed below ground and within slabs.

B. Flexible Pre-Insulated Pipe Distribution System (ASTM Ecoflex) for Hot and Cold Fluids:

1. Potable HDPE distribution system.
2. Potable PEX-a distribution system.
3. Thermal single distribution system.
4. Thermal twin distribution system.

1.2 REFERENCES

A. ASTM International (ASTM):

1. ASTM D 6394 - Standard Specification for Sulfone Plastics.
2. ASTM E 119 - Standard Test Methods for Fire Tests of Building Construction and Materials.
3. ASTM F 876 - Standard Specification for Crosslinked Polyethylene (PEX) Tubing.
4. ASTM F 877 - Standard Specification for Crosslinked Polyethylene (PEX) Plastic Hot- and Cold-Water Distribution Systems.
5. ASTM F 1960 - Standard Specification for Cold Expansion Fittings with PEX Reinforcing Rings for Use with Cross-linked Polyethylene (PEX) Tubing.
6. ANSI/NSF Standard 359 Valves for Crosslinked Polyethylene (Pex) Water Distribution Tubing Systems.

1.3 REFERENCES

A. ASTM International (ASTM):

1. ASTM F714 - Standard Specification for Polyethylene (PE) Plastic Pipe (SDR-PR) Based on Outside Diameter
2. ASTM D3350 - Standard Specification for Polyethylene Plastics Pipe and Fittings Materials.

B. American National Standards Institute (ANSI)/American Water Works Association (AWWA)

1. ANSI/AWWA C901 AWWA Standard for Polyethylene (PE) Pressure Pipe and Tubing, 1/2 inch (13 mm) Through 3 inch (76 mm), for Water Service
2. ANSI/AWWA C906 AWWA Standard for Polyethylene (PE) Pressure Pipe and Fittings, 4-inch (100 mm) Through 63 inch (1575 mm), for Water Distribution.
3. American Standards Institute (ANSI)/National Sanitation Foundation (NSF): ANSI/NSF 61 Drinking Water System Components - Health Effects
4. International Code Council (ICC): International Plumbing Code (IPC)
5. International Association of Plumbing and Mechanical Officials (IAPMO): Uniform Plumbing Code (UPC)
6. Plastic Pipe Institute (PPI): PE 3408/PE 3608 IPS Geothermal Pipe Specifications
7. Uponor, Inc.: Uponor Pre-insulated Pipe Systems Design and Installation Manual, current edition.

1.4 SUBMITTALS

A. Submit under provisions of Section 01 30 00 - Administrative Requirements.

B. Product Data: Provide manufacturer's product submittal data, including pressure and temperature rating, oxygen-barrier performance, and fire-performance characteristics.

C. Shop Drawings: Provide installation drawings indicating: piping layout, size dimension by installation segment, vault locations, support fixtures and schedules with all details required for installation of the system.

D. Shop Drawings: Submit the following piping layouts, calculations and reports.

1. Piping layout scale: 1/8 inch = 1 foot.
2. Submit manufacturer's detailed drawings showing layouts, fixing details and piping details of all areas where hydronic radiant systems are indicated. Submit a cross-referenced manifold schedule indicating loop lengths, tubing diameter, flow rate, operating water temperatures, and pressure drop to meet the required performance listed on the contract documents along with product and performance data for each component.
3. Indicate all valves, pumps and items of equipment that are required to control and operate the hydronic radiant system as shown on the plans and described in the sequence of operations. Submit a valve and pump schedule listing each number, type, size, model and service. Cross reference to supporting product data.
4. Provide calculations that support the [heating] [and] [cooling] performance requirements of the hydronic radiant system. These calculations should indicate the slab construction and the depth of the tubing in relation to the exposed surface. Calculations must show the required flow rate, operating temperatures and pressure drops through the system.
5. Submit manifold details, including all connections, fittings, valves and mounting requirements.
6. Submit details for embedded tubing through concrete expansion joints.
7. Provide drawings showing piping manifold locations and installation details.
8. Provide control sequences and requirements for control hardware devices. Indicate compliance and coordination with requirements of other specification sections.
9. Provide piping sample with complete print stream indicating certification of properties.

E. Samples: Submit selection and verification samples of piping.

F. Quality Assurance/Control Submittals

1. Test Reports: Upon request, submit test reports from recognized testing laboratories.
2. Submit the following documentation.

    a. Manufacturer's certificate stating that products comply with specified requirements.
    b. Manufacturer's flow schedule for the distribution system.
    c. Documentation that the installer is trained to install the manufacturer's products.

G. Operation and Maintenance Data: Provide operation and maintenance manuals for valves, manifolds, and controls.

H. Closeout Documentation:

1. Submit manufacturer's report detailing that the hydronic radiant system has been installed in accordance with the contract documents and the manufacturer's specified instructions. Provide manufacturer's instructions. Note any exceptions.
2. Submit start-up report demonstrating that system meets required capacity, is fully functional and commissioned to the satisfaction of system manufacturer.
3. Provide final as-built drawings indicating tubing layout, manifold locations, zoning and manifold schedules with details required for installation of the system.

4. Provide documentation indicating that the installer is trained to install the manufacturer's products.
5. Warranty documents specified herein

A. Closeout Submittals: Submit the following documents.

1. Warranty documents specified herein.
2. Operation and maintenance data.
3. Manufacturer's field reports specified herein.
4. Final as-built piping layout drawing.

1.5 QUALITY ASSURANCE

A. Hydronic radiant system manufacturer shall have successfully completed five installations of similar type and scope. Manufacturer shall provide a representative for field support during the installation and commissioning of the hydronic radiant system.

B. Installer Qualifications: Use an installer with demonstrated experience on projects of similar size and complexity and possessing documentation proving familiarization training by the tubing manufacturer.

1. Regulatory Requirements and Approvals: Ensure the piping distribution system complies with all applicable codes and regulations.
2. Certifications: Provide letters of certification indicating: Installer uses skilled workers holding a trade qualification license or equivalent, or apprentices under the supervision of a licensed trades person.

C. Pre-installation Meetings:

1. Verify project requirements, excavation conditions, system performance requirements, manufacturer's installation instructions and warranty requirements.
2. Review project construction timeline to ensure compliance or discuss modifications as required.
3. Interface with other trade representatives to verify areas of responsibility.
4. Establish the frequency and construction phase the project engineer intends for site visits and inspections by the tubing manufacturer's representative.

1.6 DELIVERY, STORAGE and HANDLING

A. General: Comply with Division 1 Product Requirement Section.

B. Comply with manufacturer's ordering instructions and lead-time requirements to avoid construction delays.

C. Delivery: Deliver materials in manufacturer's original, unopened, undamaged containers with identification labels intact.

D. Storage and Protection: Store materials protected from exposure to harmful environmental conditions and at temperature and humidity conditions recommended by the manufacturer.

1. Store PEX tubing in cartons or under cover to avoid dirt or foreign material from entering the tubing.
2. Do not expose PEX tubing to direct sunlight for more than 30 days. If construction delays are encountered, cover the tubing to prevent exposure to direct sunlight
3. Store potable pre-insulated piping coils under cover to prevent dirt or foreign material from entering the service tubing.

4. Do not expose the service pipe to direct sunlight for more than 30 days. If construction delays are encountered, cover piping that is exposed to direct sunlight.

1.7 WARRANTY

A. Manufacturer's Warranty for Hydronic Piping: Manufacturer's standard 30 year warranty for PEX-a piping.

B. Manufacturer's Warranty for Pre-Insulated Pipe Distribution Systems: Submit, for owner's acceptance, USA manufacturer's standard 5-year warranty document executed by authorized company official. Manufacturer's warranty is in addition to, and not a limitation of, other rights owner may have under contract documents.

1. Warranty covers the repair or replacement of any piping or fittings proven defective.
2. Warranty may transfer to subsequent owners.
3. The most recent limited warranty published by the manufacturer takes precedence at the time of installation.

C. Manufacturer's Warranty for Radiant Heating and Cooling Systems: Submit, for Owner's acceptance, manufacturer's standard warranty document executed by authorized company official. Manufacturer's warranty is in addition to, and not a limitation of, other rights Owner may have under contract documents.

1. Warranty may transfer to subsequent owners.
2. Warranty Period for PEX Tubing: 30-year, non-prorated warranty against failure due to defect in material or workmanship, beginning with date of installation.
3. Warranty Period for Manifolds and Fittings: 5-year, non-prorated warranty against failure due to defect in material or workmanship, beginning with date of installation.
4. Warranty Period for Radiant Rollout Mat: 25-year, non-prorated warranty against failure due to defect in material or workmanship, beginning with date of installation for tubing. 10-year, non-prorated warranty against failure due to defect in material or workmanship, beginning with date of installation for in-slab engineered polymer fittings.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Acceptable Manufacturer: Uponor , which is located at: 5925 148th St. W.; Apple Valley, MN 55124; Toll Free Tel: 800-321-4739; Tel: 952-891-2000; Fax: 952-891-2008; Email:request info (daniel.worm@uponor.com); Web:www.uponorpro.com

B. Requests for substitutions will be considered in accordance with provisions of Section 01 60 00 - Product Requirements.

2.2 RADIANT HEATING SYSTEMS

A. Crosslinked Polyethylene (Pex) Pipe and Fittings:

1. To ensure system compatibility consistency, all products, manifolds, components, etc. specified herein shall be manufactured by and/or available from the PEX tubing manufacturer.

B. Tubing:

1. Material: Engel-method crosslinked polyethylene (PEX-a)

2. Material Standard: Manufactured in accordance with ASTM F876 and ASTM F877 and tested for compliance by an independent third-party agency.
3. Pressure Ratings: Standard Grade hydrostatic design and pressure ratings as issued by the Plastics Pipe Institute (PPI), a division of the Society of the Plastics Industry (SPI).

    a. 200 degrees F (93 degrees C) at 80 psi (551 kPa).
    b. 180 degrees F (82 degrees C) at 100 psi (689 kPa).
    c. 73.4 degrees F (23 degrees C) at 160 psi (1102 kPa).

4. Show compliance with ASTM E119 and ANSI/UL 263 through certification listings through UL.

    a. UL Design No. L557 1 hour wood frame floor/ceiling assemblies.
    b. UL Design No. K913 2 hour concrete floor/ceiling assemblies.
    c. UL Design No. U372 1 hour wood stud/gypsum wallboard wall assemblies.
    d. UL Design No. V444 1 hour steel stud/gypsum wallboard wall assemblies.

5. Minimum Bend Radius (Cold Bending): Six times the outside diameter.

6. Barrier Tubing Type: Wirsbo hePEX or equal

    a. Tubing shall have an oxygen-diffusion barrier that does not exceed an oxygen diffusion rate of 0.10 grams per cubic meter per day at 104 degrees F (40 degrees C) water temperature in accordance with German DIN 4726.

    b. Nominal Inside Diameter: Provide tubing with nominal inside diameter in accordance with ASTM F876, as indicated in the system design.

C. Fittings:

1. ASTM F1960 cold-expansion fitting manufactured from the following material types:

    a. UNS No. C69300 Lead-free (LF) Brass.
    b. 20% glass-filled polysulfone as specified in ASTM D6394.
    c. Unreinforced polysulfone (group 01, class 1, grade 2) as specified in ASTM D6394.
    d. Polyphenylsulfone (group 03, class 1, grade 2) as specified in ASTM D6394.
    e. Blend of polyphenylsulfone (55-80%) and unreinforced polysulfone (rem.) as specified in ASTM D6394.
    f. Reinforcing cold-expansion rings shall be manufactured from the same source as PEX-a piping manufacturer and marked F1960.

D. Distribution Manifolds:

1. Stainless Steel Manifolds:

    a. Stainless Steel manifold assemblies shall be constructed of stainless-steel, with minimum 1 inch (25 mm) barrel or 1-1/4 inches barrel, sized for flow rates required on submitted manifold schedule and R32 union connections.
    b. Manifold assemblies shall be furnished and installed with:

        1) Supply and return ball valves with temperature gauges.
        2) Loop balancing and isolation valves.
        3) Supply and return vent and drain connections.
        4) Mounting bracket.

5) Manual balancing valves with visual flow indicators 1.5 gpm (5.7 Lpm) for 1 inch (25 mm) barrel manifolds and 2 gpm (7.6 Lpm) for 1-1/4 inches (32 mm) barrel manifolds.
6) ASTM F1960 fitting assemblies.
7) Individual loop actuators with adapter rings, as needed.

c. Install flow setter on the return leg from the manifold to provide flow balancing between manifolds.
d. Manifolds support 5/16 inch (8 mm) through 3/4 inch (19 mm) PEX tubing.
e. Each manifold location shall have the ability to vent air manually from the system.
f. Use appropriately sized manifolds cabinets to allow the manifold assemblies to be mounted inside the wall cavity. Provide manifold elbows and offsets, as required.

1. Copper Manifolds:

a. At Contractor's option.

A. Piping Specialties And Accessories:

1. Fixing Wire: 6 inches (152 mm) galvanized steel alloy wire ties shall be used to secure PEX tubing to wire mesh or reinforcing bar.
2. Plastic PEX Rails: 1-1/2 inches (38 mm) wide, 1 inch (25 mm) tall polyethylene plastic rails, with snap fit to hold tubing with spacing intervals. Spacing as indicated on approved shop drawings.
3. PVC Bend Supports: 90 degree PVC bend supports shall be used to sleeve tubing at slab penetrations. Bend supports shall be sized for appropriate tubing diameter.

2.3 HYDRONIC PIPING AND FITTINGS (PEX-a)

A. Performance Requirements: PEX-a piping and fittings shall meet the following pressure and temperature ratings:

1. 200 degrees F (93 degrees C) at 80 psi (551 kPa).
2. 180 degrees F (82 degrees C) at 100 psi (689 kPa).
3. 73.4 degrees F (23 degrees C) at 160 psi (1,102 kPa).

B. Plastic Pipe and Fittings:

1. PEX-a (Engle-method Crosslinked Polyethylene) Piping: Uponor Wirsbo hePEX , ASTM 876 with oxygen-diffusion barrier that meets DIN 4726.
2. PEX-a Fittings, Elbows and Tees (1/2 inch through 2 inch nominal pipe size): ASTM F1960 cold-expansion fitting manufactured from the following material types:

a. UNS No. C69300 Lead-free (LF) Brass.
b. 20 percent glass-filled polysulfone as specified in ASTM D6394.
c. Unreinforced polysulfone (group 01, class 1, grade 2) as specified in ASTM D6394.
d. Polyphenylsulfone (group 03, class 1, grade 2) as specified in ASTM D6394
e. Blend of polyphenylsulfone (55-80%) and unreinforced polysulfone (rem.) as specified in ASTM D6394.
f. Reinforcing cold-expansion rings shall be manufactured from the same source as PEX-a piping manufacturer and marked "F1960".

3. PEX-a Fittings (2-1/2 inch through 4 inch nominal pipe size): SDR9 compression type fitting consisting of a double O-ring insert with a compression sleeve tightened around the pipe and insert.

C. Plastic-to-Metal Transition Fittings:

1. Manufacturer: Provide fittings from the same manufacturer of the piping.
2. Threaded Brass to PEX-a Transition: One-piece brass fitting with male or female threaded adapter and F1960 cold-expansion end, with PEX-a reinforcing cold-expansion ring. Typically used for PEX sizes 2 inch and below.
3. Brass Sweat to PEX-a Transition: One-piece brass fitting with sweat adapter and F1960 cold-expansion end, with PEX-a reinforcing cold-expansion ring. Typically used for PEX sizes 2 inch and below.
4. Dezincification-resistant (DZR) Brass to PEX-a Transition: Male NPT thread and PEX compression fitting. Editor: Typically used for PEX sizes 2-1/2 inch through 4 inch.

D. Plastic-to-Metal Transition Unions:

1. Manufacturer: Provide unions from the same manufacturer of the piping.
2. Threaded Brass to PEX-a Union: One-piece brass fitting with male or female threaded adapter and F1960 cold-expansion end, with PEX-a reinforcing cold-expansion ring. Typically used for PEX sizes 2 inch and below.
3. Brass Sweat to PEX-a Union: One-piece brass fitting with sweat adapter and F1960 cold-expansion end, with PEX-a reinforcing cold-expansion ring. Typically used for PEX sizes 2 inch and below.

E. Piping Applications:

1. Snow-melt heating piping installed below ground and within slabs shall be any of the following:

   a. 2 inch and below: Sleeved PEX-a piping with engineered polymer (EP) polyphenylsulfone F1960 cold-expansion fittings. Use the fewest possible joints and install per manufacturer's recommendations.
   b. 1 inch through 2 inch: Pre-insulated PEX-a piping with multi-layer, closed-closed cell PEX-foam insulation and a corrugated HDPE jacket with engineered polymer (EP) polyphenylsulfone F1960 cold-expansion fittings. Use the fewest possible joints and install per manufacturer's recommendations.
   c. 2-1/2 inch through 4 inch: Pre-insulated PEX-a piping with multi-layer, closed-cell, PEX-foam insulation and a corrugated HDPE jacket with compression fitting. Use the fewest possible joints and install per manufacturer's recommendations.

2.4 ASTM ECOFLEX PRE-INSULATED THERMAL SINGLE DISTRIBUTION SYSTEM

A. Design Requirements: The PEX-a service tubing is USA manufactured and tested in accordance with ASTM F876, ASTM F877, ASTM F1960, CSA B137.5 and NSF-rfh. The PEX service tubing has hydrostatic ratings in accordance with the temperatures and pressures listed in the ASTM standard. The hydrostatic ratings are:

1. 200 degrees F (93 degrees C) at 80 PSI (551 kPa).
2. 180 degrees F (82 degrees C) at 100 PSI (689 kPa).
3. 73.4 degrees F (23 degrees C) at 160 psi (1102 kPa).

B. Performance Requirements: Provide a pre-insulated distribution system that is USA manufactured, fabricated and installed to comply with regulatory agencies and authorities with jurisdiction, and that maintains performance criteria stated by the tubing manufacturer without defects, damage or failure.

1. Show compliance with ASTM F876 regarding Crosslinked Polyethylene (PEX) Tubing.

2. Show compliance with ASTM F877 regarding Crosslinked Polyethylene (PEX) Plastic Hot- and Cold-Water Distribution Systems.
3. Show compliance with DIN 4726 regarding Oxygen Diffusion.
4. Show compliance with ASTM F1960 regarding Cold Expansion Fittings with PEX Reinforcing Rings for Use with Cross-linked Polyethylene (PEX) Tubing.
5. Show compliance with CSA B137.5 regarding Crosslinked Polyethylene (PEX) Tubing Systems for Pressure Applications.
6. Show compliance with NSF-rfh regarding Radiant Floor Heating Applications

C. Service Tubing:

1. Material: Crosslinked polyethylene (PEX) manufactured to PEX-a or Engel-method standard

2. Material Standard: Manufactured in accordance with ASTM F876 and F877

3. Pressure Ratings: Hydrostatic design and pressure ratings are in accordance with the ASTM standard. Operating limits are as follows.

    a. -58 degrees F to 203 degrees F at 80 psi (-50 degrees C to 95 degrees C at 551 kPA).

1. The PEX service tubing in the Ecoflex Thermal Single pipe has an oxygen diffusion barrier that does not exceed an oxygen diffusion rate of 0.10 grams per cubic meter per day at 104 degrees F (40 degrees C) water temperature in accordance with German DIN 4726.

2. Nominal Inside Diameter: Provide tubing with nominal inside diameter in accordance with ASTM F876, as indicated. Note: Numbers in brackets are the metric equivalent pipe size.

    a. 1 inch (25mm).
    b. 1-1/4 inch (32mm).
    c. 1-1/2 inch (40mm).
    d. 2 inch (50mm).
    e. 2-1/2 inch (63mm).
    f. 3 inch (75mm).
    g. 3-1/2 inch (90mm).
    h. 4 inch (110mm).

D. Outer Jacket:

1. Material: Corrugated seamless high-density polyethylene (HDPE)
2. The HDPE jacket completely encompasses and protects the insulation from moisture and damage.
3. Outer jacket shall be extruded directly over the insulation and is flexible.
4. The outer jacket shall contain 2 percent carbon black, finely divided and thoroughly dispersed to provide protection from UV degradation.
5. Minimum Bend Radius:
    a. 1-inch pre-insulated tubing with 5.5-inch (140mm) jacket has a bend radius of 10 inches (254mm).
    b. 1-1/4-inch pre-insulated tubing with 5.5-inch (140mm) jacket has a bend radius of 12 inches (304mm).
    c. 1-1/2-inch pre-insulated tubing with 6.9-inch (175mm) jacket has a bend radius of 16 inches (406mm).
    d. 2-inch pre-insulated tubing with 6.9-inch (175mm) jacket has a bend radius of 18 inches (457mm).

e. 2-1/2-inch pre-insulated tubing with 6.9-inch (175mm) jacket has a bend radius of 30 inches (762mm).
f. 3-inch pre-insulated tubing with 7.9-inch (200mm) jacket has a bend radius of 32 inches (812mm).
g. 3-1/2-inch pre-insulated tubing with 7.9-inch (200mm) jacket has a bend radius of 44 inches (1117mm).
h. 4-inch pre-insulated tubing with 7.9-inch (200mm) jacket has a bend radius of 48 inches (1219mm).

E. Insulation:

1. The insulation shall be layered expanded cross-linked water-resistant polyethylene closed-cell foam.
2. All seams of the insulation shall be sealed.
3. Insulation shall not be bonded to the service tubing.

F. End Seals:

1. The piping manufacturer will supply all EPDM rubber end caps with water-stop seal.
2. EPDM rubber end caps are to be installed on each end prior to connecting the service pipes and insulating the field joints.
3. The EPDM end caps will seal onto the tubing and outer jacket forming a watertight seal.

G. Cold Expansion Fittings for PEX-a Service Tubing:

1. For system compatibility, use fittings offered by the tubing manufacturer.
2. Fittings must comply with the performance requirements of ASTM F877.
3. Fittings are to be manufactured in accordance with ASTM F1960.
4. The fitting assembly consists of a barbed adapter and an applicable-sized PEX ring.
5. All buried fittings will be installed, insulated, and sealed in accordance with the instructions of the piping manufacturer.

H. Compression Fittings for PEX-a Service Tubing:

1. For system compatibility, use fittings offered by the tubing manufacturer.
2. Fittings are to be manufactured from dezincification-resistant brass and lead-free brass.
3. The fitting assembly must comply with performance requirements of ASTM F877.
4. Fittings will consist of a compression fitting with a coupling sleeve, a fitting body insert with o-ring(s) and a bolt and nut.
5. All buried fittings will be installed, insulated, and sealed in accordance with the piping manufacturer's instructions.
6. Male NPT thread for each compression fitting is shown below.

a. 1 inch PEX compression fitting has 1-inch male NPT thread.
b. 1-1/4 inch PEX compression fitting has 1-1/4 inch male NPT thread.
c. 1-1/2 inch PEX compression fitting has 1-1/2 inch male NPT thread.
d. 2 inch PEX compression fitting has 2 inch male NPT thread.
e. 2-1/2 inch PEX compression fitting has 2 inch male NPT thread.
f. 3 inch PEX compression fitting has 2-1/2 inch male NPT thread.
g. 3-1/2 inch PEX compression fitting has 3 inch male NPT thread.
h. 4 inch PEX compression fitting has 4 inch male NPT thread.

7. All transition fittings connecting to the compression fittings will be manufactured of dezincification-resistant brass.

I. Pipe and Fitting Identification: The pipe shall be marked in accordance with the standards to which it is manufactured.

1. Color identification by the use of stripes on pipe to identify pipe service shall be optional. If used, stripes or colored exterior pipe product shall be blue for potable water, green for wastewater/sewage, or purple for reclaimed water.
2. Tracing wire shall be placed parallel and 18 inches above, but separate from, the pipe and shall be 10 AWG.
3. Marking tape shall be approved by the engineer and placed between 12 and 18 inches above the crown of the pipe.
4. Accessories: Use accessories associated with the installation of the piping system as recommended by or available from the manufacturer.

J. Insulation Kits: Insulation kits will be manufactured of ABS shells or HDPE sleeves, will feature equal thickness of closed-cell PEX insulation as the pipe, and sealed watertight.

K. Connection Vaults:

1. The piping manufacturer will provide the connection vaults when required by the project construction.
2. Connection vaults shall be constructed of rotationally molded composite polyethylene and PE foam, providing a structurally sound and thermally insulated chamber.
3. Heat shrink seals as provided by the tubing manufacturer shall be installed to prevent introduction of water into the vault.

L. Anchors: The project engineer will determine the use of anchors, if required, within the distribution system.

2.5 ASTM ECOFLEX PRE-INSULATED THERMAL TWIN DISTRIBUTION SYSTEM

A. Design Requirements: The PEX-a service tubing is USA manufactured and tested in accordance with ASTM F876, ASTM F877, ASTM F1960, CSA B137.5 and NSF-rfh. The PEX service tubing has hydrostatic ratings in accordance with the temperatures and pressures listed in the ASTM standard. The hydrostatic ratings are:

1. 200 degrees F (93 degrees C) at 80 PSI (551 kPa).
2. 180 degrees F (82 degrees C) at 100 PSI (689 kPa).
3. 73.4 degrees F (23 degrees C) at 160 psi (1102 kPa).

B. Performance Requirements: Provide a pre-insulated distribution system that is USA manufactured, fabricated and installed to comply with regulatory agencies and authorities with jurisdiction, and that maintains performance criteria stated by the tubing manufacturer without defects, damage or failure.

1. Show compliance with ASTM F876 regarding Crosslinked Polyethylene (PEX) Tubing.
2. Show compliance with ASTM F877 regarding Crosslinked Polyethylene (PEX) Plastic Hot- and Cold-Water Distribution Systems.
3. Show compliance with DIN 4726 regarding Oxygen Diffusion.
4. Show compliance with ASTM F1960 regarding Cold Expansion Fittings with PEX Reinforcing Rings for Use with Cross-linked Polyethylene (PEX) Tubing.
5. Show compliance with CSA B137.5 regarding Crosslinked Polyethylene (PEX) Tubing Systems for Pressure Applications.
6. Show compliance with NSF-rfh regarding Radiant Floor Heating Applications.

C. Service Tubing:

1. Material: Crosslinked polyethylene (PEX) manufactured to PEX-a or Engel-method standard
2. Material Standard: Manufactured in accordance with ASTM F876 and F877.
3. Pressure Ratings: Hydrostatic design and pressure ratings are in accordance with the ASTM standard. Operating limits are as follows.

    a. -58 degrees F to 203 degrees F at 80 psi (-50 degrees C to 95 degrees C at 551 kPA).

4. The PEX service twin tubing in the Ecoflex Thermal Twin pipe have an oxygen diffusion barrier that does not exceed an oxygen diffusion rate of 0.10 grams per cubic meter per day at 104 degrees F (40 degrees C) water temperature in accordance with German DIN 4726.
5. Nominal Inside Diameter: Provide tubing with nominal inside diameter in accordance with ASTM F876, as indicated. Note: Numbers in brackets are the metric equivalent pipe size.

    a. 1 inch (25mm).
    b. 1-1/4 inch (32mm).
    c. 1-1/2 inch (40mm).
    d. 2 inch (50mm).
    e. 2-1/2 inch (63mm).

D. Outer Jacket:

1. Material: Corrugated seamless high-density polyethylene (HDPE).
2. The HDPE jacket completely encompasses and protects the insulation from moisture and damage.
3. Outer jacket shall be extruded directly over the insulation and is flexible.
4. The outer jacket shall contain 2 percent carbon black, finely divided and thoroughly dispersed to provide protection from UV degradation.
5. Minimum Bend Radius:

    a. 1-inch pre-insulated twin tubing with 6.9-inch (175mm) jacket has a bend radius of 20 inches (254mm).
    b. 1-1/4-inch pre-insulated twin tubing with 6.9-inch (175mm) jacket has a bend radius of 28 inches (711mm).
    c. 1-1/2-inch pre-insulated twin tubing with 6.9-inch (175mm) jacket has a bend radius of 32 inches (812mm).
    d. 2-inch pre-insulated twin tubing with 7.9-inch (200mm) jacket has a bend radius of 40 inches (1016mm).
    e. 2-1/2-inch pre-insulated twin tubing with 7.9-inch (200mm) jacket has a bend radius of 48 inches (1219mm).

E. Insulation:

1. The insulation shall be layered expanded cross-linked water-resistant polyethylene closed-cell foam.
2. All seams of the insulation shall be sealed.
3. Insulation shall not be bonded to the service tubing.

F. End Seals:

1. The piping manufacturer will supply all EPDM rubber end caps with water-stop seal.
2. EPDM rubber end caps are to be installed on each end prior to connecting the service pipes and insulating the field joints.

3. The EPDM end caps will seal onto the tubing and outer jacket forming a watertight seal.

G. Cold Expansion Fittings for PEX-a Service Tubing:

1. For system compatibility, use fittings offered by the tubing manufacturer.
2. Fittings must comply with the performance requirements of ASTM F877.
3. Fittings are to be manufactured in accordance with ASTM F1960.
4. The fitting assembly consists of a barbed adapter and an applicable-sized PEX ring.
5. All buried fittings will be installed, insulated, and sealed in accordance with the instructions of the piping manufacturer.

H. Compression Fittings for PEX-a Service Tubing:

1. For system compatibility, use fittings offered by the tubing manufacturer.
2. Fittings are to be manufactured from dezincification-resistant brass and lead-free brass.
3. The fitting assembly must comply with performance requirements of ASTM F877.
4. Fittings will consist of a compression fitting with a coupling sleeve, a fitting body insert with o-ring(s) and a bolt and nut.
5. All buried fittings will be installed, insulated, and sealed in accordance with the piping manufacturer's instructions.
6. Male NPT thread for each compression fitting is shown below.

    a. 1 inch PEX compression fitting has 1-inch male NPT thread.
    b. 1-1/4 inch PEX compression fitting has 1-1/4 inch male NPT thread.
    c. 1-1/2 inch PEX compression fitting has 1-1/2 inch male NPT thread.
    d. 2 inch PEX compression fitting has 2 inch male NPT thread.
    e. 2-1/2 inch PEX compression fitting has 2 inch male NPT thread.

7. All transition fittings connecting to the compression fittings will be manufactured of dezincification-resistant brass.

I. Pipe and Fitting Identification: The pipe shall be marked in accordance with the standards to which it is manufactured.

1. Color identification by the use of stripes on pipe to identify pipe service shall be optional. If used, stripes or colored exterior pipe product shall be blue for potable water, green for wastewater/sewage, or purple for reclaimed water.

2. Tracing wire shall be placed parallel and 18 inches above, but separate from, the pipe and shall be 10 AWG.

3. Marking tape shall be approved by the engineer and placed between 12 and 18 inches above the crown of the pipe.

J. Accessories: Use accessories associated with the installation of the piping system as recommended by or available from the manufacturer.

K. Insulation Kits: Insulation kits will be manufactured of ABS shells or HDPE sleeves, will feature equal thickness of closed-cell PEX insulation as the pipe, and sealed watertight.

L. Connection Vaults:

1. The piping manufacturer will provide the connection vaults when required by the project construction.
2. Connection vaults shall be constructed of rotationally molded composite polyethylene and PE foam, providing a structurally sound and thermally insulated chamber.

3. Heat shrink seals as provided by the tubing manufacturer shall be installed to prevent introduction of water into the vault.

M. Anchors: The project engineer will determine the use of anchors, if required, within the distribution system.

PART 3 - PRODUCTS

3.1 EXAMINATION

A. Site Verification of Conditions: Verify that site conditions are acceptable for installation of the piping distribution system. Do not proceed with installation until unacceptable conditions are corrected.

3.2 RADIANT SYSTEMS INSTALLATION

A. Installation:

1. Install radiant system according to approved shop drawings or coordination drawings.
2. Comply with manufacturer's product data, including product technical bulletins, installation instructions and design drawings, including the following.

    a. Uponor Complete Design Assistance Manual (CDAM), current edition
    b. Uponor Radiant Floor Installation Handbook, current edition

3. Slab-on-Grade Installation:

    a. Fasten the tubing to the wire mesh or reinforcing bar using wire ties or plastic cable ties. Space ties at a maximum of 36 inches (914 mm). Secure tubing at the base and center of each bend.
    b. Install edge insulation when the controlled system directly contacts an exterior wall.
    c. Install tubing at a consistent depth below the surface elevation. Maintain minimum cover as shown on plans. Ensure sufficient clearance to avoid control joint cuts.
    d. In areas where tubing must cross expansion joints in the concrete, ensure the tubing passes below the joints. If tubing must pass through an expansion joint, tubing shall be wrapped with pipe insulation for 6 inches on both sides of joint.
    e. For tubing that exits the slab in a 90-degree bend, use PVC bend supports.
    f. System shall be pressure-tested per the manufacturer's recommendations at a pressure no less than 40 psig (152 kPa). Maintain minimum 40 psig (152 kPa) pressure during the concrete pour for 24 hours during curing.

4. Suspended Slab Construction:

    a. Fasten the tubing to the wire mesh or reinforcing bar using wire ties or plastic cable ties. Space ties at a maximum of 36 inches (914 mm). Secure tubing at the base and center of each bend.

5. Topping Installation:

    a. Fasten the tubing to the wire mesh using wire ties or plastic cable ties. Space ties at a maximum of 36 inches (914 mm). Secure tubing at the base and center of each bend.

6. Manifold Installation: Mount manifolds in manifold wall cabinets per the approved shop drawings. Coordinate door panel finish with architectural finish schedule. Install manifold cabinets in accordance with manufacturer's recommendations.

7. All piping to be identified with loop numbers marked on pipe wall before connecting to manifold using a permanent tag. Verify actual loop length for each loop on a manifold. All loops shall be identified to allow for future balancing.
8. Coordinate slab tubing layout with other devices (electrical conduits and boxes, telecommunication conduits and boxes, plumbing penetrations, construction and furniture supports) and all other services within or attaching to the slab. Zones designated on the drawings shall be kept clear of all radiant floor tubing.
9. Provide survey documentation of tubing layout after installation of tubing and prior to pouring concrete. Notify Owner's Representative three days in advance of concrete pour to allow inspection of installation and survey documentation.

B. Adjusting:

1. Balancing Loops Across the Manifold:

a. Balance all loops across each manifold to the flow rates specified on the approved manifold schedule.
b. Balancing is unnecessary when all loop lengths across the manifold are within 3% of each other in length. Install the supply-and-return piping to the manifold in a reverse-return configuration to ensure self-balancing.

C. Cleaning/Recycling:

1. Remove temporary coverings and protection.
2. Repair or replace damaged installed products.
3. Clean installed products in accordance with manufacturer's instructions prior to Owner's acceptance.
4. Remove construction debris from project site and legally dispose of debris. Divert waste tubing and packaging for recycling

3.3 HYDRONIC SYSTEMS INSTALLATION

A. Install hydronic piping according to approved shop drawings or coordination drawings.

B. Comply with manufacturer's product data, including product technical bulletins, installation instructions and design drawings, including the following.

1. Uponor Pre-insulated Pipe Systems Design and Installation Manual, current edition.

C. Below-grade Installation:

1. Pre-insulated piping shall be installed in accordance with manufacturer's recommendations and the details as shown on the contract drawings.
2. The system will be installed with the fewest number of underground joints as possible.
3. The system does not require expansion loops, expansion joints or compensators of any type.
4. An EPDM rubber end cap shall be applied at all terminations of the piping system, including all fitting locations, to form a watertight seal.
5. All buried fittings will be installed, insulated and sealed in accordance with the piping manufacturer's instructions.
6. Connection Vaults or Insulation Kits are required for all below-grade installations.

D. Backfill:

1. The pre-insulated piping system will be backfilled with clean sand material.

2. Minimum vertical distance from the bottom of the tubing to the trench floor is 4 inches (100 mm).
3. Minimum lateral distance from the side of the tubing to the trench wall is 6 inches (150 mm).
4. Install a minimum of 12 inches (300 mm) of clean fill over the top of the potable pre-insulated piping.
5. The balance of the trench can be backfilled with native soil void of stone greater than 2 inches (50m) in diameter.

3.4 FIELD QUALITY CONTROL

A. Site Tests: To ensure system integrity, pressure-test the tubing before and during backfilling of the piping. The service tubing will be air tested at 1-1/2 times the operating pressure for a minimum of 1 hour prior to system burial.

3.5 PROTECTION

A. Protect installed work from damage caused by subsequent construction activity on the site

END OF SECTION 23 2111

SECTION 23 2112 - STEAM AND CONDENSATE PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings, General Provisions of Contract, including General and Supplementary Conditions and other Division 1 Specification Sections, and Section 22 0501 apply to this Section.

1.2 SUMMARY

A. Furnish and install steam and condensate piping as described in Contract Documents.

1.3 QUALITY ASSURANCE

A. Cleaning System:
   1. Thoroughly clean equipment, piping, and other material under this contract.
   2. Remove rust, scale, and other dirt before painting or covering.
   3. Remove rust, scale, and other dirt before operating the system.

B. Operate heating system at 10 psi for at least 6 hours, then -
   1. Fill boiler to the top with water to wash any film, oil or grease over the top.
   2. Drain boiler and refill to proper level with fresh water.
   3. Use 1 pound tri-sodium phosphate for every 100 gallons of water during cleaning operation.

C. Tests:
   1. No piping systems shall be covered or concealed until hydraulically tested at 50 psi in excess of maximum working pressure (100 psi minimum) and inspected and approved by Architect and any local inspector having jurisdiction.
   2. When directed by Architect or Engineer, Contractor shall conduct an operating test on any piece of equipment to demonstrate its capacity and operating characteristics.

PART 2 - PRODUCTS

2.1 MANUFACTURED UNITS

A. Steam Supply Piping
   1. Schedule 40-A-120 black steel piping.
   2. Pipe ends shall be reamed out before being made up into fittings.
   3. Use graphite and oil applied to male threads only in making pipe joint fittings.
   4. Fittings shall be standard weight 150 lb. malleable iron screwed pattern up to 2 1/2 inches.
   5. Piping over 2 1/2 inches shall be welded with full weld fittings.

B. Condensate Piping:
   1. Schedule 80 black steel piping.
   2. Pipe ends shall be reamed out before being made up into fittings.
   3. Use graphite and oil applied to male threads only in making up pipe joint fittings.
   4. Fittings shall be standard weight 300 lb. malleable iron screwed pattern up to 2 1/2 inches.
   5. Piping over 2 1/2 inches shall be welded with full weld fittings.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Heating piping shall run generally as indicated on the Drawings.

B. Pipe ends shall be reamed and burrs removed.

C. Unions shall be installed where necessary and on both sides of equipment and drip traps.

D. Install float and thermostatic drip traps in sizes shown on drawings.
   1. Install at ends of steam mains.
   2. Install on raises in steam mains.
   3. Install dirt strainer and gate valve ahead of each drip trap.

E. Runs of main piping shall start as high as possible.

F. Keep as close to the ceiling as possible.

G. Make sufficient allowance for grade and branches to be taken off top at 45 degree angles.

H. Steam and return mains shall be graded downward in direction of flow 1 inch in 20 feet.

I. Runouts and branches that grade back against flow of steam shall be graded 1/4 inch per foot.

END OF SECTION 23 2112

23 2113 – STEAM AND STEAM CONDENSATE SPECIALTIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings, General Provisions of Contract, including General and Supplementary Conditions and other Division 1 Specification Sections, and Section 15055 apply to this Section.

1.2 SUMMARY

A. Furnish and install steam and steam condensate specialties as described in Contract Documents.

PART 2 - PRODUCTS

2.1 MANUFACTURED UNITS

A. Drip Traps and Steam Coil Traps:
   1. Combination float and thermostatic type.
      a. Thermostatic element shall form automatic air vent and conform to applicable requirements of thermostatic radiator traps.
      b. Main trap body, float, and valve mechanism shall be capable of withstanding constant steam pressure of 15 psi.
      c. Traps shall deliver rated capacity called for on drawings at 1/2 pound differential pressure.
   2. Approved Manufacturers:
      a. Illinois Series G
      b. Hoffman
      c. Armstrong

B. Valves:
   1. Approved Manufacturers:
      a. Crane
      b. Nibco
      c. Jenkins
      d. Stockham
      e. Milwaukee
   2. Full port ball valves rated for steam service at 250ºF.

C. Swing Check Valves:
   1. Provision for re-grinding without removal of the valve from the line.
   2. 2 Inch & Smaller - All bronze, 125 psi swp at 350 deg F.
   3. 2-1/2 Inch & Larger - Flanged iron body, bronze mounted, 125 psig swp at 450 deg F.
   4. Approved Manufacturers:
      a. 2 Inch & Smaller:
         1) Stockham B319
      b. 2-1/2 Inch & Larger:
         1) Stockham G931
      c. Equals by Crane, Jenkins, Lunkenheimer, or Walworth.

D. Strainers:
   1. Strainers shall be basket type with cast iron body and brass basket easily removable.
   2. Provide manual blowdown valve with removable handle and hose connection on each strainer.

E. Steam Coil Vacuum Breakers:
   1. Furnish and install on all steam coils with automatic valves a 1/2 inch vacuum breaker rated at 100 psig maximum pressure and 300 deg. F. maximum temperature.
   2. Vacuum breaker shall be all brass housing with stainless steel valve, seat and spring.
   3. Approved Manufacturers:
      a. Sarco Model 1821

b. Barnes & Jones Model VB3856
c. or approved equal

F. Make-up Water Backflow Preventer:
1. Reduced pressure backflow device shall consist of two independently operating center guided, spring loaded, "Y" pattern check valves and one hydraulically dependent differential relief valve.
2. The device shall automatically reduce pressure in the "zone" between the check valves to at least 5 psi lower than the inlet pressure.
3. If differential between upstream and zone of the unit drops to 2 psi, differential relief valve shall open and maintain proper differential.
4. Provide with air-gap drain.
5. Approved Manufacturers:
a. Febco or approved equal

END OF SECTION 23 2113

SECTION 23 2114 - HYDRONIC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings, General Provisions of Contract, including General and Supplementary Conditions and Section 23 0501 apply to this Section.

1.2 SUMMARY

A. This Section includes piping, special-duty valves, makeup water for these systems; blowdown drain lines; and condensate drain piping.

1.3 DEFINITIONS

A. CPVC: Chlorinated polyvinyl chloride.

B. PVC: Polyvinyl chloride.

1.4 SUBMITTALS

A. Product Data: For each type of special-duty valve indicated. Include flow and pressure drop curves based on manufacturer's testing for diverting fittings, calibrated balancing valves, and automatic flow-control valves.

B. Shop Drawings: Detail fabrication of pipe anchors, hangers, special pipe support assemblies, alignment guides, expansion joints and loops, and their attachment to the building structure. Detail location of anchors, alignment guides, and expansion joints and loops.

C. Welding Certificates: Copies of certificates for welding procedures and personnel.

D. Field Test Reports: Written reports of tests specified in Part 3 of this Section. Include the following:
1. Test procedures used.
2. Test results that comply with requirements.
3. Failed test results and corrective action taken to achieve requirements.

E. Maintenance Data: For hydronic specialties and special-duty valves to include in maintenance manuals specified in Division 23.

F. Water Analysis: Submit a copy of the water analysis to illustrate water quality available at Project site.

1.5 QUALITY ASSURANCE

A. Welding: Qualify processes and operators according to the ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."

B. ASME Compliance: Comply with ASME B31.9, "Building Services Piping," for materials, products, and installation. Safety valves and pressure vessels shall bear the appropriate ASME label. Fabricate and stamp air separators and expansion tanks to comply with the ASME Boiler and Pressure Vessel Code, Section VIII, Division 1.

C To assure uniformity and compatibility of piping components in grooved end piping systems, all grooved products utilized shall be supplied by a single manufacturer. Grooving tools shall be supplied by the same manufacturer as the grooved components.

1.6 COORDINATION

A. Coordinate layout and installation of hydronic piping and suspension system components with other

construction, including light fixtures, HVAC equipment, fire-suppression-system components, and partition assemblies.

B. Coordinate pipe sleeve installations for foundation wall penetrations.

C. Coordinate piping installation with roof curbs, equipment supports, and roof penetrations.

D. Coordinate pipe fitting pressure classes with products specified in related Sections.

E. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into base. Concrete, reinforcement, and formwork requirements are specified in Division 3 Sections.

F. Coordinate installation of pipe sleeves for penetrations through exterior walls and floor assemblies. Coordinate with requirements for firestopping specified in Division 7 Section "Through-Penetration Firestop Systems" for fire and smoke wall and floor assemblies.

1.7 EXTRA MATERIALS

A. Water Treatment Chemicals: Furnish sufficient chemicals for initial system startup and for preventive maintenance for one year from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Grooved Mechanical-Joint Fittings and Couplings:
   a. Central Sprinkler Company; Central Grooved Piping Products.
   b. Grinnell Mechanical Products.
   c. Victaulic Company of America.
2. Calibrated Balancing Valves:
   a. Armstrong Pumps, Inc.
   b. Flow Design, Inc.
   c. Gerand Engineering Company.
   d. Griswold Controls.
   e. ITT Bell & Gossett; ITT Fluid Technology Corp.
   f. Taco, Inc.
   g. Tour Andersson supplied by Victaulic
3. Pressure-Reducing Valves:
   a. Amtrol, Inc.
   b. Armstrong Pumps, Inc.
   c. Conbraco Industries, Inc.
   d. ITT Bell & Gossett; ITT Fluid Technology Corp.
   e. Spence Engineering Company, Inc.
   f. Watts Industries, Inc.; Watts Regulators.
4. Safety Valves:
   a. Amtrol, Inc.
   b. Armstrong Pumps, Inc.
   c. Conbraco Industries, Inc.
   d. ITT McDonnell & Miller Div.; ITT Fluid Technology Corp.
   e. Kunkle Valve Division.
   f. Spence Engineering Company, Inc.
5. Automatic Flow-Control Valves:
   a. Flow Design, Inc.
   b. Griswold Controls.
6. Expansion Tanks:
   a. Amtrol, Inc.

b. Armstrong Pumps, Inc.
c. ITT Bell & Gossett; ITT Fluid Technology Corp.
d. Taco, Inc.

7. Air Separators and Air Purgers:
   a. Amtrol, Inc.
   b. Armstrong Pumps, Inc.
   c. ITT Bell & Gossett; ITT Fluid Technology Corp.
   d. Taco, Inc.

2.2 PIPING MATERIALS

A. General: Refer to Part 3 "Piping Applications" Article for applications of pipe and fitting materials.

2.3 COPPER TUBE AND FITTINGS

A. Drawn-Temper Copper Tubing: ASTM B 88, Type L.

B. Annealed-Temper Copper Tubing: ASTM B 88, Type K.

C. DWV Copper Tubing: ASTM B 306, Type DWV.

D. Wrought-Copper Fittings: ASME B16.22.

E. Wrought-Copper Unions: ASME B16.22.

F. Solder Filler Metals: ASTM B 32, 95-5 tin antimony.

G. Brazing Filler Metals: AWS A5.8, Classification BAg-1 (silver).

2.4 STEEL PIPE AND FITTINGS

A. Steel Pipe, NPS 2 and Smaller: ASTM A 53, Type S (seamless) or Type F (furnace-butt welded), Grade B, Schedule 40, black steel, plain ends.

B. Steel Pipe, NPS 2-1/2 through NPS 12: ASTM A 53, Type E (electric-resistance welded), Grade B, Schedule 40, black steel, plain ends.

C. Steel Pipe, NPS 14 through NPS 18: ASTM A 53, Type E (electric-resistance welded) or Type S (seamless), Grade B, Schedule 30, black steel, plain ends.

D. Steel Pipe, NPS 20: ASTM A 53, Type E (electric-resistance welded) or Type S (seamless), Grade B, Schedule 20, black steel, plain ends.
   1. Steel Pipe Nipples: ASTM A 733, made of ASTM A 53, Schedule 40, black steel; seamless for NPS 2 and smaller and electric-resistance welded for NPS 2-1/2 and larger.

E. Cast-Iron Threaded Fittings: ASME B16.4; Classes 125 and 250.

F. Malleable-Iron Threaded Fittings: ASME B16.3, Classes 150 and 300.

G. Malleable-Iron Unions: ASME B16.39; Classes 150, 250, and 300.

H. Cast-Iron Pipe Flanges and Flanged Fittings: ASME B16.1, Classes 25, 125, and 250; raised ground face, and bolt holes spot faced.

I. Wrought-Steel Fittings: ASTM A 234/A 234M, wall thickness to match adjoining pipe.

J. Wrought Cast- and Forged-Steel Flanges and Flanged Fittings: ASME B16.5, including bolts, nuts, and gaskets of the following material group, end connections, and facings:
   1. Material Group: 1.1.

2. End Connections: Butt welding.
3. Facings: Raised face.

K. Grooved Mechanical-Joint Fittings: ASTM A 536, Grade 65-45-12 ductile iron; ASTM A 47, Grade 32510 malleable iron; ASTM A 53, Type F, E, or S, Grade B fabricated steel; or ASTM A 106, Grade B steel fittings with grooves or shoulders designed to accept grooved end couplings.

L. **Standard Mechanical Couplings, 2 inch through 12 inch**: Manufactured in two segments of cast ductile iron, conforming to ASTM A-536, Grade 65-45-12. Gaskets shall be pressure-responsive synthetic rubber, grade to suit the intended service, conforming to ASTM D-2000. (Gaskets used for potable water applications shall be UL classified in accordance with ANSI/NSF-61 for potable water service.) Mechanical Coupling bolts shall be zinc plated (ASTM B-633) heat treated carbon steel track head conforming to ASTM A-449 and ASTM A-183, minimum tensile strength 110,000 psi (758450 kPa).
   a. **Rigid Type**: Coupling housings with offsetting, angle-pattern bolt pads shall be used to provide system rigidity and support and hanging in accordance with ANSI B31.1, B31.9, and NFPA 13.
      1. 2 inch through 12 inch: Installation ready rigid coupling for direct stab installation without field disassembly. Gasket shall be Grade EPDM compound designed for operating temperatures from -30 deg F to +250 deg F. Gasket temperature rating shall be met without the use of special lubricants.
   b. **Flexible Type**: Use in locations where vibration attenuation and stress relief are required. Flexible couplings may be used in lieu of flexible connectors at equipment connections. Three couplings, for each connector, shall be placed in close proximity to the vibration source.
      1. 2” through 8”: Installation-ready flexible coupling for direct stab installation without field disassembly. Gasket shall be grade EPDM compound designed for operating temperatures from -30 deg F to +250 deg F. Gasket temperature rating shall be met without the use of special lubricants.
      2. 10” through 12”: Standard flexible couplings. Gasket shall be Grade “E” EPDM compound designed for operating temperatures from -30 deg F to +230 deg F.

M. Flexible Connectors: Stainless-steel bellows with woven, flexible, bronze, wire-reinforcing protective jacket; 150-psig minimum working pressure and 250 deg F maximum operating temperature. Connectors shall have flanged or threaded-end connections to match equipment connected and shall be capable of 3/4-inch misalignment.

N. Spherical, Rubber, Flexible Connectors: Fiber-reinforced rubber body with steel flanges drilled to align with Classes 150 and 300 steel flanges; operating temperatures up to 250 deg F and pressures up to 150 psig.

O. Packed, Slip, Expansion Joints: 150-psig minimum working pressure, steel pipe fitting consisting of telescoping body and slip-pipe sections, packing ring, packing, limit rods, flanged ends, and chrome-plated finish on slip-pipe telescoping section.

P. Welding Materials: Comply with Section II, Part C, of the ASME Boiler and Pressure Vessel Code for welding materials appropriate for wall thickness and for chemical analysis of pipe being welded.

Q. Gasket Material: Thickness, material, and type suitable for fluid to be handled; and design temperatures and pressures.

2.5 VALVES

A. Gate, globe, check, ball, and butterfly valves are specified in Division 23 Section "Valves."

B. Grooved-End Butterfly Valves
1. 2" through 12" Sizes: 300 psi CWP suitable for bidirectional and dead-end service at full rated pressure. Body shall be grooved end black enamel coated ductile iron conforming to ASTM A536. Disc shall be electroless nickel plated ductile iron with blowout proof 416 stainless steel stem. Disc shall be offset from the stem centerline to allow full 360 degree circumferential seating. Seat shall be pressure responsive EPDM. Valve bearings shall be TFE lined fiberglass, and stem seals shall be of the same grade elastomer as the valve seat. Valve shall be complete with ISO flange for actuation mounting. Valve operators shall be lever handle or gear operator, available with memory

stop feature, locking device, chainwheel, or supplied bare. (Valve with EPDM seat is UL classified in accordance with ANSI/NSF-61.)

C. Grooved-End Check Valves
1. 2 inch through 12 inch sizes: Spring Assisted: Black enamel coated ductile iron body, ASTM A-536, Grade 65-45-12, elastomer encapsulated ductile iron disc suitable for intended service, stainless steel spring and shaft, welded-in nickel seat, 300 psi. Valve with pre-tapped ports as available option.

D. Refer to Part 3 "Valve Applications" Article for applications of each valve.

E. Calibrated Balancing Valves, NPS 2 and Smaller: Bronze body, ball type, 125-psig working pressure, 250 deg F maximum operating temperature, and having threaded ends. Valves shall have calibrated orifice or venturi, connections for portable differential pressure meter with integral seals, and be equipped with a memory stop to retain set position.

F. Calibrated Balancing Valves, NPS 2-1/2 and Larger: Cast-iron or steel body, ball type, 125-psig working pressure, 250 deg F maximum operating temperature, and having flanged or grooved connections. Valves shall have calibrated orifice or venturi, connections for portable differential pressure meter with integral seals, and be equipped with a memory stop to retain set position.

G. Pressure-Reducing Valves: Diaphragm-operated, bronze or brass body with low inlet pressure check valve, inlet strainer removable without system shutdown, and noncorrosive valve seat and stem. Select valve size, capacity, and operating pressure to suit system. Valve shall be factory set at operating pressure and have capability for field adjustment.

H. Safety Valves: Diaphragm-operated, bronze or brass body with brass and rubber, wetted, internal working parts; shall suit system pressure and heat capacity and shall comply with the ASME Boiler and Pressure Vessel Code, Section IV.

I. Automatic Flow-Control Valves: Gray-iron body, factory set to maintain constant flow with plus or minus 5 percent over system pressure fluctuations, and equipped with a readout kit including flow meter, probes, hoses, flow charts, and carrying case. Each valve shall have an identification tag attached by chain, and be factory marked with the zone identification, valve number, and flow rate. Valve shall be line size and one of the following designs:
1. Gray-iron or brass body, designed for 175 psig at 200 deg F with stainless-steel piston and spring.
2. Brass or ferrous-metal body, designed for 300 psig at 250 deg F with corrosion-resistant, tamperproof, self-cleaning, piston-spring assembly easily removable for inspection or replacement.
3. Combination assemblies, including bronze ball valve and brass alloy control valve, with stainless-steel piston and spring, fitted with pressure and temperature test valves, and designed for 300 psig at 250 deg F.

J. Plastic Butterfly Valves: 150-psig working pressure, 250 deg F maximum operating temperature, PVC wafer body, polytetrafluoroethylene seats, lever lock handle, and wafer style for installation between flanges.

2.6 HYDRONIC SPECIALTIES

A. Manual Air Vent: Bronze body and nonferrous internal parts; 150-psig working pressure; 225 deg F operating temperature; manually operated with screwdriver or thumbscrew; with NPS 1/8 discharge connection and NPS 1/2 inlet connection.

B. Automatic Air Vent: Designed to vent automatically with float principle; bronze body and nonferrous internal parts; 150-psig working pressure; 240 deg F operating temperature; with NPS 1/4 discharge connection and NPS 1/2 inlet connection.

C. Expansion Tanks: Welded carbon steel, rated for 125-psig working pressure and 375 deg F maximum operating temperature, with taps in bottom of tank for tank fitting and taps in end of tank for gage glass. Tanks shall be factory tested with taps fabricated and labeled according to the ASME Boiler and Pressure Vessel Code, Section VIII, Division 1. Include the following fittings and accessories:

1. Air-Control Tank Fitting: Cast-iron body, copper-plated tube, brass vent tube plug, and stainless-steel ball check, 100-gal. unit only; sized for compression-tank diameter. Design tank fittings for 125-psig working pressure and 250 deg F maximum operating temperature.
2. Tank Drain Fitting: Brass body, nonferrous internal parts; 125-psig working pressure and 240 deg F maximum operating temperature; designed to admit air to compression tank, drain water, and close off system.
3. Gage Glass: Full height with dual manual shutoff valves, 3/4-inch- diameter gage glass, and slotted-metal glass guard.

D. Expansion Tanks: Welded carbon steel, rated for 125-psig working pressure and 375 deg F maximum operating temperature. Separate air charge from system water to maintain design expansion capacity by a flexible bladder securely sealed into tank. Include drain fitting and taps for pressure gage and air-charging fitting. Support vertical tanks with steel legs or base; support horizontal tanks with steel saddles. Factory fabricate and test tank with taps and supports installed and labeled according to the ASME Boiler and Pressure Vessel Code, Section VIII, Division 1.

E. Tangential-Type Air Separators: Welded black steel; ASME constructed and labeled for 125-psig minimum working pressure and 375 deg F maximum operating temperature; perforated stainless-steel air collector tube designed to direct released air into expansion tank; tangential inlet and outlet connections; threaded connections for NPS 2 and smaller; flanged connections for NPS 2-1/2 and larger; threaded blowdown connection. Provide units in sizes for full-system flow capacity.

F. In-Line Air Separators: One-piece cast iron with an integral weir designed to decelerate system flow to maximize air separation at a working pressure up to 175 psig and liquid temperature up to 300 deg F.

G. Air Purgers: Cast-iron body with internal baffles that slow the water velocity to separate the air from solution and divert it to the vent for quick removal. Maximum working pressure of 150 psig and temperature of 250 deg F.

H. Bypass Chemical Feeder: Welded steel construction; 125-psig working pressure; 5-gal. capacity; with fill funnel and inlet, outlet, and drain valves.
1. Chemicals: Specially formulated, based on analysis of makeup water, to prevent accumulation of scale and corrosion in piping and connected equipment.

I. Diverting Fittings: 125-psig working pressure; 250 deg F maximum operating temperature; cast-iron body with threaded ends, or wrought copper with soldered ends. Indicate flow direction on fitting.

J. Y-Pattern Strainers: 125-psig working pressure; cast-iron body (ASTM A 126, Class B), flanged ends for NPS 2-1/2 and larger, threaded connections for NPS 2 and smaller, bolted cover, perforated stainless-steel basket, and bottom drain connection.

K. Grooved Y-Pattern Strainer: 2 inch through 18 inch sizes, 300 PSI Y-Type Strainer shall consist of ductile iron body, ASTM A-536, Grade 65-45-12, Type 304 stainless steel perforated metal removable baskets with 1/16" (1,6mm) diameter perforations 2"-3" strainer sizes, 1/8" (3,2mm) diameter perforations 4"-12" strainer sizes, and 0.156” (4mm) diameter perforations 14” -18” strainer sizes. Strainer basket shall be accessed by removal of mechanical coupling.

L. Basket Strainers: 125-psig working pressure; high-tensile cast-iron body (ASTM A 126, Class B), flanged-end connections, bolted cover, perforated stainless-steel basket, and bottom drain connection.

M. T-Pattern Strainers: 750-psig working pressure; ductile-iron or malleable-iron body, grooved-end connections, stainless-steel basket with 57 percent free area; removable access coupling and end cap for strainer maintenance.

N. Grooved T-Pattern Strainer: 2” through 12” sizes, 300 PSI T-Type Strainer shall consist of ductile iron (ASTM A-536, Grade 65-45-12) body, Type 304 stainless steel frame and mesh removable basket with No. 12 mesh, 2"-3" strainer sizes, or No. 6 mesh, 4"-12" strainer sizes, 57% free open area. Strainer basket shall be accessed by removal of mechanical coupling.

O. Flexible Connectors: Stainless-steel bellows with woven, flexible, bronze, wire-reinforcing protective

jacket; 150-psig minimum working pressure and 250 deg F maximum operating temperature. Connectors shall have flanged- or threaded-end connections to match equipment connected and shall be capable of 3/4-inch misalignment.

P. Spherical, Rubber, Flexible Connectors: Fiber-reinforced rubber body with steel flanges drilled to align with Classes 150 and 300 steel flanges; operating temperatures up to 250 deg F and pressures up to 150 psig.

Q. Packed, Slip, Expansion Joints: 150-psig minimum working pressure, steel pipe fitting consisting of telescoping body and slip-pipe sections, packing ring, packing, limit rods, flanged ends, and chrome-plated finish on slip-pipe telescoping section.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS

A. Heating Water, NPS 2 and Smaller: Aboveground, use Type L drawn-temper copper tubing with soldered joints or Schedule 40 steel pipe with threaded joints. Belowground or within slabs, use Type K annealed-temper copper tubing with soldered joints. Use the fewest possible joints belowground and within floor slabs.

B. Heating Water, NPS 2-1/2 and Larger: Schedule 40 steel pipe with welded and flanged joints.

C. Cooling Water, All sizes: Schedule 40 steel pipe with welded and flanged joints.

D. Condensate Drain Lines: Type L drawn-temper copper tubing with soldered joints or Schedule 40, PVC pipe with solvent-welded joints.

3.2 VALVE APPLICATIONS

A. General-Duty Valve Applications: Unless otherwise indicated, use the following valve types:
1. Shutoff Duty: Gate, ball, and butterfly valves.
2. Throttling Duty: Globe, ball, and butterfly valves.

B. Install shutoff duty valves at each branch connection to supply mains, at supply connection to each piece of equipment, unless only one piece of equipment is connected in the branch line. Install throttling duty valves at each branch connection to return mains, at return connections to each piece of equipment, and elsewhere as indicated.

C. Install calibrated balancing valves in the return water line of each heating or cooling element and elsewhere as required to facilitate system balancing.

D. Install check valves at each pump discharge and elsewhere as required to control flow direction.

E. Install safety valves on hot-water generators and elsewhere as required by the ASME Boiler and Pressure Vessel Code. Install safety-valve discharge piping, without valves, to floor. Comply with the ASME Boiler and Pressure Vessel Code, Section VIII, Division 1, for installation requirements.

F. Install pressure-reducing valves on hot-water generators and elsewhere as required to regulate system pressure.

3.3 PIPING INSTALLATIONS

A. Refer to Division 23 Section "Basic Mechanical Materials and Methods" for basic piping installation requirements.

B. Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.

C. Install drains, consisting of a tee fitting, NPS 3/4 ball valve, and short NPS 3/4 threaded nipple with cap, at

low points in piping system mains and elsewhere as required for system drainage.

D. Install piping at a uniform grade of 0.2 percent upward in direction of flow.

E. Reduce pipe sizes using eccentric reducer fitting installed with level side up.

F. Unless otherwise indicated, install branch connections to mains using tee fittings in main pipe, with the takeoff coming out the bottom of the main pipe. For up-feed risers, install the takeoff coming out the top of the main pipe.

G. Install strainers on supply side of each control valve, pressure-reducing valve, solenoid valve, in-line pump, and elsewhere as indicated. Install NPS 3/4 nipple and ball valve in blowdown connection of strainers NPS 2 and larger. Match size of strainer blowoff connection for strainers smaller than NPS 2.

H. Anchor piping for proper direction of expansion and contraction.

3.4 HANGERS AND SUPPORTS

A. Hanger, support, and anchor devices are specified in Division 23 Section "Hangers and Supports." Comply with requirements below for maximum spacing of supports.

B. Install the following pipe attachments:
1. Adjustable steel clevis hangers for individual horizontal piping less than 20 feet long.
2. Adjustable roller hangers and spring hangers for individual horizontal piping 20 feet or longer. cal runs at roof, at each floor, and at 10-foot intervals between floors.

3.5 PIPE JOINT CONSTRUCTION

A. Refer to Division 23 Section "Basic Mechanical Materials and Methods" for joint construction requirements for soldered and brazed joints in copper tubing; threaded, welded, and flanged joints in steel piping; and solvent-welded joints for PVC and CPVC piping.

3.6 HYDRONIC SPECIALTIES INSTALLATION

A. Install manual air vents at high points in piping, at heat-transfer coils, and elsewhere as required for system air venting.

B. Install automatic air vents in mechanical equipment rooms only at high points of system piping, at heat-transfer coils, and elsewhere as required for system air venting.

C. Install dip-tube fittings in boiler outlet. Install piping to expansion tank with a 2 percent upward slope toward tank. Connect boiler-outlet piping.

D. Install in-line air separators in pump suction lines. Install piping to compression tank with a 2 percent upward slope toward tank. Install drain valve on units NPS 2 and larger.

E. Install combination air separator and strainer in pump suction lines. Install piping to compression tank with a 2 percent upward slope toward tank. Install blowdown piping with gate valve; extend to nearest drain.

F. Install bypass chemical feeders in each hydronic system where indicated, in upright position with top of funnel not more than 48 inches above floor. Install feeder in bypass line, off main, using globe valves on each side of feeder and in the main between bypass connections. Pipe drain, with ball valve, to nearest equipment drain.

G. Install expansion tanks above air separator. Install gage glass and cocks on end of tank. Install tank fitting in tank bottom and charge tank. Use manual vent for initial fill to establish proper water level in tank.
1. Support tank from floor or structure above with sufficient strength to carry weight of tank, piping connections, and fittings, plus weight of a full tank of water. Do not overload building components and structural members.

H. Install expansion tanks on floor. Vent and purge air from hydronic system, and ensure tank is properly charged with air to suit system design requirements.

3.7 TERMINAL EQUIPMENT CONNECTIONS

A. Size for supply and return piping connections shall be same as for equipment connections.

B. Install control valves in accessible locations close to connected equipment.

C. Install bypass piping with globe valve around control valve. If multiple, parallel control valves are installed, only one bypass is required.

D. Install ports for pressure and temperature gages at coil inlet connections.

3.8 CHEMICAL TREATMENT

A. Perform an analysis of supply water to determine the type and quantities of chemical treatment needed to keep system free of scale, corrosion, and fouling, and to sustain the following water characteristics:

B. Fill system and perform initial chemical treatment.

3.9 FIELD QUALITY CONTROL

A. Prepare hydronic piping according to ASME B31.9 and as follows:
1. Leave joints, including welds, uninsulated and exposed for examination during test.
2. Provide temporary restraints for expansion joints that cannot sustain reactions due to test pressure. If temporary restraints are impractical, isolate expansion joints from testing.
3. Flush system with clean water. Clean strainers.
4. Isolate equipment from piping. If a valve is used to isolate equipment, its closure shall be capable of sealing against test pressure without damage to valve. Install blinds in flanged joints to isolate equipment.
5. Install safety valve, set at a pressure no more than one-third higher than test pressure, to protect against damage by expanding liquid or other source of overpressure during test.
6. Grooved pipe ends shall be clean and free from indentations, projections and roll marks in the area from pipe end to groove for proper gasket sealing.
7. The grooved couplings gasket style and elastomeric material (grade) shall be verified as suitable for the intended service as specified.
8. Grooved couplings installation shall be complete when visual metal-to-metal contact is reached.

3.10 GROOVED PIPING TRAINING

A. A factory trained representative (direct employee) of the grooved coupling supplier shall provide on-site training for contractor’s field personnel in the use of grooving tools, application of groove, and product installation.

PART 4 - Testing

A. Perform the following tests on hydronic piping:
1. Use ambient temperature water as a testing medium unless there is risk of damage due to freezing. Another liquid that is safe for workers and compatible with piping may be used.
2. While filling system, use vents installed at high points of system to release trapped air. Use drains installed at low points for complete draining of liquid.
3. Check expansion tanks to determine that they are not air bound and that system is full of water.
4. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the design pressure. Test pressure shall not exceed maximum pressure for any vessel, pump, valve, or other component in system under test. Verify that stress due to pressure at bottom of vertical runs does not exceed either 90 percent of specified minimum yield strength or 1.7 times "SE" value in Appendix A of ASME B31.9, "Building Services Piping."

5. After hydrostatic test pressure has been applied for at least 10 minutes, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components and repeat hydrostatic test until there are no leaks.
6. Prepare written report of testing.

4.8 ADJUSTING

A. Mark calibrated nameplates of pump discharge valves after hydronic system balancing has been completed, to permanently indicate final balanced position.

B. Perform these adjustments before operating the system:
1. Open valves to fully open position. Close coil bypass valves.
2. Check pump for proper direction of rotation.
3. Set automatic fill valves for required system pressure.
4. Check air vents at high points of system and determine if all are installed and operating freely (automatic type), or bleed air completely (manual type).
5. Set temperature controls so all coils are calling for full flow.
6. Check operation of automatic bypass valves.
7. Check and set operating temperatures of boilers, chillers, and cooling towers to design requirements.
8. Lubricate motors and bearings.

4.9 CLEANING

A. Flush hydronic piping systems with clean water. Remove and clean or replace strainer screens. After cleaning and flushing hydronic piping systems, but before balancing, remove disposable fine-mesh strainers in pump suction diffusers.

END OF SECTION 23 2114

SECTION 23 2115 – HOT WATER HEATING & CHILLED WATER-COOLING SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings, General Provisions of Contract, including General and Supplementary Conditions and Section 23 0501 apply to this Section.

1.2 SUMMARY

A. Furnish and install system of supply and return piping, boiler water make-up lines, and boiler drain lines as described in Contract Documents.

PART 2 - NOT USED

PART 3 - EXECUTION

3.1 INSTALLATION

A. Ends of all pipe shall be reamed out before being made up into fittings.

B. Use graphite and oil applied to male threads only in making up all pipe joint fittings.

C. Install unions on downstream side of shut-off valves and specialty valves and meters. Also install unions on both ends of radiation piping where piping goes from floor level into steel pipe troughs in floor slab.

D. Use teflon tape for lubricating threads on all threaded connections.

3.2 PIPING GRADE

A. Heating supply and return lines are to be graded up 1 inch to 40 feet, in the direction of flow with the high and low points in every case being in the boiler room to permit drainage.

B. Provide an automatic air eliminator at the high of each circuit and on the heating coils.

C. If it is necessary to change the grade of a flow main due to an obstruction, the high point shall be vented with an automatic air vent.

D. All runouts shall be taken off the top of the main and at least three elbow joints used on the spring piece to provide for expansion and contraction.

3.3 CLEANING SYSTEM

A. Thoroughly clean all equipment, piping and all other material controlled under this contract free from rust, scale, and other dirt before any painting or covering is done or the system is put into operation.

B. The heating system shall be thoroughly cleaned by operating at 10 psi for at least 6 hours.
   1. At end of run, the boiler is to be filled to the top with water and any film of oil or grease is to be washed over the top.
   2. Drain the boiler completely and refill to proper level with fresh water.
   3. Repeat this process three (3) times.
   4. Use 1 pound tri-sodium phosphate for every 100 gallons of water during cleaning operation.

3.4 FIELD QUALITY CONTROL

A. Piping systems shall be subjected to the following tests and no piping shall be covered or concealed until it

has been so tested, inspected, and approved by the Architect and any local inspector having jurisdiction.

1. Heating piping shall be hydrostatically tested at 50 psi in excess of maximum working pressures, 100 psi minimum.
2. Without connecting equipment items rated below 100 psi, pressure test system at 100 psi for two hours. Correct leaks and defective work and repeat test until no leaks appear.
3. When so directed by Architect or Engineer, the Contractor shall conduct an operating test on any piece of equipment to demonstrate its capacity and/or operating characteristics.

END OF SECTION 23 2115

SECTION 23 2116 – HOT WATER HEATING SYSTEM & CHILLED WATER-COOLING SYSTEMS SPECIALTIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings, General Provisions of Contract, including General and Supplementary Conditions and Section 23 0501 apply to this Section.

1.2 SUMMARY

A. Furnish and install specialties as described in Contract Documents.

PART 2 - PRODUCTS

2.1 MANUAL AIR VALVES

A. On each coil or piece of equipment wherever an air pocket can form.

B. On each high point of piping or as shown on plans.

C. Approved Manufacturers:
1. Hoffman #500 or equal complete with #550 air chamber.

2.2 AUTOMATIC AIR ELIMINATORS

A. Furnish and install at the high point of each zone piping, or wherever an air pocket can form because of obstructions in the piping, a 3/4" float operated automatic air eliminator, Hoffman #79.

2.3 BALANCING FITTINGS

A. Automatic flow regulator kits complete with ball valve and strainer with capacity shown. Provide P/T test valves.
1. Approved Manufacturers:
a. Griswold
b. Auto flow

B. Manual balance valves with capacity shown. Provide with PT gage taps.
1. Approved Manufacturers:
a. Bell & Gossett circuit setters
b. Armstrong

2.4 COMPRESSION TANKS

A. Welded steel compression tanks of sizes shown, ASME Code for 30 lb. W.P., made of steel plate.

B. Provide a water column with water gauge and gauge cocks on ends of tanks.

C. Tanks to be furnished with three 3/4 inch I.P.S. female thread connections, one at either end and one in the middle.

D. Approved Manufacturers
1. B&G

2.5 AIR SEPARATORS

A. Furnish and install as shown on plans, air separator with tangential nozzles. The air separator shall be

fitted with an NPT vent connection to facilitate installation of piping to connect a compression tank.

B. An NPT tapping shall be provided on the bottom of the air separator to facilitate blowdown.

C. The air separator shall also be equipped with a steel system strainer with a free area of not less than four times the cross sectional area of the connecting piping.

D. Air separators shall be fabricated steel with flanged connections, designed and constricted for 165 psig @ 375F, and in accordance with Section VIII Division I of ASME Boiler & Pressure Vessel Code.

E. Approved Manufacturers
1. B&G Rollairtrol
2. Armstrong VAS

2.6 PRESSURE GAUGES

A. Cases shall be black enameled cast aluminum with back flange for surface or line mounting.

B. Gauges shall be of the repairable type with sturdy brass movements and phosphor bronze tubes.

C. Range shall be selected so that normal operating pressure shall be approximately at the center of the dial.

D. 3-1/2 inch figure bourdon tube type pressure gauge.

E. Install on inlet of each pressure gauge a No. 38, 1/4 inch consolidated brass "T" handle gauge cock.

F. Approved Manufacturers:
1. U. S. Gauge
2. Trerice

2.7 BOILER FITTINGS & COMPRESSION TANK FITTINGS

A. Boiler fittings as detailed on plans.
1. Approved Manufacturers:
a. Bell & Gossett Airtrol

B. Compression Tank Fittings:
1. Install according to detail and manufacturer's instructions.
2. Fitted for diameter tanks shown.
3. Tank fittings to be connected with 1 inch black pipes pitched up to tanks.
4. Compression tanks fitted with 3/4 inch drain piped to floor of boiler room to permit draining of tanks.
5. Approved Manufacturers:
a. Bell & Gossett ATFL Airtrol

2.8 SELF-FILLING VALVES

A. 3/4 inch reducing valves (self-filling)

B. Brass body and bronze interior

C. Install on water service to boiler.

D. Approved Manufacturers:
1. Bell & Gossett No. 12
2. Or equal

2.9 BOILER RELIEF VALVE

A. ASME Code relief valve.

B. Approved Manufacturers:
   1. Bell & Gossett
   2. Or Equal

2.10 THERMOMETERS AND ACCESSORIES

A. Red reading, mercury, separable socket, 7 inch cast, adjustable with 3 1/2 inch stem.

B. Range: Heating 30 degrees to 240 degrees F.

C. Provide other accessories as shown.

D. Approved Manufacturers:
   1. Weiss
   2. Trerice
   3. Palmer

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install pressure gauges on each side of each pump and elsewhere as shown on plans.

B. Install "T" handle gauge cock on the inlet of each pressure gauge.

END OF SECTION 23 2116

SECTION 23 2118 – BACKFLOW PREVENTER VALVE

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings, General Provisions of Contract, including General and Supplementary Conditions and Section 23 0501 apply to this Section.

1.2 SUMMARY

A. Furnish and install a backflow preventer valve as described in Contract Documents.

PART 2 - PRODUCTS

2.1 MANUFACTURED UNITS

A. Designed to provide separation of radiant hot water heating system water from domestic cold water supply in accordance with Code.
   1. Rated flow at 30 psi pressure drop rated for 175 psi inlet pressure and 140 deg. F maximum operating temperature.
   2. Brass body construction with 3/4 inch NPT connections.

B. Approved Manufacturers:
   1. Beeco 12
   2. Watts 900
   3. Equal by Febco
   4. Equal by Conbraco

PART 3 - EXECUTION

3.1 INSTALLATION

A. Furnish and install a drain cup and pipe the waste line to the nearest floor drain or floor sink.

END OF SECTION 23 2118

SECTION 23 2123 – CIRCULATING PUMPS AND ACCESSORIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings, General Provisions of Contract, including General and Supplementary Conditions and Section 22 0501 apply to this Section.

1.2 SUMMARY

A. Furnish and install circulating water pumps and accessories as described in the Contract Documents.

PART 2 - PRODUCTS

2.1 GRUNDFOS MAGNA3 (D) MATERIAL OF CONSTRUCTION:

1. Pump housing: Cast iron EN-GJL-250 / EN1561 or stainless steel EN 1.4308
2. Impeller: Composite PES-GF30
3. Neck ring: Stainless steel EN 1.4301
4. Secondary seals: EPDM
5. Thrust bearing Aluminium oxide/carbon
6. Stator housing: Aluminium
7. Rotor can: PPS
8. Shaft: Ceramics or Stainless steel EN 1.4404 (dependent on motor size)
9. Shaft Stainless steel (terminal-connected versions) EN 1.4404

2.2 PUMP SUCTION DIFFUSERS:

A. Match system pipe size and pump inlet size shall be furnished and installed where shown on drawings.

B. Angle type body with inlet vanes and combination diffuser-strainer-orifice cylinder.

C. Approved Manufacturers:
1. Bell & Gossett
2. Armstrong
3. Or approved equal

2.3 TRIPLE DUTY VALVES

A. Place on each pump discharge. Valve serves as a non-slam check valve with spring loaded disk check, calibrated adjustable and lockable balance valve and full shutoff valve with memory stop. Valve shall be back-seated so as to allow repacking under full line pressure.

B. Cast iron body

C. Bronze disk and seat with stainless steel stems and springs.

D. Teflon packing

E. Maximum valve working pressure of 175 psig and a maximum operating temperature of 300 deg. F.

F. Approved Manufacturers:
1. Bell & Gossett
2. Armstrong

2.4 EXPANSION JOINT PUMP CONNECTORS

A. Precision machine molded neoprene and nylon construction internal reinforced by means of steel wire.

B. Cadmium steel floating flanges tapped to mate with 150# ASA companion flanges.

C. Capable of operating at a temperature of 20 deg. F. thru 220 deg. F. and at a pressure ranging from 10" HG vacuum thru 150 psi working pressure.

D. Capable of 15 deg. angular deflection.

E. Twin quiet-sphere design with control rods.

F. Approved Manufacturers:
1. Vibration Mountings & Controls, Inc.
2. Metraflex

2.5 IN-LINE CIRCULATORS

A. Bronze fitted with ceramic seal, spring coupling, and 1750-rpm, drip-proof motor with overload protection.

B. Substantially supported in piping with a full size leg to floor.

C. Approved Manufacturers:
1. Bell & Gossett
2. Armstrong
3. Grundfos

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install equipment in accordance with manufacturers instructions.

B. Align pump and motor shafts in accordance with manufacturers requirements before starting equipment. Provide report in the M&O manual regarding pump alignment.

C. Remove start-up filter screen on suction diffuser after system has been cleaned and flushed. Leave main filter screen in place.

END OF SECTION 23 2123

SECTION 23 2125 - CLEANING AND FLUSHING WATER CIRCULATING SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings, General Provisions of Contract, including General and Supplementary Conditions and Section 23 0501 apply to this Section.

1.2 SUMMARY

A. Furnish labor and materials to thoroughly clean water circulating systems as described in Contract Documents.

B. Mechanical contractor shall procure the services of an independent treatment contractor as described in this specification.

1.3 QUALITY ASSURANCE

A. System Additives: This Contractor shall not add any water treatment chemicals or "stop-leak" compounds to the system.

PART 2 - NOT USED

PART 3 - EXECUTION

3.1 FIELD QUALITY ASSURANCE

A. Water circulating systems for project shall be thoroughly cleaned before placing in operation to rid system of dirt, piping compound, mill scale, oil, and other materials foreign to water being circulated.

B. During construction extreme care shall be exercised to prevent dirt and other foreign matter from entering pipe or other parts of system. Pipe stored on project shall have open ends capped and equipment shall have openings fully protected. Before erection, each piece of pipe, fittings, or valve shall be visually examined and dirt removed.

C. Hydronic Closed Loop Cleaning
1. Prior to any introduction of fluids to the closed loop system the Mechanical Contractor shall close isolation valves at each heat pump and open the bypass valve to prevent flow through the strainer, flow control device and heat pump during the initial flushing and subsequent cleaning. The side stream filter bag shall be removed during the initial flushing process.
2. The Mechanical Contractor shall fill each hydronic system with clean fresh water prior to cleaning and thoroughly leak check system piping. A cleaning and passivating agent supplied by the Chemical Treatment Contractor shall be added to the system at the direction of the Treatment Contractor during the leak check process to minimize initial corrosion. If the system is filled multiple times during the leak check and repair process the Mechanical Contractor shall coordinate with the Treatment Contractor to maintain this initial protection. The Treatment Contractor is responsible for providing chemical for up to two refills of the system. If additional chemical is required due to multiple refillings the Mechanical Contractor shall be responsible for the additional time and chemical.
3. Following leak check the closed system shall be flushed by the Mechanical Contractor until the leaving water runs clear. All primary runs shall be flushed at their ends to obtain maximum sweep of debris from the system. The inlet screens on the circulating pumps must be kept clear during this initial cleaning process and inspected following cleaning. When flushing is complete the system is to be left full.
4. Prior to flushing the Mechanical Contractor shall coordinate with Treatment Contractor so that the Treatment Contractor can be available immediately following flush and final refill to add cleaning chemical within 4 hours to prevent initial corrosion.

5. Following initial flushing the Chemical Treatment Contractor shall refill all systems with cleaning and passivating agents raising the PH to a minimum of 10, circulate and flush until thoroughly clean. All primary piping runs shall be flushed at the ends during this cleaning process. When boiler operation is available the loop temperature should be raised to 110 to 120° to accelerate cleaning. Cleaning with availability of boiler operation should be anticipated to last 7 to 10 days or longer depending on initial loop conditions. If boiler operation is unavailable loop cleaning duration should be expected to double. The Chemical Treatment Contractor shall verify and adjust cleaning chemistry, and inspect side stream filter bags at a minimum of every two days, exception for weekends. Filter bags shall be changed as required during this cleaning process. Cleaning shall continue until these bags no longer show signs of debris.
6. Following cleaning process the Treatment Contractor shall close the bypass valves at each heat pump and open isolation valves for normal operation and check for leaks of local piping connections. Any leaks found shall be referred to the Mechanical Contractor for repair. The bypass valve handle shall be removed and tied to the valve. The system shall then be charged with final operating chemical to control long term corrosion and a clean bag filter shall be installed in the system.
7. The Treatment Contractor shall provide final inspection report for inclusion in the Operation and Maintenance Manual. Additionally the Treatment Contractor shall take loop samples approximately 12 months following completion, add or adjust chemical as required and provide a post construction report to the owner prior to warranty closeout. Chemical required is the responsibility of the Treatment Contractor.

END OF SECTION 23 2125

SECTION 23 2166 - SPLIT SYSTEM HEAT PUMP UNITS

PART 1 - GENERAL

1.1 SUMMARY

A. Includes But Not Limited To
   1. Furnish and install heat pumps as described in Contract Documents.

B. Related Sections
   1. Section 02776 - Concrete pads
   2. Section 23 0501 - Common HVAC Requirements

1.2 SUBMITTALS

A. Quality Assurance / Control - Equipment check-out sheets

1.3 QUALITY ASSURANCE

A. Requirements of Regulatory Agencies - Each unit shall be UL or ETL labeled.

1.4 WARRANTY

A. Provide five year warranty on compressors beginning from date of start-up. Record start-up date on warranty certificate for each unit.

PART 2 - PRODUCTS

2.1 MANUFACTURED UNITS

A. Heat Pumps
   1. Indoor Units -
      a. Compact wall mounted units.
      b. Supplementary electric heater, size as scheduled.
      c. Cabinet finish as selected by Architect.
      d. Isolate moving parts from cabinets to reduce noise.
   2. Outdoor Units -
      a. Compressor shall be of rotary or scroll design.
      b. Fans shall be direct driven and discharge horizontally.
      c. Casing shall be fully weatherproof for outdoor installations.
      d. Microprocessor Controls shall be factory wired with field installed remote pendant station.
      e. Refrigerant shall be R-410A.
      f. Isolate moving parts from cabinets to reduce noise.
      g. Use dry-charged tubing for connection of unit's refrigerant system.
   3. Approved Products -
      a. Carrier Corp, Syracuse, NY (800) 227-7437 or (315) 432-6000 www.carrier-commercial.com
      b. Friedrich Air Conditioning Co, Austin, TX (800) 541-6645 or (210) 225-2000 www.friedrich.com
      c. Mitsubishi Electronics America Inc, HVAC Div, Norcross, GA (800) 421-1140 or (770) 448-1268
      d. Sanyo Air Conditioning Products, Chatsworth, CA (818) 998-7322 www.sanyo.com
      e. L.G. Electronics, USA, Englewood Cliffs, NJ (201) 585-0018, www.lghvac.com

PART 3 - EXECUTION

3.1 FIELD QUALITY CONTROL

A. Manufacturer's Field Service - Units shall be started up, checked out, and adjusted by Unit Manufacturer's authorized factory trained service mechanic. Use equipment check-out sheet provided by Manufacturer. Complete and sign all items on sheet.

END OF SECTION 23 2166

SECTION 23 2185 - CONDENSATE RETURN PUMP

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings, General Provisions of Contract, including General and Supplementary Conditions and other Division 1 Specification Sections, and Section 15055 apply to this Section.

1.2 SUMMARY

A. Furnish and install a condensate return pump as described in Contract Documents.

PART 2 - PRODUCTS

2.1 MANUFACTURED UNITS

A. Simplex packaged unit with duplex heavy cast iron receiver with supports and two pumps all piped on one base.

B. Each pump shall have a capacity as shown and shall be operated from float switches, magnetic starter, and alternator provided with the pump and mounted on pump assembly.

C. Approved Manufacturers:
1. Federal
2. Roth
3. Pacific

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install check valve and gate valve on pump discharge.

B. Run vent line from receivers and terminate as high as possible with return bends.

END OF SECTION 23 2185

SECTION 23 2300 - REFRIGERANT PIPING SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings, General Provisions of Contract, including General and Supplementary Conditions and Section 23 0501 apply to this Section.

1.2 SUMMARY

A. Furnish and install piping for refrigeration systems as described in Contract Documents.

1.3 QUALITY ASSURANCE

A. Qualifications:
   1. Refrigerant piping shall be installed by a refrigeration contractor licensed by State.

PART 2 - PRODUCTS

2.1 REFRIGERANT PIPING

A. Meet requirements of ASTM B 280-88, "Specification for Seamless Copper Tube for Air Conditioning & Refrigeration Field Service", hard drawn straight lengths.

B. Do not use pre-charged refrigerant lines.

2.2 REFRIGERANT FITTINGS

A. Wrought copper with long radius elbows.

B. Approved Manufacturers:
   1. Mueller Streamline
   2. Nibco Inc
   3. Grinnell
   4. Elkhart Products Corp

2.3 CONNECTION MATERIAL

A. Brazing Rods:
   1. Copper to Copper Connections:
   2. AWS Classification BCuP-4 Copper Phosphorus (6% silver).
   3. AWS Classification BCuP-5 Copper Phosphorus (15% silver).
   4. Copper to Brass or Copper to Steel Connections:
   5. AWS Classification BAg-5 Silver (45% silver).
   6. Do not use rods containing Cadmium.

2.4 FLUX

A. Approved Manufacturers:
   1. "Stay-Silv white brazing flux" by J W Harris Co
   2. High quality silver solder flux by Handy & Harmon

PART 3 - EXECUTION

3.1 INSTALLATION

A. Do not install refrigerant piping underground or in tunnels.

B. Slope suction lines down toward compressor one inch/10 feet. Locate traps at vertical rises against flow in suction lines.

C. Refrigeration system connections shall be copper-to-copper, copper-to-brass, or copper-to-steel type properly cleaned and brazed with specified rods. Use flux only where necessary.
   1. No soft solder (tin, lead, antimony) connections will be allowed in system.

D. Braze valve, sight glass, and flexible connections.

E. Circulate dry nitrogen through tubes being brazed to eliminate formation of copper oxide during brazing operation.

3.2 FIELD QUALITY CONTROL

A. Make evacuation and leak tests in presence of Architect's Engineer after completing refrigeration piping systems. Positive pressure test will not suffice for procedure outlined below.
   1. Draw vacuum on each entire system with vacuum pump to 200 microns using vacuum gauge calibrated in microns. Do not use cooling compressor to evacuate system nor operate it while system is under high vacuum. Isolate compressor from system piping using shut-off valves prior to pulling vacuum.
   2. Break vacuum with freon to be used and re-establish vacuum test. Vacuum shall hold for 24 hours at 200 microns without compressor running.
   3. Conduct tests at 70 deg F ambient temperature minimum.
   4. Do not run systems until above tests have been made and systems started up as specified. Inform Owner's Representative of status of systems at time of final inspection and schedule start-up and testing if prevented by outdoor conditions before this time.
   5. After testing, fully charge system with refrigerant and conduct test with Halide Leak Detector.

END OF SECTION 23 2300

SECTION 23 2310 - REFRIGERANT SPECIALTIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings, General Provisions of Contract, including General and Supplementary Conditions and Section 23 0501 apply to this Section.

1.2 SUMMARY

A. Furnish and install refrigeration specialties as described in Contract Documents except for expansion valves on 2 through 5 ton condensing units.

PART 2 - PRODUCTS

2.1 EXPANSION VALVES

A. For pressure type distributors, externally equalized with stainless steel diaphragm, and same refrigerant in thermostatic elements as in system.

B. Size valves to provide full rated capacity of cooling coil served. Coordinate selection with evaporator coil and condensing unit.

C. Approved Manufacturers:
1. Alco
2. Henry
3. Mueller
4. Parker
5. Singer
6. Sporlan

2.2 FILTER-DRIER

A. On lines 3/4 inch outside diameter and larger, filter-drier shall be replaceable core type with Schraeder type valve.

B. On lines smaller than 3/4 inch outside diameter, filter-drier shall be sealed type using flared copper fittings.

C. Size shall be full line size.

D. Approved Manufacturers:
1. Alco
2. Mueller
3. Parker
4. Sporlan
5. Virginia

2.3 SIGHT GLASS

A. Combination moisture and liquid indicator with protection cap.

B. Sight glass shall be full line size.

C. Sight glass connections shall be solid copper or brass, no copper-coated steel sight glasses allowed.

D. Approved Manufacturers:
1. Alco

2. Mueller
3. Parker
4. Superior
5. Virginia

2.4 MANUAL REFRIGERANT SHUT-OFF VALVE

A. Ball valves designed for refrigeration service and full line size.

B. Valve shall have cap seals.

C. Valves with hand wheels are not acceptable.

D. Provide service valve on each liquid and suction line at compressor.

E. If service valves come as integral part of condensing unit, additional service valves shall not be required.

F. Approved Manufacturers:
1. ConBraCo (Apollo)
2. Henry
3. Mueller
4. Superior
5. Virginia

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install valves and specialties in accessible locations. Install refrigeration distributors and suction outlet at same end of coil.

END OF SECTION 23 2310

SECTION 23 2500 – CHEMICAL WATER TREATMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings, General Provisions of Contract, including General and Supplementary Conditions and Section 23 0501 apply to this Section.

1.2 SUMMARY

A. Procure services of Water Treatment Service Organization which will:
   1. Furnish and install required chemical feeding equipment and perform other related services as described in Contract Documents.
   2. Perform initial cleaning and flushing procedures.
   3. Provide chemicals required for cleaning and flushing systems.

B. Related Work Specified Elsewhere:
   1. Owner will supply operating chemicals after start-up chemicals have been exhausted.

1.3 SUBMITTALS

A. Quality Control:
   1. Submit written recommended treatment procedures, chemicals, chemical feeding equipment, and basic water analyses test equipment, based on its experience and chemical analysis of representative sample of water supply.

1.4 MAINTENANCE

A. Test Equipment:
   1. Provide water analysis test kit and adequate supply of reagents suitable to control treatment chemical dosage requirements.

PART 2 - PRODUCTS

2.1 HOT WATER SYSTEMS

A. Two Gallon bypass feeder complete, including piping, valves, and accessories.
   1. Provide adequate supply of Dearborn Aqua-Serv B-547 liquid borate-nitrite based corrosion inhibitor.

B. Approved Manufacturers:
   1. M. A. Fleckenstein
   2. Neptune
   3. Wingert

PART 3 - EXECUTION

3.1 INSTALLATION

A. Provide initial start up and adjustment of all chemical systems.

B. Provide instruction to owner in the use and operation of the test kit.

C. Provide (2) two additional trips to the site during the warrantee period to check and adjust the chemical treatment system.

END OF SECTION 23 2500

SECTION 23 2510 – GLYCOL SYSTEM

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings, General Provisions of Contract, including General and Supplementary Conditions and Section 23 0501 apply to this Section.

1.2 SUMMARY

A. Furnish and install glycol system as described in Contract Documents.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Chilled Water Cooling shall be a 50% glycol and water system. Furnish and install a manual glycol pump and fill system and fill the chiller, coils and piping system with the solution.

B. Coils, pumps, and piping have been sized to handle the 50% solution.

C. Glycol shall be of a permanent type with rust inhibitors and shall have an identifying odor and color.
   1. Approved Manufacturer:
      a. Dowtherm Type SR-1.

PART 3 - EXECUTION

3.1 Provide warning stickers on equipment and piping indicating the solution in system.

END OF SECTION 23 2510

SECTION 23 2600- CONDENSATE DRAIN PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Includes But Not Limited To:
   1. Furnish and install condensate drain piping as described in Contract Documents.

B. Related Requirements:
   1. Section 23 0501: Common HVAC Requirements.

1.2 REFERENCES

A. Reference Standards:
   1. ASTM International:
      a. ASTM B 88-03, 'Standard Specification for Seamless Copper Water Tube.'

PART 2 - PRODUCTS

2.1 SYSTEMS

A. Materials:
   1. Condensate Drains:
      a. Schedule 40 PVC for condensate drains from furnace combustion chambers and furnace cooling coils, and auxiliary drain pans.

B. Manufactured Units
   1. Condensate Pump
      a. Rated at 225 gph at 15 feet total head. Complete with one gallon polystyrene tank with pump and automatic float control. 1**/**5 hp, 120 V, one phase, 60 Hertz.
      b. Condensate piping shall be Type M copper or Schedule 40 PVC.
      c. Approved Manufacturers -
         1) No. CU551UL by Beckett Pumps, (888) 232-5388
         2) No. VCL45S by Little Giant Pump Co, Oklahoma City, OK (405) 947-2511

PART 3 - EXECUTION

3.1 INSTALLATION

A. Condensate Drains:
   1. Support piping and protect from damage.
   2. Do not combine PVC condensate drain piping from furnace combustion chamber with copper condensate drain piping from cooling coil.
   3. Do not combine auxiliary drain pan piping with furnace / Cooling Coil Condensate drain piping.

END OF SECTION 23 2600

SECTION 23 3114 - LOW-PRESSURE STEEL DUCTWORK

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings, General Provisions of Contract, including General and Supplementary Conditions and Section 23 0501 apply to this Section.

1.2 SUMMARY

A. Furnish and install above-grade ductwork and related items as described in Contract Documents.

PART 2 - PRODUCTS

2.1 DUCTS

A. Fabricate of zinc-coated lockforming quality steel sheets meeting requirements of ASTM 653A/653M, "Specification for Sheet Steel Zinc-Coated (Galvanized) by the Hot-Dip Process, Lock Forming Quality", with G 60 coating.

B. Use of aluminum, non-metallic, or round ducts is not permitted. [Specification writer: Use of aluminum ducts in areas with high chlorine content (eg.: ventilation for pools, spas, etc.) should be considered on a per job basis.]

2.2 DUCT JOINTS

A. Ducts with sides up to and including 36 inches shall be as detailed in the SMACNA manual.

B. Duct sizes over 36 inches shall be fabricated using SMACNA T-24 flange joints or pre-fabricated systems as follows:
   1. Ducts with sides over 36 inches to 48 inches:
      a. transverse duct joint system by Ductmate*/*25, Nexus, Ward, or WDCI (Lite) (SMACNA "E" or "G" Type connection).
   2. Ducts 48 inches & larger:
      a. Ductmate*/*35, Nexus, or WDCI (Heavy) (SMACNA "J" Type connection).
   3. Approved Manufacturers:
      a. Ductmate Industries Inc, 10760 Bay Meadows Drive, Sandy, UT 84092 (801) 571-5308
      b. Nexus, Exanno Corp, P O Box 729, Buffalo, NY 14206 (716) 849-0545
      c. Ward Industries Inc, 1661 Lebanon Church Road, Pittsburg, PA 15236 (800) 466-9374
      d. WDCI, P O Box 10868, Pittsburg, PA 15236 (800) 245-3188

2.3 ACCESS DOORS IN DUCTS

A. At each manual outside air damper and at each motorized damper, install factory built insulated access door with hinges and sash locks. Locate doors within 6 inches of installed dampers. Construction shall be galvanized sheet metal, 24 ga minimum.

B. Fire and smoke damper access doors shall have a minimum clear opening of 12" x 12" or as specified on Drawings to easily service fire or smoke damper. Doors shall be within 6 inches of fire and smoke dampers and in Mechanical Room if possible.

C. Identify each door with 1/2" high letters reading “smoke damper” or “fire damper”.

D. Approved Manufacturers:
   1. AirBalance - Fire*/*Seal #FSA 100
   2. Air Control Products - HAD-10
   3. Cesco-Advanced Air - HAD-10

4. Elgen - Model 85 A
5. Kees Inc - ADH-D.
6. Louvers & Dampers - #SMD-G-F
7. Nailor-Hart Industries Inc - Series 0831
8. National Controlled Air Inc - Model AD-FL-1

2.4 FLEXIBLE EQUIPMENT CONNECTIONS

A. 30 oz closely woven UL approved glass fabric, double coated with neoprene.

B. Fire retardant, waterproof, air-tight, resistant to acids and grease, and withstand constant temperatures of 250 deg F.

C. Approved Manufacturers:
1. Cain - N-100
2. Duro Dyne - MFN
3. Elgen - ZLN
4. Ventfabrics - Ventglas

2.5 CONCEALED CEILING DAMPER REGULATORS

A. Approved Manufacturers:
1. Cain
2. Duro Dyne
3. Metco Inc
4. Vent-Lock - #666
5. Young - #303

2.6 VOLUME DAMPERS

A. In Main Ducts:
1. 16 gauge galvanized steel, opposed blade type with 3/8 inch pins and end bearings. Blades shall have 1/8 inch clearance all around.
2. Damper shall operate within acoustical duct liner.
3. Provide channel spacer equal to thickness of duct liner.
4. Approved Manufacturers:
   a. Air Balance - Model AC-2
   b. Air Control Products - CD-OB
   c. American Warming - VC-2-AA
   d. Greenheck - VCD-1100
   e. NCA, Safe Air
   f. Vent Products - 5100

B. In Sheet Metal Branch Ducts:
1. Extruded aluminum, opposed blade type. When in open position, shall not extend beyond damper frame.
2. Maximum blade length 12 inches.
3. Damper Regulator shall be concealed type with operation from bottom or with 90 deg miter gear assembly from side.
4. Approved Manufacturers:
   a. Air Control Products - TCD-OB
   b. Air Guide - OB
   c. Arrow - OBDAF-207
   d. CESCO - CDA
   e. Reliable Metals - OBD-RO
   f. Tuttle & Bailey - A7RDDM
   g. Safe Air
   h. Young - 820-AC

C. Dampers above removable ceiling and in Mechanical Rooms shall have locking quadrant on bottom or side of duct. Otherwise, provide concealed ceiling damper regulator and cover plate.

2.7 MOTORIZED OUTSIDE AIR DAMPERS

A. Damper Blades:
   1. 18 gauge galvanized steel or equivalent aluminum with replaceable rubber blade edges, 9 inches wide maximum.
   2. End seals shall be flexible metal compression type.
   3. Opposed blade type.

B. Make provision for damper actuators and actuator linkages to be mounted external of air flow.

C. Approved Manufacturers & Models:
   1. Air Balance - AC-2
   2. American Warming - VC-2-AAVA
   3. Arrow - OBDAF-207
   4. Greenheck - VCD-2100
   5. Honeywell - D641
   6. Johnson - D1300
   7. Louvers & Dampers - TSD400
   8. Ruskin - CD36 or CD60
   9. Safe Air - 610
   10. Vent Products - 5800

2.8 BACKDRAFT DAMPER

A. Backdraft blades shall be nonmetallic and shall be neoprene coated fiberglass.

B. Stop shall be galvanized steel screen or expanded metal, 1/2 inch mesh.

C. Frame shall be galvanized steel or extruded aluminum alloy.

D. Approved Models & Manufacturers:
   1. Air Control Products - FBD
   2. American Warming - BD-15
   3. CESCO - FBD 101
   4. Ruskin - NMS2
   5. Safe Air

2.9 DUCT HANGERS

A. 1" x 18 gauge galvanized steel straps or steel rods as shown on Drawings, and spaced not more than 8 feet apart. Do not use wire hangers.

B. Attaching screws at trusses shall be 1-1/2 inch No. 10 round head wood screws. Nails not allowed.

2.10 DUCT SEALER

A. Cain - Duct Butter or Butter Tak

B. Design Polymerics - DP 1010

C. DSC - Stretch Coat

D. Duro Dyne - S2

E. Hardcast - #601 Iron-Grip or Peel-N-Seal Tape
   1. Kingco - 15-325
   2. Mon-Eco - 44-41
   3. Trans-Continental Equipment Co - Multipurpose Duct Sealant
   4. United - Sheet Metal duct-sealer

PART 3 - EXECUTION

3.1 INSTALLATION

A. Ducts:
1. Straight and smooth on inside with joints neatly finished unless otherwise directed.
2. Duct panels through 48 inch dimension having acoustic duct liner need not be crossbroken or beaded.
3. Crossbreak unlined ducts and duct panels larger than 48 inch or bead 12 inches on center.
4. Securely anchor ducts to building structure with specified duct hangers attached with screws. Do not hang more than one duct from a duct hanger.
5. Brace and install ducts so they shall be free of vibration under all conditions of operation.
6. Ducts shall not bear on top of structural members.
7. Make duct take-offs to branches, registers, grilles, and diffusers as detailed on Drawings.
8. Ducts shall be large enough to accommodate inside acoustic duct liner. Dimensions shown on Drawings are net clear inside dimensions after duct liner has been installed.
9. Properly flash where ducts protrude above roof.
10. Install internal ends of slip joints in direction of flow. Make joints air tight using specified duct sealer.
11. Cover horizontal and longitudinal joints on exterior ducts with two layers of Hardcast tape installed with Hardcast HC-20 adhesive according to Manufacturer's recommendations.
12. Paint ductwork visible through registers, grilles, and diffusers flat black.

B. Install flexible inlet and outlet duct connections to each furnace, fan, fan coil unit, and air handling unit.

C. Install concealed ceiling damper regulators.
1. Paint cover plates to match ceiling tile.
2. Damper regulators will not be required for dampers located directly above removable ceilings or in Mechanical Rooms.

D. Provide each take-off with an adjustable volume damper to balance that branch.
1. Anchor dampers securely to duct.
2. Install dampers in main ducts within insulation.
3. Dampers in branch ducts shall fit against sheet metal walls, bottom and top of duct, and be securely fastened. Cut duct liner to allow damper to fit against sheet metal.
4. Where concealed ceiling damper regulators are installed, provide a cover plate.

E. Install grilles, registers, and diffusers. Level floor registers and anchor securely into floor.

F. Air Turns:
1. Permanently installed, consisting of single thickness curved metal blades with one inch straight trailing edge to permit air to make abrupt turn without appreciable turbulence, in 90 degree elbows of above ground supply and return ductwork.
2. 4-1/2 inch wide minimum vane rail. Do not use junior vane rails.
3. Double thickness vanes not acceptable.
4. Quiet and free from vibration when system is in operation. See SMACNA Manual

G. Dirty Filter Manometer or Magnehelic Gauge:
1. Install on each air-handling unit housing adjacent to filters.
2. Provide pressure sensing tips with connecting tubing on each side of filter.
3. Provide required oil for manometer.

H. Install motorized dampers

END OF SECTION 23 3114

SECTION 23 3346 - FLEX DUCT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings, General Provisions of Contract, including General and Supplementary Conditions and Section 23 0501 apply to this Section.

1.2 SUMMARY

A. Furnish and install supply air branch duct runouts to diffusers as described in Contract Documents.

PART 2 - PRODUCTS

2.1 DUCTS

A. Formable, flexible, circular duct which shall retain its cross-section, shape, rigidity, and shall not restrict air flow after bending.

B. Nominal 1-1/2 inches thick, 3/4 lb/cu ft density fiberglass insulation with air-tight, polyehtylene or polyester core, sheathed in seamless vapor barrier jacket factory installed over flexible assembly.

C. Assembly, including insulation and vapor barrier, shall meet Class I requirement of NFPA 90A and be UL 181 rated, with flame spread of 25 or less and smoke developed rating of 50 or under.

D. Length of flexible ductwork shall not exceed 8'-0".

2.2 APPROVED MANUFACTURERS

A. ANCO-FLEX - 4625

B. Flex-Aire - PF/UPC #090

C. Hart & Cooley - F114

D. Thermaflex - G-KM

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install duct in fully extended condition free of sags and kinks.

B. Make duct connections by coating exterior of duct collar for 3 inches with duct sealer and securing duct in place over sheet metal collar with 1/2 inch wide metal cinch bands and sheet metal screws.

END OF SECTION 23 3346

SECTION 23 3400 - EXHAUST FANS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings, General Provisions of Contract, including General and Supplementary Conditions and Section 23 0501 apply to this Section.

1.2 SUMMARY

A. Furnish and install exhaust fans as described in Contract Documents.

1.3 QUALITY ASSURANCES

A. Requirements of Regulatory Agencies:
   1. Bear AMCA seal and UL label.

PART 2 - PRODUCTS

2.1 CEILING MOUNTED EXHAUST FANS

A. Acoustically insulated housings.

B. Sound level rating of 4.6 sones maximum for fan RPM and CFM listed on Drawings.

C. Include chatterproof integral back-draft damper with no metal to metal contact.

D. True centrifugal wheels.

E. Entire fan, motor, and wheel assembly shall be easily removable without disturbing housing.

F. Suitably ground motors and mount on rubber-in shear vibration isolators.

G. Provide wall or roof cap, as required.

H. Approved Manufacturers:
   1. Cook-Gemini
   2. Greenheck Sp
   3. Pace
   4. Penn Zephyr
   5. Twin City

2.2 ROOF MOUNTED EXHAUST FANS

A. Direct drive or have adjustable pitch V-belt as noted on Drawings.

B. Wheels shall be backward curved and housing shall be removable or hinged aluminum.

C. Isolate motor with vibration dampeners.

D. Provide quiet type back-draft dampers.

E. Insulated, pre-fabricated metal roof curb shall be for flat or sloped roof as shown on Drawings.

F. Approved Manufacturers:
   1. Fans:

a. Penn
b. Centri-Master
c. Cook
d. Greenheck G, GB
e. Twin City

2. Standard curbs:
a. Penn
b. Cook
c. Greenheck

3. Sound attenuating curbs:
a. Penn
b. Greenheck

2.3 CENTRIFUGAL IN-LINE FANS

A. Non-overloading design and of arrangement indicated.

B. Constructed of low carbon steel and painted with an approved rust resistant coating or all aluminum as shown.

C. Fan performance shall be based on tests conducted in accordance with the AMCA Standard test code of air moving devices and shall be licensed to bear the AMCA Certified Air and Sound Rating Seal. Fans shall have a sharply rising pressure characteristic extending through the operating range and continuing to rise well beyond the efficiency peak to assure quiet and stable operation under all conditions. Horsepower characteristics shall be truly self-limiting and shall reach a peak in the normal selection area.

D. Wheel diameters shall be in accordance with the standard sizes adopted by AMCA for centrifugal in-line type fans. Inlets shall be fully streamlined and housings shall be suitably braced to prevent vibration or pulsation. Housings shall be arc welded steel throughout.

E. Fan wheel shall include die formed AIRFOIL blades designed for maximum efficiency and quiet operation. Blades shall be continuously welded to back plate and welded to wheel cone. Class 2 fan with inlet and outlet bell fittings.

F. Wheels shall be statically and dynamically balanced and assembled fan shall be tested for balance at specified speed at the factory prior to shipment. Such tests shall be performed with an IRD analyzer to measure radial and axial displacements.

G. Bearings are to be ball or roller anti-friction type, and shall be equipped with extended lubrication lines to grease fittings outside of the fan housing. Shafts shall operate at no more than 70% of first critical speed to assure smooth operation.

H. Accessories for in-line fans to include belt guard, inlet and outlet flanges, and other accessories as called for in the plans.

I. All fans shall be equipped with an adjustable motor base integral with the fan housing. This motor base shall be completely welded and consist of frame and reinforcing side sheets to assure maximum strength and rigidity.

J. Submittals for approval of equipment shall include copies of outline drawings, AMCA Certified Sound Ratings, and percentage pressure-volume performance curves showing point of operation.

K. Approved Manufacturers:
1. Barry
2. Cook
3. Penn

PART 3 - EXECUTION

3.1 INSTALLATION

A. Anchor fan units securely to structure or curb.

END OF SECTION 23 3400

SECTION 23 3515 - WOOD SHOP EXHAUST COLLECTOR

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Dust Collector
2. Dust Collector Fan
3. Dust Collection Spark Detection/Suppression
4. Deflagration
5. Dust Collector Accessories

1.2 SUBMITTALS

A. Product Data: For each dust collection unit and respective accessory indicated.

1. Unit dimensions (include unit base anchor bolt pattern) and weight.
2. Cabinet material, metal thickness, finishes, and accessories.
3. Fans:
   a. Certified fan-performance curves, at project specific site altitude, with system operating conditions indicated.
   b. Certified fan-sound power ratings
   c. Fan construction and accessories
   d. Motor ratings, electrical characteristics, and motor accessories
4. Filters with performance characteristics.
5. Electrical wiring diagrams.

B. Operation and maintenance data.

C. Duct system and spark detection and extinguishing system design and shop drawings

1. Provide deflagration isolation on the clean and dirty air side of the collector. Secondary safety monitoring filters, spark detection and duct mounted suppression system design and layout in the project shop drawings. Show all required piping connections, electrical connections, ductwork, wiring, etc. Locate spark detectors and suppression heads for proper operation.

1.3 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. NFPA Compliance: Comply with NFPA 654 and NFPA 664 for design, fabrication, and installation of dust collection systems in wood working facilities. Comply with NFPA 69. Standard on Explosion Protection Systems and NFPA 68 Standard on Explosion Protection by Deflagration Venting.

C. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1-2004, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

D. Comply with NFPA 70 and NFPA 496.

1.4 WARRANTY

A. 12-year for the collector unit.

B. Manufacture’s standard warranty for the Explosion Isolation Valve.

1.5 PREFABRICATED ELEMENTS

A. The characteristics described in the technical binders are those that are defined during tests made by the manufacturer, or in his name by an independent laboratory, stating the respect for existing rules and regulations.

1.6 PURPOSE

A. Vertical cartridge dust collector with over-bags must be designed to collect, filter and store dust coming from wood working equipment. Manufacturer of collector must be certified to make, assemble and distribute industrial air purification equipment. Dust collector must be made in accordance with safety rules and regulations. Written verification that collector and all safety components used in conjunction with have been tested as such, and are in compliance with NFPA standards, to be provided by manufacturer.

PART 2 - PRODUCT

2.1 MANUFACTURERS

A. Manufacturers: Must be compliant with requirements, provide products by the following:

1. Dust Collector:
    a. Camfil APC
    b. All other manufacturers MUST submit for alternate approval prior to bid, in accordance with bid documents “Substitution Request”. In addition, the following documentation shall be REQUIRED for consideration as an alternate dust collection manufacture.
        i. Shop drawing of exact proposed equipment substitution, including dimensions and drafted duct connections/arrangement to demonstrate complete function within project conditions. General Literature is unacceptable.
        ii. Documentation from 3rd party NOTIFIED body of testing and compliance of proposed equipment with ALL applicable NFPA deflagration isolation requirements.
        iii. Verification that proposed substitution MEETS or EXCEEDS sq. ft. of media within the SAME size or SMALLER footprint as basis of design. With Fan documentation verifying performance at given location.
        iv. Verification that proposed cartridge dust collection unit will be provided with over bags.
        v. Written documentation for the substitution of the applicable Back Draft Damper, Detect and Suppress System, Rotary Airlock, Fast Acting Valve, Pinch Valve, Broken Bag Detection System, and Secondary Filtering System is complete and is provided with 3rd party certification for compliance with applicable NFPA standards, shown on computer drafted drawings, appropriately positioned for correct application with proposed alternate equipment. If additional life safety devices are deemed necessary, at the sole discretion of the ENGINEER, in conjunction with alternative equipment manufacture and, are not required by the basis of design, maintenance of such additional equipment shall be guaranteed to the OWNER, materials and labor, for the life of the proposed substitution, and such guarantee shall be provided in writing and accompany the substitution request.
        vi. Documentation that unit SHALL BE manufactured in the USA.
        vii. Incomplete substitution requests will be rejected WITHOUT review as INCOMPLETE.

2. Dust Collector Fan
    a. New York Blower; -Baldor Super Premium E Motor ,VFD Compatible

3. Spark Detection and Suppression System
    b. FLAMEX

4. Inlet Isolation Device
    a. Camfil APC

2.2 GENERAL DESCRIPTION

A. Furnish a completely packaged, fully assembled, pre-wired, inclusive of remote mounted control package, dust collector complying with the performance conditions listed in the mechanical drawings and schedules.

2.3 DUST COLLECTOR

A. Job installation and units will conform to NFPA 664,654,69

B. Collector:

1. The collector shall be vertical cartridge type, designed for continuous operation and automatic reverse-pulse cleaning. Construction shall be 10-gage steel and heavier. Major sections shall be modular, bolted construction for maximum installation flexibility. Collector shall consist of:

    a. Filter module with inlet baffle, single hopper w/quick release bin.
    b. Custom Electrical Panel with VFD and static controls, dust collector cleaning controls and solenoid heaters.
    c. Fan with silencer.
    d. INTEGRATED Riga-Flo Flame-Front Arrestor and Safety Monitoring Filter Module.

C. Filter Module and Hopper Section:

1. Filter module section shall contain cartridge elements, cartridge access doors, reverse- pulse cleaning components, cartridge sealing hardware, dirty-air inlet, support frame and side walls. Filter module and hopper section shall maintain integrity to +/- 25" w.g.
2. Cartridge access door shall incorporate "truck door" type operating hardware and require no tools when accessing cartridges. Door shall have "lock-out, tag-out" capability.
3. Filter Module shall have a dirty air inlet on one side. Air inlet shall be a low-velocity (1,000fpm or less) and include a staggered-channel baffle to prevent large particles from impinging directly on the filters.
4. Pulse cleaning components shall include blow pipes, internal piping, compressed air header, solenoid valves and diaphragm valves. The solenoid housing shall be fitted with a thermostatically-controlled, 1-amp heater (115V/1-phase) to prevent freeze-ups during cold weather.
5. Collector shall have single-hopper with discharge. Hopper wall angle shall be 60- degrees. Hopper outlets shall have quick release bin with dust drawer for NFPA-compliance.. Support legs will allow a clearance to accommodate dust drawer.
6. Collector shall be supplied with explosion venting suitable for dusts with KST values of up to 200.
7. The collector parts shall be individually electrostatic powder painted and, once all parts are painted, the unit is fully assembled. There shall be no bare metal surfaces underneath any component. Color to be: Custom selected by architect.
8. Filter cartridges shall be self-positioning and each row shall be locked and sealed in place by means of cam locking bars with handles at the door end to easily lock and unlock cartridges into place. Cam bars to be supported by heavy duty cast iron support clips.
9. Cartridges will utilize a hot-melt bead between the pleats on clean-side of filter to maintain pleat spacing. Hot-melt beads will be spaced every inch along the entire height of cartridge. Each cartridge will have a minimum of 375 sq. ft. of filter media. Media shall be a blend of cellulose and 20% polyester and have an efficiency of at least 99.99% on 0.5 micron and larger particles. Filter media to be eXtreme Polytech laminant. The cartridges shall seal to filter module tube sheet by means of double gaskets of a continuous, seamless design.

D. Cartridge over-bags shall be provided to act as a pre-filler to the primary cartridge protecting it from larger materials that tend to pack in pleated cartridges. Over-bag to be – micron nylon mesh

E. Sawdust Collection System Control Box (Integrated Cleaning Controls with VFD and Static blower control):

1. VFD provides complete control of the blower during and after start-up. This method uses a set of points and feedback from sensor to automatically determine the speed at which it needs to operate.
2. The FDC Photohelic Controls with adjustments for pulse timing and duration, pulse pressure differential settings, auto fan-shutdown pulsing (with delay) and low and high static alarms. Display shall have

digital and LED-analog displays of pressure differential, and LED display of differential cleaning set points as well as high and low alarm set points. Controls shall have a three-position switch for “OFF”, “ON DEMAND”, and CONTINUOUS cleaning. FDC controller shall be suitable for 115V/1-phase/60-Hz operation.

3. Fan Motor shall be premium-efficiency TEFC. Fan wheel shall be backward-inclined. Design performance: rated at 4,900 ft. elevation.

F. INTEGRATED Flame-Front Arrestor and Safety Monitoring Filter Module (Deflagration Isolation device and Secondary Filters):

1. Provide an integrated Riga-Flo safety filter factory-mounted to the top of the dust collector. The safety filter shall match the unit capacity. Unit will include filter access doors directly above the cartridge access doors with the same “truck door” type latching hardware. Riga- Flo filters shall utilize the same cam-bar locking system as the filter cartridges. Module shall meet NFPA standards 68, 654 and 664 to prevent both unintentional return of contaminated air to the facility and prevent transmission of energy from a fire or explosion to the building. Provide NFPA compliant testing information to meet the NFPA codes listed above. REMOTE Mounted Safety Monitoring Filters WILL NOT be accepted unless they are rated to performing both functions.

G. Interconnections:

1. Installer shall locate the custom electrical control boxes inside the wood shop as indicated and supply it with 120V/1-ph/60hz power sufficient to operate cleaning controls and 480V/3-ph/60Hz suitable for powering the fan motor via dust collector control panel. The interconnections required between the custom control box (located inside) and the collector (located outside) will include:

2. Five (5) 12 gage wires (in conduit) to the collector solenoid box (2 for the compressed air solenoids, 1 for the solenoid heater, 1 common and 1 ground), by E.C.

3. Four (4) ¼” plastic UV resistant tubes. One (1) to the tap provided on the collector clean air plenum and one (1) to the tap provided on the collector dirty air plenum (static pressure reading across two filter banks).

4. Wiring (in separate conduit) as required by electrical code suitable for operating the 3- phase fan motor.

5. The piping contractor will be responsible for running 1” compressed air piping to collector air header (compressed air to be delivered at 15 SCFM at 90 psig).

6. Wire Flamex spark detection/suppression system to fire alarm system (by E.C.).

7. Wire Flamex spark detection control panel to spark detectors (see plans for location).

8. Wire from Flamex water nozzle solenoid to Flamex control panel.

9. Provide 120 Volt stand-alone power to "Flamex" fire suppression spark detection panel.

10. Wire from Inlet Isolation Device to suppression control panel (by T.C.).

11. Wire from explosion vent to dust collector control panel (by E.C.)

12. Pipe water from fire suppression system to duct suppression system (17 gpm at 44 psi residual required)

13. Wire from bin level indicator to dust collector controller.

14. All other wiring and piping required for proper operation or recommended by the manufacturer.

2.4 DUST COLLECTOR FAN

A. GENERAL DESCRIPTION

1. The fans shall be capable of operating over the entire range in accordance with the equipment schedule and as defined in AMCA Standard 99-2408. Fan wheels shall utilize non-overloading flat, single thickness blades in all sizes. Unless otherwise directed, fans shall be in compliance with the layout shown on the drawings.

B. PERFORMANCE

1. Fan ratings shall be based on tests made in accordance with AMCA Standard 210 and licensed to bear the AMCA certified ratings seal for air performance. Fans not licensed to bear the AMCA seal for performance shall be tested, at supplier's expense, in an accredited AMCA laboratory. (Option: Only AMCA certified fans will be accepted.) Fans shall have a sharply rising pressure characteristic extending throughout the operating range to assure quiet and stable operation. Fan brake horsepower shall be equal to or more than 5.7.

C. SOUND

1. Fan manufacturers shall provide sound power level ratings for fans tested and rated in accordance with AMCA Standards 300 and 301. Tests shall be performed in an accredited AMCA laboratory. Sound power ratings shall be in decibels (reference 10^{-12} watts) in eight octave bands. Sound power levels will be corrected for installation by the specifying engineer…dBA levels only are not acceptable.

D. CONSTRUCTION

1. Fan housings are to be heavy gauge, continuously welded construction. Housings with lock seams or partially welded construction are not acceptable. Housings are to be reinforced with rigid bracing to increase structural integrity and prevent vibration. Housing inlet cones shall be aerodynamically designed and spun providing a minimum separation of air flow. Wheel diameters and outlet areas shall be in accordance with the standard dimensions adopted by AMCA for centrifugal fans. Designs not in accordance with AMCA Standard 99-240 1 are not acceptable.

E. BEARINGS

1. Bearings are to be heavy duty, grease lubricated, precision anti- friction ball or spherical roller, self-aligning, pillow block design. Bearings shall be designed for a minimum L-10 life of 40,000 hours (200,000 hour L-50 life) when rated at the fan's maximum cataloged operating speed. (Optional: bearings to have mini- mum L-10 life of 250,000 hours.)

F. SHAFT

1. Shaft are to be ASTM A-108 steel, grade 1040/1045, precision turned, ground and polished. Grade 1018 steel is not accept- able. The shaft's first critical speed shall be at least 125% of the fan's maximum operating speed. The drive end of the fan shaft shall be counter-sunk for tachometer readings.

G. MOTOR

1. All motors furnished shall be designed, manufactured, and tested in accordance with the latest applicable standards of NEMA, ANSI, IEEE, and ASTM. As a minimum requirement, all motors shall conform to the latest applicable sections of NEMA Standard No. MG-1. Motors must meet or exceed CEE Premium Efficiency™ full load efficiencies. The Consortium for Energy Efficiency (CEE).
2. Motors shall be premium efficiency severe duty type, NEMA Design B.
3. Motor shall be TEFC, NEMA T frame, NEMA F1 assembly for horizontal applications and designed for the environment where the motor will be used.
4. Enclosures shall be rolled steel band or cast iron construction depending on horsepower. End brackets shall be die cast aluminum with steel bearing inserts or cast iron construction. Conduit box shall be die cast aluminum or cast iron construction.
5. Motors shall have drain openings suitably located for the type assembly being provided.
6. For frames 215 and above, shouldered lifting eyebolts or cast provisions within the frame shall be furnished for handling convenience.
7. Motor enclosures shall have a bi-directional, spark-proof, abrasion and corrosive resistant fan made of a material that is strong and durable. Fan will be keyed to shaft on frames 254 and above.
8. Motor nameplate shall be mounted on enclosure with stainless steel fastening pins. Nameplate shall have, as a minimum, all information as described in NEMA Standard MG-1-20.60.

9. Motor bearing numbers shall be included on nameplate. Motor connection diagram shall be attached to motor and easily readable

H. PAINT

1. All fan surfaces are to be thoroughly prepared prior to painting using a combination of washing and hand and power tool cleaning as required. After cleaning, all surfaces are to be coated with an industrial grade alkyd enamel. Surfaces of bolted components not accessible after assembly shall be coated and allowed to dry prior to final assembly. Primer only will not be accepted.

I. FINAL INSPECTION

1. All fans shall receive a final inspection by a qualified inspector prior to shipment. Inspection to include: fan description and accessories, balance, welding, dimensions, bearings, duct and base connection points, paint finish and overall workmanship.

2.5 DUST COLLECTION SPARK DETECTION

A. Furnish and install a spark detection and suppression system with to serve the dust collector exhaust system. The spark detection shall be a micro-processor based system designed to detect sparks. System must be Factory Mutual Approved, and approval report number must be listed.

B. CONTROL CABINET:

1. Control Panel shall be the FLAMEX FLE 5000 Console with capacity for two detection inputs and one extinguishing output. Incoming Power requirement shall be 110/60/1. The panel shall include a 24V DC 3 Amp power supply and Two (2)- 12V 2.5H Batteries to provide emergency back-up power for a minimum of 24 Hours to the panel in the event of loss of incoming power. The panel shall feature programmable shutdown capability for the interlocking or fans and associated equipment. The Panel shall be housed in an IP 66 (NEMA 12) enclosure and must be installed in a dry heated area.

2. Provide Two (2) YMX 5000 FUX OS Infrared Spark Detectors with automatic self-monitoring of detector lens capability. Detectors to be connected to One (1) YMX 5000 Control Unit to provide external LED indications of fire and fault. Detector Lens must be field removable and wear resistant. Detectors must be suitable for outdoor use in temperatures ranging from –40 Degrees F to 221 Degrees F

3. Provide One (1) 1” Extinguishing Assembly complete with 21 VDC Solenoid Valve, Brass Y strainer with Stainless Steel Screen, and Ball Valve with Locking Strap, Lock and Key. The solenoid Valve shall be the slow closing type to eliminate water hammer. A Stainless Steel directional Spray Nozzle shall be provided as part of this Assembly which will produce a 180 degree Fan Shaped Spray Pattern. Stainless Steel mounting hardware for Nozzle shall also be provided. The Extinguishing Assembly must be capable of flowing a minimum of 17GPM at 44 PSI flowing pressure at the solenoid Valve. The extinguishing assembly will come equipped with an inline flow monitor capable of detecting a minimum water flow through the unit of 3L/minute.

4. The System shall be Factory Mutual Approved

5. The control cabinet shall be programmed to allow the extinguishing system to function without interrupting production.

6. The control cabinet shall provide a constant visual readout of extinguishments during a specific period of time. A battery back-up emergency power supply will be provided to assure continued operation upon main power failure.

7. The control cabinet shall provide powered terminals for an external horn or light device, summation alarm and trouble dry contacts, trouble contacts for system disabled.

8. The system is to be installed consistent with the Manufacturers recommendations.

2.5 OTHER REQUIREDACCESSORIES

A. One (1) quick release bin with dust drawer shall be provided with the dust collector.

B. Factory installed magnehelic gage to read the pressure across the main filter cartridge

C. Explosion Isolation Valve to be installed on the dirty air inlet:

1. Camfil Stinger Explosion Isolation Valve.

    a. NFPA 69-2014, 654 and 664 continuous dust compliant.
    b. Written documentation from a NOTIFIED 3rd PARTY verifying NPFA compliance
    c. Documentation indicating minimum and maximum distance valve must be installed from collector for proper operation.
    d. 12 gauge duct with flanged or welded connections required between Explosion Isolation Valve and Dust Collector.

2. Purpose: Explosion Isolation Valves are designed to prevent flame front from propagating back through the ductwork to the occupied space in the event of a deflagration in the dust collector.

D. Refer to schedules on mechanical drawings for any additional information and accessories.

PART 3 – EXECUTION

3.1 INSTALLATION

A. Assembly dust collection unit per the manufacture's installation guidelines.

B. Install in accordance with manufacturer's Installation & Maintenance instructions.

C. Use all factory provided lifting lugs to rig the units or modules. Ensure that spreader bars are used to prevent damaging the cabinets.

D. Lift modules in an upright position.

E. Level unit horizontally and vertically, using steel shims under legs where required. Shims shall have a corrosion resistant coating.

F. Support collector silencer and transition independently from the dust collector.

G. Contractor shall protect the dust collector inlet and outlet during construction to prevent construction debris from entering the collector prior to making duct connection to the unit. Do not operate fan system until filters are in place.

H. Connect exhaust and return ducts to dust collection unit, flexible connections shall not be used.

I. Perform preliminary start-up unit check per the dust collector manufacture's installation guidelines.

J. Check fan motors for rotation and amp draw for each phase. Record information on the start-up data sheets.

3.2 Factory Start up and Verification:

1. Factory trained technicians shall inspect and commission all components including:
    a. Dust Collection System b.
    Spark Detection System

END OF SECTION 23 3515

SECTION 23 3516 - DUST COLLECTOR DUCTS

PART 1 - GENERAL

1.1 SUMMARY

A. Refer to Division 23 Section “Metal Ducts” for duct requirements not related to dust collector ductwork requirements.

B. Section Includes:

1. Rectangular ducts and fittings.
2. Round ducts and fittings.
3. Sheet metal materials.
4. Sealants and gaskets.
5. Hangers and supports.

C. Related Sections:

1. Division 23 Section "Testing, Adjusting, and Balancing" for testing, adjusting, and balancing requirements for metal ducts.

1.2 PERFORMANCE REQUIREMENTS

A. Delegated Duct Design: Duct construction, including sheet metal thicknesses, seam and joint construction, reinforcements, and hangers and supports, shall comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible", NFPA 664 “Processes Operations and Special Systems”, NFPA 654 “Standard for the Prevention of Fire and Dust Explosions from the Manufacturing, Processing, and Handling of Combustible Particle Solids,” and performance requirements and design criteria indicated in "Duct Schedule" Article.

B. Structural Performance: Duct hangers and supports for horizontal ductwork serving the dust collection system shall meet NFPA 664 requirements for supporting the weight of the duct system plus the weight of the duct half filled with water or material being conveyed, whichever has the high density. Duct hangers and supports shall withstand the effects of gravity loads (duct weight plus water weight for horizontal dust collector ductwork) and stresses within limits and under conditions described in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible".

C. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.

1.3 SUBMITTALS

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

B. Shop Drawings: Detailed shop drawings for dust collector exhaust air and return air (clean air back to the woodshop) ductwork.

1.4 QUALITY ASSURANCE

A. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1-2004, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-Up."

B. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1-2004, Section 6.4.4 - "HVAC System Construction and Insulation."

PART 2 - PRODUCTS

2.1 CLAMP-TOGETHER ROUND DUCTS AND FITTINGS

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

1. Nordfab Ducting
2. US Duct

B. General Fabrication Requirements:

1. Ductwork shall be of a clamp- together design using a die-formed, rolled edge which is then joined together by a single lever clamp of similar material unless otherwise noted. All clamp together ducting shall be of continuous laser welded construction along the longitudinal seam of the rolled form duct. All connections shall have PVC seal in clamp for standard installs.
2. Clamp together ductwork shall use flanged duct connections with gasket seals where noted in the duct schedule.
3. All clamp together ductwork shall maintain electrical continuity through the respective clamp together joint and shall not require the use of grounding each section of duct on each side of the respective joint.
4. Duct material sheet blanks shall be five feet long, which is then rolled and fused together with a laser weld process along the longitudinal seam.
5. The ends of the duct shall be pressed in a die to from a rolled bead on each end of the duct. This rolled end is used for clamping components together as well as reinforcement every 5 feet.
6. Straight duct and other connecting components to be constructed of galvanized sheets produced by the continuous galvanizing process which conforms to ASTM-A-527, and commercial quality ASTM A-527. Galvanized sheeting shall be produced with a minimum spangle.
7. Ducting constructed of stainless steel to be 304 2B finish (2B finish is annealed, pickled and bright cold rolled.

2.2 DUST COLLECTION FLOOR SWEEPS

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

1. Nordfab Ducting, Part Number 3248
2. US Duct

B. Galvanized sheet metal construction with closing door.

2.3 DIVERTER VALVES

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

1. Nordfab Ducting
2. US Duct

B. Electrical/pneumatic automatic diverter valve. C.

Electrical: 120 volt

D. Pneumatic: 75 psi minimum.

2.4 MANUAL BLAST GATES

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

1. Nordfab Ducting
2. US Duct

B. Manual blast gate with handle and no set screw shall be used to serve floor sweeps and bench sweeps. All other manual blast gates shall have a set screw.

2.5 FLEXIBLE RUBBER HOSE WITH STEEL COIL

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

1. Nordfab Ducting, RFH Hose
2. US Duct

B. Constructed of thermoplastic rubber and reinforced with wire helix.

C. Provide hose end adapters as specified on the mechanical drawings.

2.6 VIBRATION ISOLATOR

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

1. Nordfab Ducting, Part Number 3206
2. US Duct

2.7 RECTANGULAR DUCTS AND FITTINGS

A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class unless otherwise indicated.

B. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 1-4, "Transverse (Girth) Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

C. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 1-5, "Longitudinal Seams - Rectangular Ducts," for static-pressure class, applicable sealing requirements, materials involved, duct- support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

D. Elbows, Transitions, Offsets, Branch Connections, and Other Duct Construction: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 2, "Fittings and Other Construction," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.8 NON-CLAMP-TOGETHER ROUND DUCT & FITTINGS

A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 3, "Round, Oval, and Flexible Duct," based on indicated static-pressure class unless otherwise indicated.

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

a. Lindab Inc.
b. McGill AirFlow LLC.
c. SEMCO Incorporated.
d. Sheet Metal Connectors, Inc.
e. Spiral Manufacturing Co., Inc.
f. Other qualified fabricator subject to compliance with requirements.

B. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Transverse Joints - Round Duct," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

1. Transverse Joints in Ducts Larger Than 60 Inches in Diameter: Flanged.

C. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Seams - Round Duct and Fittings," for static-pressure class, applicable sealing requirements, materials involved, duct- support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

1. Fabricate round ducts larger Than 90 inches in diameter with butt-welded longitudinal seams.

D. Tees and Laterals: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-4, "90 Degree Tees and Laterals," and Figure 3-5, "Conical Tees," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.9 SHEET METAL MATERIALS FOR RECTANGULAR AND NON-CLAMP-TOGETHER ROUND DUCT & FITTINGS

A. General Material Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

B. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.

1. Galvanized Coating Designation: G90.
2. Finishes for Surfaces Exposed to View: Mill phosphatized.

C. Carbon-Steel Sheets: Comply with ASTM A 1008/A 1008M, with oiled, matte finish for exposed ducts.

D. Reinforcement Shapes and Plates: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.

1. Where black- and galvanized-steel shapes and plates are used to reinforce aluminum ducts, isolate the different metals with butyl rubber, neoprene, or EPDM gasket materials.

E. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8- inch minimum diameter for lengths longer than 36 inches.

2.10 SEALANT AND GASKETS FOR RECTANGULAR AND NON-CLAMP-TOGETHER ROUND DUCT & FITTINGS

A. General Sealant and Gasket Requirements: Surface-burning characteristics for sealants and gaskets shall be a maximum flame-spread index of 25 and a maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.

B. Water-Based Joint and Seam Sealant:

1. Application Method: Brush on.
2. Solids Content: Minimum 65 percent.
3. Shore A Hardness: Minimum 20.
4. Water resistant.
5. Mold and mildew resistant.
6. VOC: Maximum 75 g/L (less water).
7. Maximum Static-Pressure Class: 10-inch wg, positive and negative.
8. Service: Indoor or outdoor.
9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.

C. Flanged Joint Sealant: Comply with ASTM C 920.

1. General: Single-component, acid-curing, silicone, elastomeric.
2. Type: S.
3. Grade: NS.
4. Class: 25.
5. Use: O.
6. For indoor applications, use sealant that has a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

D. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer. E.

Round Duct Joint O-Ring Seals:

1. Seal shall provide maximum leakage class of 3 cfm/100 sq. ft. at 1-inch wg and shall be rated for 10-inch wg static-pressure class, positive or negative.
2. EPDM O-ring to seal in concave bead in coupling or fitting spigot.
3. Double-lipped, EPDM O-ring seal, mechanically fastened to factory-fabricated couplings and fitting spigots.

2.11 STEEL PIPE AND FITTINGS

A. Steel Pipe: ASTM A 53/A 53M, Type E or S, Grade A or B, Schedule 40, galvanized. Include ends matching joining method.

1. Drainage Fittings: ASME B16.12, galvanized, threaded, cast-iron drainage pattern.
2. Pressure Fittings:

a. Steel Pipe Nipples: ASTM A 733, made of ASTM A 53/A 53M or ASTM A 106, Schedule 40, galvanized, seamless steel pipe. Include ends matching joining method.
b. Malleable-Iron Unions: ASME B16.39; Class 150; hexagonal-stock body with ball-and-socket, metal-to-metal, bronze seating surface; and female threaded ends.
c. Gray-Iron, Threaded Fittings: ASME B16.4, Class 125, galvanized, standard pattern.
d. Cast-Iron Flanges: ASME B16.1, Class 125.

B. Cast-Iron, Flanged Fittings: ASME B16.1, Class 125, galvanized.

2.12 DUCT LINER

A. Fibrous-Glass Duct Liner: Comply with ASTM C 1071, NFPA 90A, or NFPA 90B; and with NAIMA AH124, "Fibrous Glass Duct Liner Standard."

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

a. CertainTeed Corporation; Insulation Group. b.
Johns Manville.
c. Knauf
Insulation. d.
Owens Corning.
e. Lewis and Lambert.

2. Maximum Thermal Conductivity:

a. Type I, Flexible: 0.27 Btu x in./h x sq. ft. x deg F at 75 deg F mean temperature. b.
Type II, Rigid: 0.23 Btu x in./h x sq. ft. x deg F at 75 deg F mean temperature.

3. Antimicrobial Erosion-Resistant Coating: Apply to the surface of the liner that will form the interior surface of the duct to act as a moisture repellent and erosion-resistant coating. Antimicrobial compound shall be tested for efficacy by an NRTL and registered by the EPA for use in HVAC systems.
4. Water-Based Liner Adhesive: Comply with NFPA 90A or NFPA 90B and with ASTM C 916.

a. For indoor applications, use adhesive that has a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

B. Insulation Pins and Washers:

1. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch- diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch galvanized carbon-steel washer.
2. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- thick galvanized steel; with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.

C. Shop Application of Duct Liner: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-19, "Flexible Duct Liner Installation."

1. Adhere a single layer of indicated thickness of duct liner with at least 90 percent adhesive coverage at liner contact surface area. Attaining indicated thickness with multiple layers of duct liner is prohibited.
2. Apply adhesive to transverse edges of liner facing upstream that do not receive metal nosing.
3. Butt transverse joints without gaps, and coat joint with adhesive.
4. Fold and compress liner in corners of rectangular ducts or cut and fit to ensure butted- edge overlapping.
5. Do not apply liner in rectangular ducts with longitudinal joints, except at corners of ducts, unless duct size and dimensions of standard liner make longitudinal joints necessary.
6. Apply adhesive coating on longitudinal seams in ducts with air velocity of 2500 fpm.
7. Secure liner with mechanical fasteners 4 inches from corners and at intervals not exceeding 12 inches transversely; at 3 inches from transverse joints and at intervals not exceeding 18 inches longitudinally.
8. Secure transversely oriented liner edges facing the airstream with metal nosing's that have either channel or "Z" profiles or are integrally formed from duct wall. Fabricate edge facings at the following locations:

a. Fan discharges.
b. Intervals of lined duct preceding unlined duct.
c. Upstream edges of transverse joints in ducts where air velocities are higher than 2500 fpm or where indicated.

9. Secure insulation between perforated sheet metal inner ducts of same thickness as specified for outer shell. Use mechanical fasteners that maintain inner duct at uniform distance

from outer shell without compressing insulation.

a. Sheet Metal Inner Duct Perforations: 3/32-inch diameter, with an overall open area of 23 percent.

10. Terminate inner ducts with buildouts attached to fire-damper sleeves, dampers, turning vane assemblies, or other devices. Fabricated buildouts (metal hat sections) or other buildout means are optional; when used, secure buildouts to duct walls with bolts, screws, rivets, or welds.

2.13 HANGERS AND SUPPORTS

A. All hangers and supports for serving the dust collection exhaust air ductwork shall be sized to support the weight of the ductwork plus the weight of water to fill the duct half full with water. Refer to the mechanical drawings for schedule of water weight per linear foot of duct.

B. Hanger Rods for Noncorrosive Environments: Cadmium-plated steel rods and nuts.

C. Hanger Rods for Corrosive Environments: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.

D. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible,"

E. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

F. Trapeze and Riser Supports:

1. Supports for Galvanized-Steel Ducts: Galvanized-steel shapes and plates.
2. Supports for Stainless-Steel Ducts: Stainless-steel shapes and plates.
3. Supports for Aluminum Ducts: Aluminum or galvanized steel coated with zinc chromate.

PART 3 - EXECUTION

3.1 DUCT INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of duct system. Indicated duct locations, configurations, and arrangements were used to size ducts and calculate friction loss for air-handling equipment sizing and for other design considerations. Install duct systems as indicated unless deviations to layout are approved on Shop Drawings and Coordination Drawings.

B. Install explosion isolation valve not less than 7’ and no more than 32’ upstream of the dust collector inlet. Install explosion isolation valve per the manufacture’s installation guidelines.

C. Install ducts according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" unless otherwise indicated.

D. Install vibration isolator at each equipment connection as noted on the mechanical drawings. E.

Install diverter valves where indicated on the drawings per the manufacture’s installation guidelines.

F. Install round ducts in maximum practical lengths.

G. Install ducts with fewest possible joints.

H. Install clamp together ductwork per the clamp together ductwork manufacture’s guidelines.

I. Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections.

J. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.

K. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.

L. Install ducts with a clearance of 1 inch.

M. Where ducts pass through non-fire-rated interior partitions and exterior walls and are exposed to view, cover the opening between the partition and duct or duct insulation with sheet metal flanges of same metal thickness as the duct. Overlap openings on four sides by at least 1-1/2 inches.

N. Where ducts pass through fire-rated interior partitions and exterior walls, install fire dampers. Comply with requirements in Division 23 Section "Air Duct Accessories" for fire and smoke dampers.

O. Protect duct interiors from moisture, construction debris and dust, and other foreign materials. Comply with SMACNA's "Duct Cleanliness for New Construction Guidelines."

P. Install an electrical ground across each section of conductive duct where joint between ducts is non-conductive. Coordinate installation with the electrical contractor.

Q. Install vacuum pump ducting per the Owner provided CNC router and vacuum pump manufacture’s guidelines. Install Owner provided filter between Owner provided CNC router and vacuum pump.

S. Support all ductwork.

3.2 INSTALLATION OF EXPOSED DUCTWORK

A. Protect ducts exposed in finished spaces from being dented, scratched, or damaged.

B. Trim duct sealants flush with metal. Create a smooth and uniform exposed bead. Do not use two-part tape sealing system.

C. Grind welds to provide smooth surface free of burrs, sharp edges, and weld splatter. When welding stainless steel with a No. 3 or 4 finish, grind the welds flush, polish the exposed welds, and treat the welds to remove discoloration caused by welding.

D. Maintain consistency, symmetry, and uniformity in the arrangement and fabrication of fittings, hangers and supports, duct accessories, and air outlets.

E. Repair or replace damaged sections and finished work that does not comply with these requirements.

F. All exposed round duct shall be spiral seamed unless noted to be clamp together ductwork. G.

Support all ductwork.

3.3 DUCT SEALING

A. Seal ducts for duct static-pressure, seal classes, and leakage classes specified in "Duct Schedule" Article according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

3.4 HANGER AND SUPPORT INSTALLATION

A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 4, "Hangers and Supports."

B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.

1. Where practical, install concrete inserts before placing concrete.
2. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
3. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches thick.
4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches thick.
5. Do not use powder-actuated concrete fasteners for seismic restraints.

C. Hanger Spacing: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 4-1, "Rectangular Duct Hangers Minimum Size," and Table 4-2, "Minimum Hanger Sizes for Round Duct," for maximum hanger spacing; install hangers and supports within 24 inches of each elbow and within 48 inches of each branch intersection.

D. Hangers Exposed to View: Threaded rod and angle or channel supports.

E. Support vertical ducts with steel angles or channel secured to the sides of the duct with welds, bolts, sheet metal screws, or blind rivets; support at each floor and at a maximum intervals of 16 feet.

F. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

G. Install schedule 40 steel pipe sleeve for vacuum pump ducting penetrations through exterior wall and concrete slab penetrations. Seal exterior wall penetrations water tight.

3.5 START UP

A. Air Balance: Comply with requirements in Division 23 Section "Testing, Adjusting, and Balancing for HVAC."

3.6 DUCT SCHEDULE

A. Fabricate ducts with galvanized sheet steel except as otherwise indicated and as follows: B.

Exhaust Ducts:

1. Exhaust Air Ducts Connected to Dust Collector:

a. Round ductwork shall be clamp-together round duct and fittings. Flanged connections with gasket seals shall be used for all exterior exhaust air ductwork.
b. 30^{O} takeoffs shall be used in the dust collector exhaust ductwork.
c. Pressure Class: Negative 15-inch wg.
d. Minimum SMACNA Seal Class: C.
e. 12 ga.vanstone flange or welded duct required between Inlet Isolation Device and dust collector rated for 15 psi.

C. Return Ducts:

1. Return Air (Clean Air) Ducts Connected to Dust Collector:

a. Round ductwork shall be clamp-together round duct and fittings between dust collector and interior space. Flanged duct connections with gasket seals shall be used for all exterior return air ductwork.
b. Round and oval ductwork shall be spiral seam construction. Flanged duct connections with gasket seals shall be used for all return air ductwork.
c. Pressure Class: Positive 3-inch wg.
d. Minimum SMACNA Seal Class: C.

D. Intermediate Reinforcement:

1. Galvanized-Steel Ducts: Galvanized steel.

F. Transfer Ducts: Fibrous glass, Type I, 1 inch thick

G. Elbow Configuration:

1. Turning vanes shall not be used in exhaust air ductwork connected to the dust collector. Radius elbows shall be used for all rectangular elbows in exhaust air ductwork connected to the dust collector.
2. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Elbows."

a. Velocity 1000 fpm or Lower:

1) Radius Type RE 1 with minimum 0.5 radius-to-diameter ratio.
2) Mitered Type RE 4 without vanes.

b. Velocity 1000 to 1500 fpm:

1) Radius Type RE 1 with minimum 1.0 radius-to-diameter ratio.
2) Radius Type RE 3 with minimum 0.5 radius-to-diameter ratio and two vanes.
3) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible, “Figure 2-3, "Vanes and Vane Runners," and Figure 2-4, "Vane Support in Elbows."

c. Velocity 1500 fpm or Higher:

1) Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
2) Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.
3) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible,” Figure 2-3, “Vanes and Vane Runners," and Figure 2-4, "Vane Support in Elbows."

3. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Elbows."

a. Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
b. Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.
c. Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-3, "Vanes and Vane Runners," and Figure 2-4, "Vane Support in Elbows."

4. Round Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-3, "Round Duct Elbows."

a. Minimum Radius-to-Diameter Ratio and Elbow Segments: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 3-1, "Mitered Elbows." Elbows with less than 90-degree change of direction have proportionately fewer segments.

   1) Velocity 1000 fpm or Lower: 0.5 radius-to-diameter ratio and three segments for 90-degree elbow.
   2) Velocity 1000 to 1500 fpm: 1.0 radius-to-diameter ratio and four segments for 90-degree elbow.
   3) Velocity 1500 fpm or Higher: 1.5 radius-to-diameter ratio and five segments for 90-degree elbow.
   4) Radius-to Diameter Ratio: 1.5.

b. Round Elbows, 12 Inches and Smaller in Diameter: Stamped or pleated.
c. Round Elbows, 14 Inches and Larger in Diameter: Standing seam or Welded.

END OF SECTION 23 3516

SECTION 23 3713 - AIR OUTLETS & INLETS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings, General Provisions of Contract, including General and Supplementary Conditions and Section 23 0501 apply to this Section.

1.2 SUMMARY

A. Furnish and install wall supply registers, transfer grilles, return air grilles, soffit grilles, ceiling diffusers, louvers connected to ductwork, and registers as described in Contract Documents.

PART 2 - PRODUCTS

2.1 GRILLES & REGISTERS

A. Approved Manufacturers:
1. Price
2. Anemostat
3. Krueger
4. Titus
5. Tuttle & Bailey

2.2 SPIN-IN FITTINGS

A. Low pressure round take-offs to diffusers shall be made with spin-in fittings. They shall incorporate a manual balancing damper. The damper shall be spring loaded and a positive locking wing nut shall secure the damper position.

B. Approved Manufacturers:
1. Sheet metal fittings: Genflex DB-1DEL, Hercules

2.3 LOUVERS

A. Extruded aluminum, with blades welded or screwed into frames and 1/2 inch mesh 16 gauge aluminum bird screen.

B. Frames shall have mitered corners.

C. Louvers shall be recessed, flanged, stationary, or removable as noted on Drawings.

D. Approved Manufacturers:
1. Airolite
2. American Warming
3. Arrow
4. Industrial Louvers
5. Ruskin
6. Vent Products

PART 3 - EXECUTION

3.1 INSTALLATION

A. Anchor securely into openings.

B. Install with screws to match color and finish of grilles and registers.

C. Touch-up any scratched finish surfaces.

D. Install in accordance with manufacturer's instructions.

E. Check location of outlets and inlets and make necessary adjustments in position to conform with architectural features, symmetry, and lighting arrangement.

F. Install diffusers to ductwork with air tight connection.

G. Provide balancing dampers on duct take-off to diffusers, and grilles and registers, despite whether dampers are specified as part of the diffuser, or grille and register assembly.

H. Paint ductwork visible behind air outlets and inlets matte black. Refer to Section 09 9000.

END OF SECTION 23 3713

SECTION 23 4100 – DISPOSABLE FILTERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings, General Provisions of Contract, including General and Supplementary Conditions and Section 23 0501 apply to this Section.

1.2 SUMMARY

A. Furnish and install filters used in mechanical equipment.

PART 2 - PRODUCTS

2.1 FAN COIL UNIT FILTERS

A. Filters shall be two inch thick throw-away type as recommended by Fan Coil Unit Manufacturer.

END OF SECTION 23 4100

SECTION 23 5134 – FLUES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings, General Provisions of Contract, including General and Supplementary Conditions and Section 23 0501 apply to this Section.

1.2 SUMMARY

A. Furnish and install flues as described in Contract Documents.

PART 2 - PRODUCTS

2.1 FLUES

A. Sections shall be UL listed.

B. Sections shall have:
1. Outer jacket of aluminum-coated or galvanized steel.
2. One inch minimum insulating air space.
3. Inner gas carrying pipe of stainless steel.
4. Capability of handling flue gas temperatures up to 1400 deg F on continuous basis.

C. Furnish items which form part of assembly including but not limited to:
1. Bracing and supports as recommended by Flue Manufacturer.
2. Cleanout sections
3. T-sections
4. Necessary straight sections
5. Ventilated roof thimble
6. Flashing and counterflashing
7. 'Backdraft preventer' installed at top of water heater and boiler flues.

D. Approved Manufacturers:
1. Metalbestos Model PS
2. Metivent Model GTD
3. Metal-Fab Inc All Fuel Chimney

2.2 VENT CAPS

A. Non-backdraft type.

B. Approved Manufacturers:
1. Ameri-cap
2. Breidert Type L
3. Triangle AFL
4. Acme Mastervent Type MVR.
5. Dura-Vent

END OF SECTION 23 5134

SECTION 23 5719 – PLATE AND FRAME HEAT EXCHANGERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings, General Provisions of Contract, including General and Supplementary Conditions and Section 23 0501 apply to this Section.

1.2 SUMMARY

A. Furnish and install heat exchanger as described in Contract Documents.

1.3 QUALITY ASSURANCE

A. Construction shall conform to latest ASME Code for unfired pressure vessels.

PART 2 - PRODUCTS

2.1 DESIGN

A. All connections should be located on the frame plate (fixed head), allowing the pressure plate (movable head) to slide back and have plates added, removed, or replaced from the plate pack without disturbing the connections or associated piping.

B. The unit shall be provided with an aluminum splash shield covering the sides and top of the plate pack. The bottom should be left open for leak detection.

C. The unit shall be designed, tested, and U stamped in accordance with ASME Section VIII Division 1 and registered with the National Board. A U-1 data report to be furnished upon request.

D. Unit shall be factory pressure tested with ASME U stamp applied on nameplate prior to leaving the factory.

E. Maximum pressure drop of 5 psi.

2.2 FRAME

A. The frame and pressure plates shall be carbon steel SA 516 grade 70.

B. The frame and pressure plates shall be of sufficient thickness to meet the ASME design pressure without the use of stiffeners or other type of reinforcement.

C. Carbon steel frame components, except hardware, shall be painted with gray macro epoxy paint to a minimum of 4 mils dry film thickness.

D. Frame plates shall have integral lifting eyes in the upper corners. Bolted ore welded on lifting lugs not allowed.

E. Units with studded port connections shall have unlined or alloy lined studded ports to mate with a raised face or flat faced ANSI flange where 150# ANSI flanges are acceptable. Rubber liners are not allowed. Studs must be provided by manufacturer.

F. Port connections shall match piping sizes shown on drawings.

G. Units shall have a minimum of two mounting feet at the frame plate and one at the support column, if a support column is used in the design.

2.3 HARDWARE

A. All bolting, including tightening bolts, shall be carbon steel SA193 grade B7 and galvanized via electroplating of zinc coating.

B. All nuts shall be carbon steel SA194 grade 2H and galvanized via electroplating of zinc coating.

C. Mounting feet shall be zinc plated carbon steel.

D. The nuts on the tightening bolt assemblies on units with 3” and greater connections shall be peened on, not welded, at the frame plate.

2.4 PLATES

A. Plates shall be pressed in a one-step stamping process.

B. Pates shall use an integral rolled edge hanging system to provide a rigid hanger device between the plate and carry bar and guide bar. Welded on hanging brackets or stiffeners are not acceptable.

C. The plate pack shall use a positive plate to plate alignment system to ensure proper plate to gasket seals throughout the plate pack. The positive alignment system shall either be a gasket lug which fits within a plate recess on the plate (tongue in groove) to align successive plates or an extended rolled edge hanger which nests successive plates through direct contact around the entire plate hanger. Plate designs which only offer alignment though contact with the carry and guide bar are unacceptable.

D. Plates shall have an enclosing groove for the entire gasket designed to contain the gasket while allowing for thermal expansion.

E. Plates shall be permanently marked to indicate plate material and thickness.

2.5 GASKETS

A. All gaskets for single pass designs, except the gasket on the first plate, shall be identical.

B. The gaskets shall be a one-piece construction with a double gasket barrier at the port region. The area isolated by the double gasket shall be vented to the atmosphere, so that a gasket failure is detected by leakage to the exterior prior to any possible cross contamination.

C. Gaskets shall have tapered sided to assure positive seating of the compressed gasket and assist in aligning the thermal plates during compression.

2.6 APPROVED MANUFACTURERS

A. Bell & Gossett

END OF SECTION 23 5719

SECTION 23 5721 - RADIANT SNOWMELT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings, General Provisions of Contract, including General and Supplementary Conditions and Section 23 0501 apply to this Section.

B. Examine all other portions of the contract documents for work or other terms and conditions related to the work of this section. Provide all work here under, as required for the support and accommodation of related work.

1.2 SUMMARY

A. All labor, materials, transportation, equipment and services to install hydronic radiant heating system where indicated on drawings supplied for the project.

PART 2 - PRODUCTS

2.1 SHOP DRAWINGS

A. Shop drawings, or descriptions of materials, and details of installation shall be submitted for approval as specified under TERMS AND CONDITIONS of contract document. No fabrication shall be performed until approval is obtained.

2.2 ALL COMPONENTS

A. Components of the buried tubing system shall be provided by one manufacturer, including: tube, fittings, manifolds, and other ancillary items required for a complete installation, as manufactured by Wirsbo Company, REHAU or approved equal.

2.3 WARRANTY

A. Tube shall carry a twenty (20) year non-prorated warranty against failure due to defect in material and workmanship. Manifolds and other ancillary components shall be warranted for eighteen (18) months from date of shipment.

2.4 MATERIALS

A. Tube:
   1. Tube shall be cross-linked polyethylene, with maximum working pressure/temperature of 100 psi @ 180°F. These temperatures and pressure ratings shall be issued by hydrostatic stress board of PPI (Plastic Pipe Institute). PPI is a division of SPI (Society of Plastics Industry).
   2. The tube shall be manufactured in accordance with ASTM standard specification F 876. The tube shall be listed to ASTM by independent third party testing laboratory.
   3. The tube shall be of cross-linked polyethylene manufactured by the “Engel Method.” The tube shall have an oxygen diffusion barrier capable of limiting oxygen diffusion through the tube to no greater than .10g/m3 /day @ 104°F water temperature.
   4. The tube dimensions shall be:
      a. 3/4" nominal inside diameter (7/8" outside diameter), in accordance with ASTM standard specification, as above, or
      b. 5/8" nominal inside diameter (3/4" outside diameter), in accordance with ASTM standard specification, as above, or
      c. 1/2" nominal inside diameter (5/8" outside diameter), in accordance with ASTM standard specification, as above, or
      d. 3/8" nominal inside diameter (1/2" outside diameter), in accordance with ASTM standard specification, as above

5. The minimum bend radius for cold bending of the tube shall not be less than six (6) times the outside diameter. Bends with a radius less than stated shall require the use of a bend support as supplied by the tube manufacturer.

B. Manifolds:
1. Manifolds shall be of cast brass construction, manufactured of alloys to prevent dezincification, and shall have integral circuit balancing valves. Manifolds shall be able to vent air from the system, and shall be provided with support brackets and tube bend supports. Manifolds shall be isolated from supply and return tubing with valves that are suitable for isolation and balancing.

C. Fittings:
1. Fittings shall be manufactured of dezincification resistant brass. These fittings must be supplied by the tube manufacturer. The fittings shall consist of a compression fitting with insert, compression ring and a compression nut.

D. Supply and return piping to manifolds:
1. Piping shall be metal pipe or cross-linked polyethylene tube with an integral oxygen diffusion barrier. Cross-linked polyethylene tube should only be used when specifically approved by the local building inspector for supply and return piping applications.
2. Fittings shall be compatible to the piping material used. Fittings used with the cross-linked polyethylene tube shall not permit excessive oxygen permeation.

E. Snow Detector and Melting Control 664, Pulse Width Modulation:
1. The system water temperature shall be based on the outdoor temperature and feedback from sensors located in the snow melting slabs.
2. The control shall have an adjustable minimum supply water temperature setting to help prevent condensation of the flue gases and subsequent corrosion and blockage of the boiler's heat exchanger and chimney.
3. The control shall have the option to directly operate a variable speed injection pump, a mixing valve with a floating action actuator motor, or a 4-20 mA device.
4. The control shall have the ability to limit the amount of cool water being returned to the boiler through the mixing device in order to prevent low boiler operating temperatures and flue gas condensation.
5. The control shall have the ability to directly control the supply temperature of one of two boiler stages or to send a boiler enable signal to another boiler operating control to allow for a staging control to be connected.
6. The control shall have the option of an automatic differential calculation for the operation of one or two boiler stages in order to prevent short cycling.
7. The control shall have an option to rotate the firing sequence of the boilers and the option for rotating the boiler firing sequence shall be based on the boilers' accumulated running hours.
8. The control shall use proportional, integral and derivative (PID) logic when staging boiler stages.
9. The control shall have four separate lockable access levels to limit the number of adjustments available to various users.
10. The control shall have a test button that activates a pre-programmed test sequence testing all of the control's outputs.
11. The control shall show a number of current sensor temperatures depending on the access level that has been selected.
12. The control shall continuously monitor its temperature sensors and provide an error message upon a control or sensor failure.
13. The control shall record and display various device running hours and minimum and maximum temperatures depending on the access level that has been selected.
14. During extended periods of inactivity, the pumps and valves that are operated by the control shall be periodically exercised to prevent seizure during long idle periods.
15. The control shall have the ability to operate two zones of snow melting.
16. The control shall have three levels of priority when operating two zones of snow melting.
17. The control shall have the ability to use a snow/ice sensor in order to automatically detect snow or ice and begin operation of the system. The system shall continue to run unit the sensor is dry or the control is manually stopped.
18. The control shall have the ability to be manually started with an adjustable running time that counts down and automatically stops the system.

19. The control shall have the option of connecting a remote display module to allow for remote monitoring and adjustment of the control.
20. The control shall have the option of connecting a remote start/stop module to allow for starting and stopping of the system.
21. The control shall not operate the system to provide heat to the snow melting zones when it enters into either a warm weather shut down (WWSD) or a cold weather cut off (CWCO) mode.
22. Approved Sensors:
    a. Outdoor Sensor 070.
    b. Snow/Ice Sensor 090, 65 foot Wire.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Hydronic radiant heat tubing loops shall be installed in accordance with the manufacturer's recommendations and the details as shown on the contract drawings.

B. All fittings should be accessible for maintenance. Tubing loops shall be installed without splices, as a minimum, from the point at which the tubing enters the panel to the point at which it exits the panel.

C. Installation shall follow the shop drawings for tubing layout, tube spacing, manifold configuration, manifold location, and controls. All notes on the drawing shall be followed.

D. The tubing system shall be pressurized, with water or air, in accordance with applicable codes, or to a pressure of 60 psig 24 hours prior to encasement in the radiant panel. The tubing system shall remain at this pressure during the panel installation and for a minimum of 24 hours thereafter to ensure system integrity. The contractor shall provide the water or air for the pressurization of the tubing system. The contractor assumes all liabilities for suitable safety precautions and testing, including the use of compressed air, when applicable.

E. At start up time, the contractor shall: follow the manufacturer's recommendations for system water and temperature balancing, record balance settings at each manifold location, and deliver to the owner a complete record of these settings for inclusion in the operation and maintenance manuals.

END OF SECTION 23 5721

SECTION 23 5726 – SHELL AND TUBE HEAT EXCHANGERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings, General Provisions of Contract, including General and Supplementary Conditions and Section 23 0501 apply to this Section.

1.2 SUMMARY

A. Furnish and install heat exchanger as described in Contract Documents.

1.3 QUALITY ASSURANCE

A. Construction shall conform to latest ASME Code for unfired pressure vessels.

B. A Manufacturer's data report for pressure vessels, form No. U-1 as required by the provisions of ASME Code Rules, is to be furnished to the Engineer for the Owner upon request. This form must be signed by an authorized inspector, holding a National Board commission, certifying that constructions conforms to the latest ASME Code for pressure vessels as detailed in Form No. U-1.

C. ASME "U" symbol shall be stamped upon heat exchanger.

PART 2 - PRODUCTS

2.1 MANUFACTURED UNITS

A. Heat exchangers shall have capacities as shown on drawings.

B. Shell and tube, U-bend removable tube bundle, steam in shell, water in tubes.

C. Equipped with mounting legs.

D. Steel shell, tube sheet and support, cast iron header and ¾" O.D. copper tubes.

E. Approved Manufacturers:
   1. Bell & Gossett
   2. Or approved equal.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install according to Manufacturer's instructions.

END OF SECTION 23 5726

SECTION 23 5728 – INTERNAL FACE & BYPASS COIL

PART 1 - GENERAL

1.1 Furnish IFB coil with performance as shown in the schedule. The unit inlet and discharge flanges shall be pre-punched and designed for easy adaptation to external duct work or optional accessories. The unit shall include all components and accessories as set forth herein.

A. Coil shall have horizontal tubes.
B. All coils will be built with orientation and control locations as indicated on drawings.
C. The coil shall be manufactured by the L.J. Wing Company.

1.2 CERTIFICATION

A. Certified in accordance with the AHRI Forced-Circulation Air-Cooling and Air-Heating Coils Certification Program which is based on AHRI Standard 410 within the Range of Standard Rating Conditions listed in Table 1 of the Standard. Certified units may be found in the AHRI Directory at www.ahridirectory.org. Each coil shall carry ETL label for compliance with UL Standard 1995 and bear the seal indicating manufacturer's compliance. All electrical components shall be UL/CSA approved devices.

PART 2 - PRODUCTS

2.1 HEATING COIL CONSTRUCTION & MATERIAL

A. Coil shall consist of a built-in series of finned heating elements.
B. By-passes with mechanically interlocked dampers shall be designed into the casing of each unit.
C. Coil shall be capable of maintaining a constant discharge air temperature within +/-5 degrees F regardless of variations in entering air temperature.
D. Finned heating elements shall be fabricated of seamless 5/8 inch O.D. hairpin type copper tubes with 0.035 inch wall thickness.
E. Each element shall be individually secured to the supply and return headers by a brazed joint. Each element shall be individually removable for ease in maintenance and repair.
F. Fins shall be rectangular embossed aluminum with a thickness of 0.010 inch.
G. Headers shall be constructed of Schedule 40 steel pipe with a minimum wall thickness of 0.216". Each tube shall be free to expand and contract individually. Channel-shaped tube retainers shall maintain distances between tubes and shall be free floating to allow for tube expansion.

2.2 DAMPERS AND CASING CONSTRUCTION

A. Dampers shall be arranged so as to completely enclose and isolate the heating elements of the coil when no temperature rise is required.
B. Intake dampers shall be constructed of heavy gauge galvannealed steel die-formed to an aerodynamic shape designed for minimum airflow resistance. Outlet dampers shall be constructed of heavy gauge galvannealed steel.
C. Damper position shall be controlled by direct coupled actuator. Individual face and by-pass damper blades shall be interconnected through precision punched 1/4" thick steel bar with brass pins. Misadjustment of individual dampers will not be possible.
D. Casing shall be constructed of heavy gauge galvannealed steel.

PART 3 - EXECUTION

3.1 OPERATION

A. Volume of air passing through the coil shall not vary more than +/-5% regardless of the position of the internal dampers.
B. The temperature at any point in a parallel plane to the face of the coil three feet downstream from

the leaving air side will not vary more than +/-5 degrees F from the average discharge air stream temperature.

3.2 OPTIONS & ACCESSORIES

A. Electric Controls with Airstream Thermostat (Option #40160)
B. Dampers shall be actuated by a direct-coupled, factory furnished, 24 volt Belimo electronic proportional damper actuator and discharge airstream thermostat to maintain constant leaving air temperature.
C. Actuator shall be designed to receive a 2 vdc control signal. In the event of a control failure, damper actuator shall remain at the last controlling position.
D. Air Dried Enamel Paint (Option #40311)
E. Damper and casing surfaces shall be finished with air-dried, alkyd enamel paint.
F. 2-10VDC Control Signal (Option #40330)
G. Manufacturer shall provide controls to accept 2-10 vdc control signal.

END OF SECTION 23 5728

SECTION 23 8820 - FAN COIL UNITS

PART 1 - GENERAL

1.1 SYSTEM DESCRIPTION

A. Horizontal and Vertical, Direct Drive,4-pipe, room fan coil unit with painted finish cabinet for exposed installation or ducting.

1.2 QUALITY ASSURANCE

A. Unit shall be tested in accordance with ARI Standard 440 and ETL listed to US and Canadian safety standards. Each coil shall be factory tested for leakage at 600 psig air pressure with coil submerged in water. Insulation and adhesive shall meet NFPA-90A requirements for flame spread and smoke generation. All equipment wiring shall comply with NEC requirements.

1.3 DELIVERY, STORAGE AND HANDLING

A. Each unit shall be individually packaged from point of manufacture. Unit shall be handled and stored in accordance with the manufacturer's instructions.

1.4 Approved Manufacturers

A. Magic Air
B. IEC
C. Or Approved Equal

PART 2 - PRODUCT

2.1 EQUIPMENT

A. General:

Factory-assembled, horizontal, vertical, draw-thru type fan coil for exposed or concealed installations, ducted or free discharge with plenum. Unit shall be complete with water cooling coil, water heating coil, fan(s), motor(s), drain pan, and all required wiring, piping, controls and special features.

B. Base Unit:

1. Units shall be fabricated of galvanized or galvannealed steel, 19gauge, exterior panels with 19gauge interior panels. Internal insulation is 1" fiberglass with1.5 pound density, providing effective acoustical and thermal control and fire safety. Cabinet shall include a removable bottom access panel with a ducted return air, filter rack and 2-in. fiberglass throwaway filter or 2-in. pleated MERV 8 filter. Cabinet exterior has a baked on polyester powder-coated finish for corrosion and scratch resistance while providing an enhanced appearance. Painted panels shall pass 500 hour salt spray test as described in ASTM B-117. Fan access and filter doors shall be hinged and utilize ¼-turn or ½-turn slot head latches for service convenience. Optional: coated inner liner panels have average 3mil thick antimicrobial coating that provides 750hr salt spray rating per ASTM B117.

2. The drain pan shall extend the entire length and width of the coil, with primary and auxiliary connections that are ¾" FPT.
   a. Standard – double-sloped polymer with zinc plated carbon steel connections.
   b. Optional – 20ga 304 stainless steel. Drain pan shall have average 3mil thick antimicrobial coating that provides 750hr salt spray rating per ASTM B117.

C. Fans:

1. Direct-driven, double-width fan wheels with forward curved blades shall be statically and dynamically balanced. The housing shall be constructed of heavy gauge galvanized steel with die-formed inlet cones. Fan wheels shall be constructed of galvanized steel.
2. Backward curved fans shall be welded construction, statically and dynamically balanced with motor integrated into the wheel.

D. Coils:

1. Standard base unit shall be equipped with a 3 or 4-row CW coil for installation in a 4-pipe system.
2. Hot water heating coils in a 4 pipe system shall be 2-row water coils, slab style perpendicular to airflow, factory installed. Coil fin spacing shall be 10, 12 or 14 fins per inch (FPI). Tube diameter options are 3/8" OD and ½" OD.
3. All coils shall have copper tubes and aluminum fins. Coil fins are mechanically bonded to tubes. The copper tubes comply with ASTM B-75. The fin thickness is 0.0045-in. All coils are tested with air under water.

E. Controls and Safeties:

1. Fan Controls: Unit shall be furnished with 24V fan controls to allow control by field-provided and installed 24V thermostat. Options include:
   a. ECM-Premium or Integrated ECM motor controls: variable speed driven by unit-mounted potentiometer
   b. ECM-Premium or Integrated ECM motor controls: variable speed driven by customer-provided 4-20mA fan signal
   c. ECM-Premium or Integrated ECM motor controls: variable speed driven by customer-provided 0-10VDC fan signal
2. Optional factory-wired selections:
   a. Integral door disconnect switch
   b. Fan current switch (dry contacts)
   c. Condensate overflow switch (shipped loose, field wired to factory-wired harness)

F. Operating Characteristics:

1. A unit with single hydronic coil installed in a 2-pipe system shall be capable of providing heating or cooling as determined by the operating mode of the central water supply system and as determined by field-provided and installed valves and controls.
2. A unit with two hydronic coils installed in a 4-pipe system shall be capable of providing heating and cooling, controlled as determined by field-provided and installed valves and controls.
3. A unit with single DX coil installed in a standard split system shall be capable of providing cooling when field-supplied and installed condensing unit is in cooling mode. Also capable of heating when heat pump condensing unit is operating in heating mode.
4. In all arrangements, the temperature controls are field-provided and installed and can interface with the unit per section “Controls and Safeties.”

G. Electrical Requirements:

1. The unit power supply shall be 60 Hz, with standard construction 208/240V/1-phase.

H. Motor(s):

1. Fan motor options are:
   a. ECM-Premium electrically commutated motor, up to 40% more efficient than permanent split-capacitor type induction motors, with control options including field-adjustable fixed speed and continuously variable speed options.
   b. Integral ECM electrically commutated motor built into the plenum fan wheel assembly, up to 40% more efficient than permanent split-capacitor type induction motors, with field-adjustable fixed speed and continuously variable speed options.

I. Field Installed Accessories:

1. Return Plenum – single wall plenum, 16” high with options: return grille, outside air damper for up to 30% OA airflow at full open position, with factory installed 24V 25in-lb actuator ready for 0-10VDC field provided position signal; ¾” closed cell insulation, 19ga galvanized steel cabinet, cabinet exterior has a baked on polyester powder-coated finish for corrosion and scratch resistance while providing an enhanced appearance. Painted panels shall pass 500 hour salt spray test as described in ASTM B-117. Fan access and filter doors shall be hinged and utilize ¼-turn or ½-turn slot head latches for service convenience. Foam seals and flanged sides allow easy field connection to the NDB unit. Plenum may be used as a discharge plenum when installed on the top of the unit.
2. Return Plenum with Filter – same as Return Plenum but 20” high and with 4” MERV 13 filter and hinged front access door with tool-less hardware for ease of service. Not for discharge service.
3. Condensate Overflow Switch – thread-in PVC housing with liquid level sensing overflow switch, field installed, for use in 24VAC or 24VDC control systems and thermostats; switch assembly is pre-wired to easily interface with the NDB unit controls and is field installed in the ¾” FPT auxiliary condensate drain connection on the unit exterior.

PART 3 - PRODUCT

3.3 INSTALLATION

A. Support horizontal unit from structure above using Unistrut P-1000 channel and Unistrut swivel hanger M2137, or equal as approved by Architect prior to bidding.

END OF SECTION 23 8820

END OF DIVISION