MECHANICAL INDEX

DIVISION 15 – MECHANICAL

SECTION 15001 - GENERAL PROVISIONS

1.1 GENERAL

A. The General Conditions and Special Conditions and all other Contract Documents shall apply to this Division of the work as well as to all other Divisions.

1.2 SCOPE

A. This branch of the work includes coordination with all utility companies; providing utility meters; utility tap on fees; agency review fees and all inspection fees; all labor, materials, tools, excavation and backfill and all equipment necessary for the installation of all Heating, Ventilating and Air Conditioning and Fire Protection as shown on the Drawings and Specifications and/or as required for complete and operating systems. The work shall include starting, balancing and the necessary and required tests to insure the proper operation of the complete system.

B. The HVAC system design shall be a 2-pipe geothermal water source heat pump system and central variable speed pumping system; variable refrigerant system for office area; DDC and Electric Temperature Control System.

C. The building addition shall be 100% sprinkled.

D. All work for this project must comply and be in strict accordance with the Kentucky Building Code, Kentucky Plumbing Code, Kentucky Boiler Code, NFPA, ADA, NEC and all local codes and regulations.

E. In general (as a minimum) all materials and equipment must be installed in strict accordance with manufacturer's requirements; and provided with all required controls, internal fusing, relays, piping connections, electrical connections, ductwork connections, etc., to provide for complete and operable systems.

1.3 PERMITS, CODES, AND APPROVALS

A. Permits and Fees

1. All permits, tap on fees and agency review and inspection fees necessary for the complete HVAC, Fire Protection and Plumbing systems shall be obtained by the Contractor from the authorities governing such work. The cost of all permits shall be borne by the Contractor.

B. Codes

1. The minimum standard for all plumbing work shall be the requirements of the Kentucky State Plumbing Law, Regulation and Code, Kentucky Building Code, ADA, The Division of Water Quality and local ordinances. HVAC and Exhaust systems and all mechanical, plumbing, fire protection and electrical work for this project must as a minimum comply and be in strict accordance with the Kentucky Building Code, Kentucky Plumbing Code, Kentucky Boiler Code, NFPA, ADA, NEC, The Division of Water Quality and the "Standards of Safety" of the Commonwealth of Kentucky.

C. Approvals

1. All work must be approved by the Architect/Engineer, Owner and all related Code Agencies before final payment will be made.

2. As a minimum, the following approval Certificates of Inspection and Approval shall be required:

a. Plumbing Inspection

b. Fire Protection Inspection

c. Health Department Inspection

d. Electrical Inspection

e. Local and Stage Building Inspections.

3. Final payment will be contingent upon all Approval Certificates.

1.4 MECHANICAL DRAWINGS AND SPECIFICATIONS

A. The Drawings and Specifications are intended to cover all work enumerated under the respective headings. The Drawings are diagrammatic only as far as final location of pipes, ducts relative size, etc., is concerned. Any item of work not clearly included, specified and/or shown, errors or conflict between Plans (Mechanical, Architectural, Structural or Electrical), Specifications, codes and field conditions, shall be clarified by a written request to the Architect by the Bidder before bidding; otherwise, the bidder shall, at his own expense, supply the proper labor and materials to include these items of work and to make good any damages or defects in his work caused by such error, omission or conflict. Under no circumstances shall a Contractor scale the Drawings for the location of equipment and work.

B. Piping schematics, risers, motors and details shown on the Drawings are for the equipment specified hereinafter. All revisions, modifications or changes in piping, accessories etc., due to using equipment of a different manufacturer than specified hereinafter, shall be the responsibility of the bidder and shall be made at no additional cost to the Owner. All modifications or changes shall be submitted to the Architect in writing and meet with his approval before the equipment is released for shipment.

C. The Contractor shall be responsible for all revisions, modifications or changes necessary in the structural, architectural or electrical drawings and/or work to accommodate the equipment to be furnished under this section of the Specifications. This shall be made at no additional cost to the Owner.

D. Mechanical as built "Record Drawings" shall be kept up to date each day. "Record Drawings" shall be reviewed by Architect/Engineer each month with contractor's pay request review.

E. Any deviation in work as shown on plans and specifications must be approved in writing by Architect/Engineer prior to installation.

1.5 MATERIAL AND WORKMANSHIP

A. Material and workmanship shall comply with the General Conditions of these Specifications.

B. All material and equipment and locations of same shall at least conform with the standards of the Underwriters' Laboratories, Inc., whenever applicable.

1.6 ACCESSIBILITY

A. All equipment, valves, motors, damper operators, traps, unions and all other items which require adjustment, maintenance, repair and observation shall be installed in such a fashion that such maintenance, repair and observation can be readily achieved without undue difficulty including complete removal of heat pump units. Where the drawings show these items in locations not conforming to the above, the Contractor shall advise the

Architect/Engineer of this conflict prior to bid Date otherwise he shall, at his own expense, relocate such items as directed by the Architect/Engineer. Where such items are installed above inaccessible ceilings or in or behind walls, this contractor shall provide approved access panels unless otherwise directed in these Specifications.

1.7 ARCHITECTURAL DRAWINGS AND SPECIFICATIONS

A. Each Contractor shall refer to the Architectural and Structural Drawings and Specifications for the general construction of the building, for floor and ceiling heights, for location of walls, partitions, beams etc., and shall be guided accordingly for the setting of all sleeves and equipment.

B. Under no circumstances shall a Contractor scale the Drawings for the locations of equipment and work.

1.8 COOPERATION WITH OTHER CONTRACTORS

A. Each Contractor shall demand and examine all Drawings and Specifications pertaining to the construction before installing the work described and shown under these Drawings and Specifications. Each Contractor shall cooperate with all other contractors in locating piping, openings, chases and equipment in order to avoid conflict with any other contractor's work. It is the responsibility of all trades to examine all shop drawings of other trades that would require equipment to occupy the same space and plane within the building to eliminate any potential conflicts. No extra payment will be allowed for relocation of piping, ductwork, and equipment not installed in accordance with the above instructions, and which interferes with work and equipment of other contractors.

1.9 INSTALLATION OF EQUIPMENT

A. All appliances, materials and equipment shall be installed and connected in accordance with the best engineering practice and in accordance with manufacturer's instructions and recommendations. All auxiliary piping, special controls, water seals, valves, electrical connections, drains, etc., recommended by the manufacturer, required for proper operation, or required by code shall be furnished and installed complete.

B. All equipment designed and constructed for indoor use shall not be shipped to the site until such time that the equipment is ready for permanent installation in a dry building or may be stored on site provided equipment is stored in a water and moisture tight storage building or job trailer. Covering equipment outdoors with plastic or tarp is not acceptable.

1.10 PROTECTION

A. No piping shall be installed in any part of the building where danger of freezing may exist without adequate protection being given, whether or not insulation is specified for the particular piping. All damage resulting from leaking pipes shall be borne by the Contractor under this Division.

B. All work, equipment and materials shall be protected at all times. All pipe openings shall be closed with caps or plugs during construction. All equipment and accessories shall be tightly covered and protected against dirt, water or other injury during the period of construction.

C. If the permanent HVAC equipment is used during construction period for temporary heating, cooling and ventilating, the equipment must be carefully protected, and filters changes at minimum of once a week. All return air and exhaust air ductwork used in

temporary HVAC systems during construction period must be filtered at each opening to prevent construction dust from entering the ductwork system.

D. Before the building is turned over to the Owner all of the equipment must be carefully cleaned of debris and dust, coils cleaned and flushed out, new filters installed, and all ductwork cleaned of debris and dust.

1.11 OPENINGS AND ESCUTCHEONS

A. The Contractor under this Division shall be responsible for the openings he may require in floors, walls or ceilings of any type construction whether or not shown on the Architectural and/or Structural Drawings.

B. Openings that have been shown on the Architectural and/or Structural Drawings will be provided under other Divisions; however, the responsibility for the correct size and location of such openings shall be that of the Contractor under this Division.

C. Openings that have not been shown on the Architectural and/or Structural Drawings shall be provided by the Contractor under this Division as follows:

1. Passages for pipe through masonry and concrete walls and floors shall be by means of standard weight steel pipe sleeves. With the approval of the Architect, holes may be cut and sleeves may be omitted in areas having thin or lightweight construction. Holes shall be cut by means of rotating drill bits or saws, producing a neat and accurate fit for the pipes. No hammer devices will be permitted. Such holes shall be not more than one half inch (1/2") greater in diameter than the external diameter of the pipe. Cutting of holes in structural slabs or members will not be permitted without approval of the Architect/Engineer.

2. Openings for insulated piping such as heating, domestic hot and cold water, etc., shall be of sufficient size to allow the insulation to pass through uninterrupted with the piping.

3. Cast iron sleeves shall be installed through walls where pipes enter the building below grade and at all fire rated assemblies. Sleeves shall be flush with each face of the wall and shall be sufficiently larger than the entering pipe to permit thorough caulking with lead and oakum between pipe and sleeve for waterproofing.

4. Openings for ductwork fixtures, equipment, etc., through floors, walls or ceilings, shall be located and sized by the Contractor under this Division who shall provide and set necessary sleeves or sheet metal forms for all such openings through concrete walls, floors or the roof slab. For openings required through ceilings, walls or roof construction, the Contractor under this Division shall furnish and install all necessary frames, supports, lintels, etc., required for the openings, such as plaster frames for registers and recessed equipment frames.

D. Smoke and Firestopping

1. Shall be provided between ductwork and its opening through all walls, floors and partitions. Firestopping shall be provided between sleeves and piping which pass through walls, floors or partitions. This contractor shall furnish and install fire protection sealant where pipes pass through fire rated walls, partitions, ceilings or floors. The fire rated integrity of the assemblies must be maintained.

2. The materials used shall be UL 263 and UL 1479 classified and meet ASTM E814 standards and be rated for assemblies where applied. Material shall be installed in strict accordance with manufacturer's recommendations and published literature.

3. Furnish and install 3M "Interam Fire Protection Systems", DOW CORNING or Hilti "Fire Stop" System.

E. All exposed piping passing through floors, ceilings and walls in finished areas shall be fitted with a chrome plated escutcheon of sufficient outside diameter to amply cover the sleeved opening and an inside diameter to closely fit the pipe around which it is installed.

F. Galvanized sheet metal collars shall be provided around all ducts, equipment, etc., exposed in finished areas. Where such openings are finished and the space around the unit is small, the collar may be omitted with the approval of the Architect.

1.12 CUTTING AND PATCHING

A. No cutting and patching of new finished work will be permitted without the approval of the Architect, and such work shall be done only under his direction. Coordinate all openings with Architectural specifications.

B. All work improperly done or not done at all, as required in preceding article "Openings and Escutcheons", will be performed as directed by the Architect/Engineer and at the expense of the Contractor whose work is affected.

1.13 SERVICE AND GUARANTEE

A. Contractor shall be responsible for guaranteeing all work, including equipment, materials and workmanship furnished under this section of the Specifications.

B. The warranty created by Article 3.5 of the General Conditions remains enforceable throughout the period of the Kentucky statute of limitations. The Warranty is different from the one-year correction period defined in General Conditions Article 12.2.2. except for items of equipment requiring explicit extended warranties, refer the Bidder/Contractor to General Conditions Articles 3.5 and 12.2.2 for warranty and correction of work.

C. Any defective work, equipment, materials and/or workmanship that develops within the guarantee period, which is not caused by ordinary wear, damage or abuse by others, shall be replaced and/or corrected without additional cost to the Owner.

D. Make a minimum of two (2) service calls during guarantee period, free of charge, to check with Owner and to check and repair malfunctioning equipment which was installed. Service calls shall be in middle and end of guarantee period and as required to maintain systems operation. Dates shall be listed in operating and maintenance manuals, along with contractor's name and phone number.

1.14 SHOP DRAWINGS

A. Each Shop Drawing and/or manufacturer's descriptive literature shall have the project name indicated thereon and shall be clearly referenced to the specification, section number, schedule, material, etc., so the Engineer may readily determine the particular item the Contractor or subcontractor proposes to furnish. Each submission shall also contain Date Submitted. If Shop Drawings and/or other items are transmitted by correspondence, each item of correspondence shall bear project name. (The shop drawings shall be submitted in ACCO Model 25071 Series binders with Presstex covers). At the Engineer's discretion, the Contractor shall submit additional shop drawings as deemed necessary.

B. The Mechanical Contractor must carefully review and stamp all shop drawings before submitting to Architect/Engineer. The Contractor must verify all quantities, sizes, left and right-hand connections, access door locations, horsepower, voltage, insure adequate clearance for installation and service, etc.

C. The Mechanical Contractor must coordinate all submittals with the Electrical Contractor to insure proper clearances with electrical equipment and to insure that all equipment with electrical connections are being submitted with proper voltage, proper left and right-hand electrical connections, proper relays, proper contactors, proper starters, etc.

D. Descriptive literature and Schedules shall be submitted as a minimum (but not limited to) the following:

Filter/Pot Feeder

Water Heaters	Insulation	Heat Pumps
Exhaust Fans	Sprinkler System	
Valves	Chemical Treatment	Pumps
Unit Heaters	Solid Separator	Louvers
Air Distribution Devices	Temperature Controls	
Misc. HVAC Specialties	Utility Trace Tape	
Energy Recovery Units /Ventilators	Multi-room split system heat pump	

1.15 CLEANING

A. After the Architect/Engineer has complete examination, this Contractor shall remove all stickers, tags, etc., and shall thoroughly clean all equipment, fixtures, and materials installed under his section of the work.

B. Surplus material, rubbish and equipment resulting from the work shall be removed from the building and premises by the Contractor upon completion of the work in accordance with the General Conditions.

C. All equipment shall be thoroughly cleaned to "Factory New" condition prior to turning over to owner. Touch up or completely repaint equipment as required.

1.16 EXAMINATION OF SITE

A. Bidders shall visit the site before submitting proposals to satisfy themselves as to the nature and scope of the work and any difficulties attending to the execution.

B. The submission of a proposal will be construed as evidence that such an examination has been made. Later claims for labor, equipment, materials, etc., required for difficulties encountered which could have been foreseen had such an examination been made, will not be recognized.

1.17 PAINTING

A. All exposed interior and exterior piping, ductwork and equipment not prefinished by equipment manufacturer or new equipment or items installed under this division shall be thoroughly cleaned and readied for painting. Painting shall be provided under the general contract, Division 9. Consult painting contractor for special surface preparations that may be required. See other paragraphs contained herein for pipe color coding for "Piping Identification".

1.18 SINGULAR NUMBER

A. In all cases where a device or piece of equipment is referred to in the singular number (such as grille, lavatory, etc.), it is intended that such reference shall apply to as many such items as are required to complete the installation.

1.19 CONCEALMENT OF PIPING AND DUCTWORK

A. In general, furred ceilings and joist spaces are provided in parts of the building to conceal horizontal piping and ductwork. Vertical risers serving downfeed heating and air conditioning units shall be installed concealed, unless shown otherwise on the Drawings.

B. In the Mechanical Room, attic and areas without ceilings and similar unfinished areas, piping and ductwork shall be installed exposed.

C. All work installed exposed shall be installed neatly to insure a pleasing final appearance. Vertical piping shall be perfectly plumbed.

D. Particular care shall be exercised in the location of ceiling diffusers and outlets to avoid conflict with the work of other Divisions. Surface units in the Ceiling shall fit into the acoustical ceiling suspension system and shall, in general, be symmetrical with the light fixtures.

E. Refer to the Architectural Room Finish Schedules for the areas having suspended ceilings and install the work accordingly.

1.20 CONCRETE WORK AND ANCHOR BOLTS

A. The Contractor under this Division shall provide all concrete bases, curbs and pads for all floor and ground mounted equipment unless otherwise indicated.

B. The Contractor under this Division shall verify the sizes and locations of all supports, bases and pads prior to pouring of same to be certain that the installed units will be compatible.

C. The Contractor under this Division shall set anchor bolts for the equipment prior to pouring of concrete. Sizes and exact locations of bolts shall be determined by the manufacturer's recommendations for the equipment served.

D. Concrete work must be provided in strict accordance with Section 03310 Concrete Work As a minimum provide pads using 3500 psi concrete reinforced with WI.4 x WI.4 welded wire fabric. Chamfer top and edge corners with 3/4" preformed chamfer strips. Slope top to floor drain if drain is provided in pad.

1.21 WORK AND EQUIPMENT UNDER OTHER DIVISIONS

A. The Contractor under Division 16 will provide all power wiring and conduit and install and connect each item of electrical equipment furnished under this Division unless specified otherwise. He will also provide starting equipment for motors not specified to have starting equipment furnished under this Division.

B. The Contractor under other Divisions will provide the following:

1. Painting of all mechanical work throughout.

2. Electrical work as noted in Paragraph (A) above.

3. Furnish and install all access doors shown on the Architectural Drawings.

1.22 FLASHINGS

A. The Contractor under this Division shall furnish and install all required flashing necessary for ducts, piping, fans, equipment, etc., which rest on or pass through the exterior walls and roof to insure a watertight installation. All penetrations shall be in strict accordance with Architects instructions. Verify prior to construction. Coordinate all roof flashing materials and procedures with Roofing Contractor.

B. Flashings for plumbing vents and drains shall be sheet lead weighing no less than 3 pounds per square foot or as required by Architect/Engineer and roofing manufacturer.

C. Flashings for all equipment must be in strict accordance with Architect/Engineer and roofing manufacturer's requirements.

1.23 VALVE TAGS AND CHARTS

A. The Contractor under this Division shall attach a numbered brass tag to each valve installed under this Contract. Each number shall be prefixed with the letter "H" for heating valves and "P" for plumbing valves. Tags shall be attached to the valves by means of brass "S" hooks. Tags shall be Seton Name Plate Co., C.H. Hanson Co. or Identifications.

B. A chart headed "HEATING AND AIR CONDITIONING VALVE CHART" and another chart headed "PLUMBING VALVE CHART" shall be prepared. Three original charts shall be prepared and approved by the engineer. One of each approved type chart shall be framed under glass and mounted on the wall in the main mechanical room where directed. Three photocopies of each chart shall be made and shall be submitted through normal shop drawing channels for approval and subsequent owner's files. Each chart shall be formatted as shown below: (All normally closed valves shall have a brass tag marked Normally Closed.)

PLUMBING VALVE CHART

OR

(HEATING AND AIR CONDITIONING VALVE CHART)

PROJECT NAME

DATE

TAG NO.	VALVE LOCATION	VALVE TYPE/SIZE	VALVE FUNCTION

1.24 DRIVES, SHEAVES AND GUARDS

A. Each belt connected fan motor unit shall be provided with a V belt drive equal to Browning, Dayton, or Worthington. Belts shall be standard or high capacity type.

B. Sheaves shall be cast iron or steel, bored to fit properly on the shafts and secured with key of proper size. Sheaves having set screws alone will not be acceptable. Sheaves shall be variable pitched and shall be designed to give the indicated RPM at approximately the mid position of adjustment. Pitch diameters of sheaves shall be not less than 3.0 inches for "A" section belts; 5.4 inches for "B" section belts; 9.0 inches for "C" section belts; and 13.0 inches for "D" section belts.

C. Belts shall be selected for a minimum service factor of 1.4 (based on motor nameplate horsepower) and selected and matched in sets for equal tension.

D. All other drives shall be as described under the respective equipment paragraphs, as applicable. The equipment manufacturer shall furnish additional belts, pulleys and/or sheaves as required to meet field conditions. The Mechanical Contractor shall install all

pulleys and belts as required and shall include labor and materials for the change-out of such devices in his base bid.

E. Belt Guards

1. Each belt drive shall be equipped with a guard, constructed of heavy sheet steel and designed to enclose all moving parts.

2. Guards shall be designed with adequate provision for motor adjustments. Means shall also be provided to permit oiling, use of speed counters and other maintenance and testing operations with the guard in place.

3. Where a guard is located on a fan inlet, guard shall have open mesh construction.

4. Guards shall be secured to the fans, foundations or floors by heavy angle supports and anchor bolts. Braces or supports secured to motors will not be permitted and braces or supports shall not "bridge" the vibration isolators.

F. Machinery Guards

1. Each rotating shaft flexible coupling shall be provided with a removable protective guard constructed of a U shaped heavy sheet steel plate with securing flange to floor or base. Length of guards shall be sufficient to overhang rotating couplings a minimum of 1" on each side.

1.25 MOTORS

A. Motors furnished under this Division shall have horsepower ratings sufficiently adequate to drive the equipment served at its rated capacity and shall have sufficient starting torque to overcome equipment inertia.

B. Motors shall be in accordance with the latest standards of the AIEE and NEMA, designed for specific voltage available and for continuous duty in 40 degrees C ambient temperature.

C. Motors shall be equal to General Electric, Westinghouse or Wagner. Unless specified otherwise, motors shall be open drip proof type.

D. Motors for all equipment shall have a nameplate rating at least 10% greater than the brake horsepower required for the equipment at rated capacity.

1.26 WIRING DIAGRAMS

A. The Contractor under this Division shall submit complete wiring diagrams to the Architect/Engineer for approval. Wiring diagrams shall show all electrical connections for air conditioning units, starters, switches, motors, controls, etc.

B. Standard wiring diagrams of manufacturer's equipment will not be acceptable for this project unless they are altered to agree with the project requirements. Wiring diagrams shall include all interlocks with other equipment, whether furnished by the manufacturer or not.

C. After review by the Architect/Engineer, a copy of the wiring diagrams shall be given to the Contractor under Division 16.

D. Unless specified otherwise, power supply wiring to power connections on equipment will be provided by the Contractor under Division 16. The Contractors under Division 15 shall be responsible for the control wiring and correct sequence of operation of all mechanical equipment after all wiring has been completed. Control wiring shall include wire, conduit and miscellaneous materials required for connecting control devices. The

Control Contractor shall provide power wiring and connections to control equipment if this required power wiring is not shown on the Electrical Drawings and Specifications.

1.27 ACCESS PANELS

A. Access panels shown on the Architectural Drawings will be furnished and installed under Division 8. In addition, the Contractor under this Division shall furnish all other access panels needed for access to valves, vents, fire dampers, heat pump units, etc., in inaccessible locations installed under this Division of the work.

B. Access panels shall have a minimum size of 12" x 12" and shall be centered beneath equipment for accessibility and maintenance. Access panels must be of adequate size to service, observe, remove and maintain equipment.

C. Access panels shall be equal to the types specified under the Architectural Specifications. As a minimum the access panels shall be equivalent to Cesco Products style FB/FB SS, Besco, Inryco/Milcor, Phillips or equivalent, 14 gauge with vandal proof lock and frame as selected by Architect.

D. Ceiling Types

1. In areas with suspended acoustical tile ceilings (installed on exposed metal grid suspension system so that the tile may be readily removed), equipment, valves, etc., install above these ceilings will be considered to be accessible. Metal grid must be installed at heat pumps in such a manor as to be removable for removal of heat pump units.

2. All plastered ceilings or ceilings having concealed spline type of suspension system will be considered as not removable for accessibility to equipment; therefore, access panels will be required.

3. See Architectural Drawings and Specifications for the types of ceilings throughout the building.

1.28 EQUIPMENT DRAINS

A. Provide a drain line from each item of equipment requiring a drain (cooling coil drain pans, pumps, backflow preventers, heat pumps, etc.) to the nearest floor drain, roof drain open receptacle, to outside of the building, or as shown.

B. Drains from units shall be trapped to provide easy water flow through the drain line. Install in strict accordance with manufacturer's recommendations.

1.29 EQUIPMENT IDENTIFICATION

A. Furnish and install on each item of equipment, such as pumps, switches, starters, pushbuttons, motors, fans, etc., a nameplate giving its name and function.

B. Nameplates shall be engraved bakelite (white letters on black background and shall be equal to Seton Nameplate Co., C.H. Hanson Co., or Identifications.

C. All names and numbers for equipment and rooms shall be approved by the Architect before nameplates are prepared so that correct identification will be used.

~~1.30 UNDERGROUND UTILITIES TRACE TAPE~~

~~A. Install in open trench approximately 14" above pipe, (but no more than 24" below finished grade), 4" wide trace tape to indicate location of water line. Tape shall be manufactured to be traceable with pipe detector above finish grade. Tape shall be bright yellow in color and stamped with the work "WATER" at regular intervals. The tape shall~~

~~be Terr Tape as manufactured by Griffolyn Co.; C. I. Thornburg, Seton Co., Bradey Co. or Craftmark.~~

~~B. Tracer tape similar to tracer tape specified above shall be provided over sanitary sewer marked "Sanitary Sewer" and over the storm sewers marked "Storm Sewers," and over gas mains marked "Gas".~~

1.31 OPERATIONAL INSTRUCTIONS

A. Furnish services of a fully competent operational instructor for a total of two (2) one day sessions days, unless otherwise specified, as directed by Architect/Engineer to instruct operating personnel in operations and care of all equipment and systems (including control systems) and their various components.

1.32 CONNECTIONS TO EQUIPMENT SPECIFIED IN OTHER SECTIONS

A. Examine all Contract Documents and be thoroughly familiar with all items of equipment in other sections or by Owner, unless otherwise specified or indicated on Drawings. Rough-in for and make final connections to all equipment which requires any of the services specified in this Section and including furnishing and install all valves, P-traps, unions, vacuum breakers and all other specialties as required to make all work and equipment final and operating. It is the intent of the Contract Drawings to detail and indicate all such equipment; however, be responsible for notifying Architect/Engineer in writing of major discrepancies seven (7) days prior to Bid Date; otherwise, all such connections shall be made at no extra cost.

B. Unless specified otherwise, all conduit, wiring and connections for power to mechanical equipment will be provided by Electrical Contractor. Be responsible for correct sequences of operation of all mechanical equipment after all wiring has been completed.

1.33 PLATFORMS AND SUPPORTING STANDS

A. Provide each piece of equipment or apparatus suspended from ceiling or mounted above floor level with suitable structural support, pipe stand, platform or carrier in accordance with best recognized practice, as approved by Architect/Engineer as indicated on Drawings. Such supporting or mounting means shall be provided by each Contractor for all equipment furnished by him, unless otherwise specified. Exercise extreme care that structural members of building are not overloaded by such equipment. Submit shop drawings on prefabricated or field erected equipment supports not detailed on Drawings.

1.34 EQUIPMENT MOUNTING

A. All equipment with moving parts such as compressor, fans and air handling units, shall be mounted on vibration supports suitable for purpose of minimizing noise and vibration transmission unless otherwise specified and, in addition, shall be isolated from external connections such as piping and ducts, by means of flexible connections, vibration, absorbers or other approved means. Unitary equipment, such as small room heating units and small exhaust fans, shall be rigidly braced and mounted to wall, floor or ceiling as required with toggle bolts or an approved expansion shield and bolt nd tightly gasketed and sealed to mounting surface to prevent air leakage and to obtain quiet operation. Flush and surface mounted equipment such as diffusers and grilles, shall be gasketed and sealed to mounting surface. All roof mounted exhaust fans shall have 1/2 inch gasket between fan and curb.

1.35 EXPANSION COMPENSATORS

A. Erect piping to provide for expansion and contraction without harmful strain to building structural members, pipe and vibrating equipment. Provide expansion bends or devices other than those indicated, if, in Architect's/Engineer's opinion, such devices are required by field conditions. Unless indicated otherwise, expansion bends are preferred to use of expansion joints and shall not be substituted without Architect's/Engineers written permission.

1.36 VIBRATION AND SOUND CONTROL

A. Be responsible for unnecessary or undue vibration or sound transmitted throughout building due to negligence of improper installation of material and equipment and be responsible for correction of such conditions.

1.37 CLEANING OF PIPING, DUCTWORK AND EQUIPMENT

A. Install and maintain pipe and equipment which is clean and free of dust, dirt and scale. Where roughed in only, provide temporary air-tight covers at all pipe, duct and equipment openings. Provide protection from elements.

B. Upon completion of work, thoroughly clean and lubricate all equipment; clean and flush all piping as often as necessary to satisfy Architect/Engineer and Owner that system is clear of oil, dirt, scale or other foreign matter; clean all strainers after flushing operation and prior to balancing; clean ductwork to insure system is clear of dirt or other foreign matter prior to balancing. See Section 15012 for Chemical Cleaning Requirements.

C. Keep all nameplates on equipment clean and exposed for easy reading. Air filters, if in equipment used during construction, shall be replaced and if field conditions warrant, vacuum clean all ductwork which is unduly filled with dust and debris, prior to balancing. See Equipment Protection Requirements listed herein.

1.38 WRENCHES - TOOLS

A. Furnish special wrenches or tools necessary to dismantle or service equipment or appliances installed. Wrenches shall include necessary keys, handles and operators for valves, cocks and hydrants. Number of wrenches furnished in proportion to devices installed shall be on a 50% basis, but not less than two (2) of each type shall be provided. All wrenches shall be neatly mounted on a three-quarter inch plywood panel properly marked with laminated plastic plates. Panel shall be fastened to wall where designated by Architect/Engineer.

1.39 UTILITY SERVICE MARKERS

A. Provide markers for underground utility service at a minimum of 200' increments and at each change in direction to define route of utility not already marked of hydrants, valves, poles or other visible surface features.

B. Markers shall consist of bronze plates, ground and polished, and marked to identify service. Markers shall be stamped with arrows indicating direction service extends.

C. Markers locating services at building shall be installed in masonry for concrete walls, approximately two feet above ground. Markers locating service elsewhere on site shall be installed in 6" x 6" x 2"-0" deep concrete bases. Coordinate all work with Architect/Engineer.

1.40 TESTS

A. See Section 15003 - Basic Materials and Methods.

1.41 STERILIZATION

A. Sterilize interior and exterior water distribution system as soon as water distribution system has been flushed out. System shall be sterilized by the following or other methods satisfactory to Architect/Engineer and State Department of Health. A written certification of the sterilization test & method of testing shall be submitted to Architect/Engineer for their review.

B. Introduce chlorine or a solution of calcium or sodium hypochlorite into entire system of domestic water piping. Fill lines slowly and apply chlorine solution at concentration of 50 parts per million. Open and close all valves and hydrants while system is being chlorinated. Let chlorine solution stand in system 24 hours and test for residual chlorine. Test shall be taken at farthest point in piping system from where chlorine is introduced. If less than 25 ppm is indicated, drain system and repeat sterilization process. After a chlorine residual of at least 25 ppm is obtained, flush system until chlorine content equals that of water supplied by public water system. Architect/Engineer shall be notified 48 hours in advance of above test and his representative shall be present when test is run.

C. The Contractor shall take four (4) water samples as directed by Architect/Engineer and have samples tested by an independent testing agency or as directed by the local Health Department. Test results shall be submitted to the Architect/Engineer.

D. Architect/Engineer reserves right to test water again at any time prior to final acceptance of work and if found unsafe bacteriologically, to require Contractor to rechlorinate system until water is proven equal to that supplied by public system.

1.42 PIPING IDENTIFICATION

A. Stencil all exposed piping, piping above lay-in ceiling, exposed piping located behind and within 4' 0" of all access panels.

B. Stencils shall be machine cut, applied after the final coat of paint using enamel paint, shall be installed on the piping at not over 20 foot intervals (or in each room whichever is greater) and shall have the following heights:

1. On pipe sizes 3" and over letters shall be 2" in height.

2. On pipe sizes smaller than 3", letters shall be 1" in height, colors for lettering shall be as scheduled herein.

C. In addition to the preceding stencils giving identification, provide arrows at each stencil giving the direction of flow of the material. Where flow can be in either direction, provide double ended arrows. Each tee in piping shall be provided with markers on all three outlets. All zones shall be properly marked by zone numbers as noted on the Drawings.

D. All stencils and arrows shall be properly orientated so that descriptive name may be easily read from the floor. Install stencils and arrows on lower curvature of overhead piping and on side panel near bottom or on bottom of ductwork. (Glue-on or stick-on labels are not acceptable.)

E. Schedule Examples

Pipe	Abbr.	Pipe Color Code
Domestic Cold Water	DCW	Blue with Black Letters

Domestic Hot Water	DHW	Blue with Black Letters
Domestic Recirculating Hot Water	DRHW	Blue with Black Letters
Condensate Drain	CD	Gray with Black Letters
Heat Pump Water Supply	HPS	Green with Black Letters
Heat Pump Water Return	HPR	Green with Black Letters
Sprinkler Piping	F	Red with White Letters

1.43 CATALOG DATA FOR THE OWNER (MAINTENANCE, OPERATION AND INSTRUCTION MANUALS)

A. The contractor under this Division shall prepare three (3) loose leaf, plastic bound 3 ring binders labeled on front cover, title page and binder edge "Job Title" (as indicated on the contract document) "Heating, Air Conditioning, Fire Protection and Plumbing Operations and Maintenance Data." Each manual shall be subdivided with section tabs and shall contain a title page and index. The title page shall contain the following information:

1. Job Title
2. Heating, Air Conditioning, Fire Protection, Plumbing Operation and Maintenance Manual
3. All Contractor Names, Address, Phone # and Contact Person
4. Architect and Engineer's Name, Address and Phone #

B. Each manual shall contain the following information:

1. Name and address of Consulting Engineer, Contractor, and index of equipment, including vendor (name and address).
2. Complete brochures, descriptive data, etc., on each piece of equipment, including all approved shop drawings. (The contractor must retain three (3) sets of approved shop drawings for this purpose).
3. Complete maintenance and operating instructions and parts list, prepared by the manufacturer, on each major piece of equipment. This includes blow-out views with labeled parts list.
4. All wiring diagrams for equipment and systems and control schematics. See paragraph on wiring diagrams listed herein before.

C. Manuals shall be submitted to the Architect prior to final inspection of the buildings.

1.44 TEMPORARY HEAT AND WATER

A. See Division 1 for temporary heat and water requirements.

B. See Protection of HVAC Equipment listed herein.

1.45 ACCEPTANCE OF MATERIAL AND MANUFACTURERS

A. The Architect/Engineer reserves the right to determine if the contractor's proposed materials and equipment of any one manufacturer is acceptable in lieu of the specified material or equipment.

B. Where materials and equipment are listed on Drawings and specifications as acceptable or equivalent, this does not relieve the contractor and/or manufacturer from providing and

proving to Architect/Engineer that their materials and equipment are equivalent to items the Architect/Engineer used as a guide specification.

C. The contractor and manufacturer must confirm to the Architect/Engineer that their equipment and materials will meet the space requirements of the project and that the equipment is easily accessible for maintenance and operation.

1.46 CLOSEOUT DOCUMENTS

A. Prior to this project to be considered as "Substantially Complete" the following documents must be presented and approved.

1. All required approval/inspection letters from the state and local government levels; to include but not limited to:

a. Certificate of Inspection and Approval - Kentucky State Department of Health Plumbing Inspector.

b. Kentucky Department of Housing, Buildings and Construction Approval Letter.

c. Division of Fire Prevention Approval Letter.

d. Kentucky Department of Environmental Protection/Division of Water Approval.

e. Kentucky Cabinet of Human Resources Approval Letter.

2. Owner's Operation and Maintenance Manuals.

3. Approved and mounted valve tag charts.

4. Complete air/hydronic balance report.

5. Hydronic system cleaning and treatment certification letter.

6. Domestic water (interior and exterior) sterilization report.

7. Record drawings approved and returned to the Architect/Engineer.

8. Evidence that all guarantees and warranties have been submitted on behalf of the owner.

9. Letter from each HVAC manufacturer stating that their equipment has been supplied in strict accordance with Contract Documents and that equipment has been checked out, started and is operating properly.

10. Letter from the Temperature Control Contractor stating that all controls have been installed in accordance with the Contract Documents and that all controls are operating properly.

END OF SECTION 15001

SECTION 15002 - PIPE TRENCHING AND BACKFILLING

1.1 GENERAL

A. The General Conditions, Special Conditions, Site Work and other Contract Documents shall apply to this Division of the work as well as to all other Divisions.

B. The Contractor under this Division shall do all excavation, backfilling, and grading required for this part of the work. Excavation shall include all earth, rock and other materials necessary for the installation of the new work. No sub surface data available except as noted in Division 2 of the Specifications. All trenching work is unclassified except as noted in Division 2.

C. See Site Utility Plans for utility work.

D. Lay in all pipe in open trenches. Open the trench sufficiently ahead of pipe laying to reveal obstruction.

E. Provide trench crossings as necessary to accommodate public travel.

F. See the following Articles for special requirements for Mechanical work.

G. No blasting will be allowed on this project unless approved by Architect.

H. Contractors must use extreme care in all excavation work and protect all existing utilities.

1. Contractors must comply with local utility companies requirements if more stringent than listed herein.

1.2 EXCAVATION

A. Separate Trenches

1. Unless otherwise shown or required, provide separate trenches for all services (sewers, water lines, etc.) with a minimum of three feet (3') of undisturbed earth between trenches. (All utilities installation must be coordinated with local utility companies and comply with their requirements; this includes materials and installation procedures).

B. Width of Trench

1. Excavate trenches of sufficient width for proper installation of work. When depth of backfill over sewer pipe exceeds ten feet (10') keep the trench at the level of the top of pipe as narrow as practicable.

C. Shoring and Bracing

1. Shore and brace trench as necessary to protect workmen and adjacent structures. Comply with local regulations or in the absence thereof, with the "Manual of Accident Prevention in Construction", of the associated General Contractors of

America, Inc. Do not remove shoring until trench is backfilled sufficiently to protect pipe and prevent injurious caving.

D. Water Removal

1. Keep trenches free from water while construction therein is in progress. Under no circumstances lay pipe or appurtences in water. Pump or bail water from bell hole to permit proper jointing of pipes. Conduct the discharge from trench dewatering to drains or natural drainage channels.

E. Disposition of Utilities

1. Local and state rules and regulations governing the utilities in this area shall be observed in executing all work under this heading. Active utilities shall be protected or relocated in accordance with instructions of the Architect, Owner, and Local Utility. Inactive and abandoned utilities encountered in trenching operations shall be removed, plugged or capped. In absence of specified requirements, plug or cap such utility lines at least three feet (3') from utility line to be installed or as required by the local regulations. Extreme care must be taken in all excavation work, since active utility lines are present throughout the area. Repair all damaged utility lines in strict accordance with the respective utility company's requirements. Coordinate with all local utility companies and the Owner prior to any excavation work.

F. Grading Trench Bottom

1. Grade the bottom of trenches evenly to insure proper slope for drainage. Perform final grading of trench bottom by hand and carry machine excavation only to such depths that soil bearing for pipes will not be disturbed. For piping to be laid on a grillage, excavate trenches to at least four inches (4") below the required bottom levels and refill to the proper grade with grillage specified hereinafter under Backfilling.

1.3 BACKFILLING

A. The utility piping systems shall be laid on a grillage of at least 6" of No. 9 crushed stone. After the systems have been installed and tested, install at least 12" of No. 9 crushed stone over piping and firmly compacted using mechanical tamper or backhoe bucket.

B. Backfill trenches only after piping has been inspected, and locations of pipe lines and appurtenances have been recorded. (See Section 15001 for requirements of underground utilities trace tape).

C. For depth of at least 12 inches above the top of the compacted crushed stone noted above, backfill with clean earth or crushed stone (free from stones, rock fragments, roots, sod, cinders, junk, refuse, scrap iron, and unused portions of welding rods). Tamp this backfill thoroughly (using mechanical tamper or backhoe bucket) in layers not exceeding 12" in thickness, taking care not to disturb the pipe or injure the pipe coating.

D. For the remaining trench depth, backfill with earth as specified in the preceding paragraph, except that the material may contain stones, rocks, concrete or masonry

materials (but no cinders) with a maximum dimension of four inches (4"), providing the voids in such coarse materials are completely filled with earth or granular material. In the event that sufficient suitable material, as specified here for trench backfill, is not available from trenching or other excavation for the project, the Contractor shall supply and place the requisite additional material without increase in the Contract Price. Compact thoroughly the backfill herein referred to with an approved mechanical tamper or backhoe bucket. Compaction must be similar to surrounding conditions. Backfill under all sidewalks, concrete slabs, and pavements shall be 100% #9 crushed stone or dense grade aggregate to under side of slab or pavement. Compact solidly with mechanical tamper in layers not more than six (6) inches.

1.4 GRADING

A. Finish grading of trenches on the site shall be as shown on the Architectural Drawings and stated in Division 2, and as directed by Architect.

B. For off site trenching or trenching beyond the normal construction limits, backfill shall be brought to existing grades.

C. Excess earth and other excavated material shall be removed from the property, unless otherwise directed by Owner.

1.5 RESTORATION OF SURFACES

A. The Contractor under this Division shall restore to their original conditions all sod, paving, curbing, surfaces, drainage ditches and structures, fences, curbs, and other items damaged or removed by his operations, which are not covered under other sections of the specifications to be replaced or repaired. Replacement and repairs shall be in accordance with good construction practice and shall match material employed in the original construction of the item to be replaced.

END OF SECTION 15002

SECTION 15003 - BASIC MATERIALS AND METHODS

1.1 WELDING AND BRAZING

A. All welds shall be of sound metal thoroughly fused to the base metal at all points, free from cracks; and reasonably free from oxidation, blow holes, and non metallic inclusions. No fins or weld metal shall project within the pipe; and should they occur shall be removed. All pipe beveling shall be done by machine. The surface of all parts to be welded shall be thoroughly cleaned free from paint, oil, rust or scale, at the time of welding except that a light coat of oil may be used to preserve the beveled surfaces from rust.

B. All pipe and fittings shall be carefully aligned with adjacent parts and this alignment must be preserved in a rigid manner during the process of welding.

C. It is required that all welding of piping covered by this Specification, regardless of conditions of service, be installed as follows:

1. Pipe welding shall comply with the provisions of the latest revisions of the applicable code whether ASME "Boiler construction Code," ANSI "Code for Pressure Piping," AWS and/or Kentucky KRS 236 "Boiler Safety Law". The Contractor shall make arrangements for inspection visits by the state boiler inspector as required by KRS 236 and must comply with all Boiler Inspector requirements.

2. The Contractor's welding procedure shall clearly set forth P numbers of parent metal to be welded, rod or filler metal to be used and positions required. Welder's qualifications shall specify results of test, or retest, positions qualified and type of welding in which qualified.

3. Before any pipe welding is performed, the Contractor shall submit to the Architect/Engineer a copy of his welding procedure Specifications together with proof of its qualification as outlined and required by the most recent issue of the code having jurisdiction.

4. Before any operator shall perform any pipe welding, the Contractor shall also submit to the Architect/Engineer, the operator's qualification record in conformance with provisions of the Code having jurisdiction, showing that the operator was tested under the approved procedure specification submitted by the Contractor.

a. Welding work shall not be performed by welders who are not approved by the Architect/Engineer, and any such work performed shall be summarily removed and replace without further recourse by the Contractor.

b. Standard Procedure Specifications and operators qualified by the National Certified Pipe Welding Bureau shall be considered as conforming to the requirements of the Specifications.

5. Each manufacturer or contractor shall be responsible for the quality of welding done by his organization and shall repair any work not in accordance with these Specifications.

6. Brazing, when specified or indicated on the Contract Drawings, shall be done in accordance with Part UB of Section VIII of the ASME Code.

D. All expenses in connection with the preceding shall be borne by the Contractor under this Division.

1.2 TESTS

A. The Architect/Engineer shall be notified by the Contractor under this Division forty eight (48) hours in advance of any tests so that the Architect/Engineer, or his representative may be present when the tests are run. Leaks or imperfections found shall be corrected and a new test run to the satisfaction of the Architect/Engineer. Upon successful completion of the test, pipe covering may be applied and piping may be concealed. A successful test, even if witnessed, however, does not relieve the Contractor under this Division of the responsibility for any failure during the guarantee period.

B. After pipe fabrication has been completed, all water piping shall be subjected to a hydrostatic test of 100 psi and proven tight and free of leaks for a 24 hour period. Tests shall be applied to the piping before being attached to any equipment which would be damaged by the test pressure. Damage to equipment caused by testing shall be repaired or replaced without additional cost to the Owner.

C. The sanitary sewer piping and sanitary waste, vent and drainage piping installed under this Division in, under or outside the building shall be tested by means of water, smoke or air in accordance with the Kentucky State Plumbing Law, Regulation and Code, Division of Water Quality and the local utility company requirements. These shall be made in the presence of the Plumbing Inspector and the Architect/Engineer.

D. Exterior water piping shall be tested in strict compliance with local water company. The minimum hydrostatic test pressure is 1 1/2 times the water pressure serving the site.

E. No insulation, paint, backfill or other prohibitive covering shall be applied to piping prior to the above tests.

F. Provide all temporary equipment, materials, valves, gauges, etc., required for the preceding tests.

G. The expense of all tests shall be borne by the Contractor under this Division.

H. All low pressure ductwork shall be air tested in strict accordance with SMACNA Standards.

1.3 EXPANSION OF PIPING

A. Risers and horizontal runs shall be equipped with the necessary expansion loops or arms to accommodate maximum expansion anticipated. Runouts to risers shall have offset swings between main and riser.

B. Provide expansion loops at the locations and of the dimensions shown on the Drawings and as required per field conditions.

1.4 GRADING OF PIPING

A. Heating and Air Conditioning Water Piping

1. In general, water piping shall be installed with top of pipes "dead level" unless shown otherwise on the Drawings. Where pitch is indicated, it shall be a minimum of 1/4" in 10 feet. Long supply and return runouts from mains shall pitch up in the direction of flow and terminate with air vents described hereinafter. System must be completely drainable. Install hose bibbs at low points as required.

B. Domestic Hot and Cold Water Piping

1. Water piping, except that installed "dead level" as necessary, shall be pitched down 1/4" in 10 feet toward low points so that the entire system can be drained completely.

C. Soil, Waste, Drainage and Vent Piping, Roof Leaders

1. Soil, waste, drainage and vent piping shall pitch 1/4" per foot where practicable, but in no case shall the pitch be less than 1/8" per foot.

D. Drain Lines

1. Drain lines from equipment shall pitch down 1/8" per foot in the direction of flow.

E. Drain and Vents

1. Low points in water piping shall be provided with 3/4" drain valves so that the entire system may be drained.

2. High points in heating/cooling water piping shall be provided with air vents as described hereinafter. Avoid piping conditions where air pockets can form.

1.5 PIPE ANCHORS

A. Provide anchors at the locations shown on the Drawings and as required per field conditions.

B. Anchors shall consist of heavy steel collars welded to pipe and secured to the building structure to prevent movement of piping.

C. Anchors shall be approved by the Architect/Engineer before installation is started.

1.6 PIPE SUPPORTS

A. Piping shall be run parallel to the building walls and shall be grouped in neat rows. Piping shall be supported to maintain required grading and to prevent vibration and shall be arranged to allow for expansion and contraction. Hanger rods longer than three feet (3') shall be restrained to prevent swinging of the pipes. Hangers shall be sized in accordance with the manufacturer's recommendations.

B. Where piping is to be supported from the concrete construction, provide inserts installed directly in the slabs. Concrete inserts shall be malleable iron; Grinnell Figure 282.

C. Where piping is to be supported from steel joist construction, provide supplementary steel angles or steel pipe welded between joists, or the use of approved joist and beam clamps. Steel members spanning between joists shall be attached to the top chord of joists not bottom chords. Where piping is to be supported from wood joist construction, hangers shall be supported by bolts thru center of joist.

D. In areas where concrete floors over steel decking is used, drill holes through deck into concrete and use expansion shields. Proof load of expansion shields in pull out shall be four times applied load. Steel decking alone shall not be used to support ductwork, piping, equipment, etc.

E. Piping, except as hereinafter specified, shall be supported by hangers, supports and/or stands, of the following Grinnell Figure Numbers:

1. Hangers

PIPE SIZES	HANGER
5" and smaller 2	60, steel clevis
6" and larger, or as detailed	171 (pipe roll with dual hanger rods)
Bare copper	CT 99 (copper plated), or CT 99C (plastic coated)

2. Stands

PIPE SIZES	FIGURE NUMBER
All sizes	274, adjustable prior pipe roll

F. Hangers and stand supports for all horizontal cold water lines shall be sized for the outside diameter of the insulated pipe. Insulation shall pass unbroken through the hanger and shall rest on insulation protector saddles fabricated from 20 gauge sheet steel. Saddles shall be 9" long and have an arc of approximately 120 degrees. Saddles may be job made or shall be Grinnell Figure No. 167.

G. Brackets for downfeed piping serving heating units shall be Fee and Mason No. 302 split ring extension hanger. Brackets shall be sized to fit the bare pipe.

H. Vertical plumbing piping shall be supported by Figure 261 riser clamps at each floor.

I. Steel supports, other than designed building structural members, required for support of piping installed under this Section of the Specifications, shall be furnished and installed under this Division.

J. Piping supports shall not be attached to any equipment having moving parts. Supports shall be independent of equipment by brackets to the floor, walls, or columns.

K. Maximum spacing of supports shall be as follows:

PIPE SIZES	SPACING
1 1/2" and smaller	8'
2" and larger	8'
Polyethylene Piping	5’
Cast iron pipe	Each length or 8' maximum

L. Comparable hangers, supports, etc., as manufactured by Fee and Mason, Elcen, or B-Line, Gateway will be considered equal to the Grinnell products providing the specifications are fully met. ½” through 2” pipe shall have 3/8” diameter hanger rods; 2 ½” and 3” pipe shall have ½” diameter hanger rods; 4” through 5” pipe shall have 5/8” diameter hanger rods; 6” through 8” pipe shall have ¾” diameter hanger rods.

1.7 PIPE AND PIPE FITTINGS

A. General

1. The General Conditions, Special Conditions, and the applicable portions of Division 1 of the Specifications are a part of this section.

2. The Contractor for this work shall be governed by any Alternate Bids requested insofar as they affect his work.

B. Scope

1. This work includes the furnishing of all pipe and pipe fittings, materials, equipment, labor, etc., necessary for the proper and complete installation of systems and equipment as shown on the drawings and/or herein specified.

C. Installation

1. All pressure pipe installations and fabrication shall be in accordance with the procedures established in the American Standard Code for Pressure Piping and the best recognized current practices of the trade. In addition, the same code shall be fully applicable to all services included herein. All sanitary soil, waste and vent piping shall be installed in accordance with the latest revisions of the Kentucky State Plumbing Code.

2. In general, all piping shall be installed concealed except in mechanical, storage, janitor rooms and etc., and shall be installed underground or beneath concrete slab on grade only where indicated. All lines at ceilings shall be held as high as possible and be run to avoid conflicts with other trades, and to facilitate the owner's use and access.

3. Piping shall be installed straight and true, parallel or perpendicular to walls, with approved offsets around obstructions. Standard pipe fittings shall be used for changing direction of piping. No mitered joints or field fabricated pipe bends are permitted, except that copper pipe 1/2" and smaller may be bent in the field with approved bending equipment, if authorized by the Engineer.

4. Tee connections for welded pipe shall be made up with welding fittings. Where the size of the side outlet is such that a different connection technique than on the run is required, a weld o let, socket o let, or thread o let type fitting may be used for the side outlet in place of reducing tees only where the outlet is 2/3 of the run size, or smaller.

5. Short radius elbows may be used only where specifically authorized by the Architect/Engineer.

6. Unless otherwise indicated on the Drawings, all piping shall be pitched to permit drainage and venting. Air vent lines shall be provided in all liquid under pressure at all high points and at drops in direction of flow and where otherwise indicated. Air vent valves in all water lines, except potable water lines, shall be manual type unless otherwise indicated and be piped to drain or as directed by the Architect/Engineer. All vents shall be installed easily accessible locations with extensions to cabinet face where installed in radiation cabinets.

7. Piping shall be erected to provide for expansion and contraction without harmful strain to building structural members, pipe and vibrating equipment. Provide expansion bends or devices other than those indicated if, in the opinion of the Engineer, such devices are required by field conditions. Unless indicated otherwise, expansion bends are preferred to the use of expansion joint and shall not be substituted without the permission of the Engineer. Expansion bends in steel pipe shall be made using long radius welding elbows. Expansion loops shall be cold sprung and welded into the line, which shall be anchored before removing the spreader from the expansion U bends.

8. Expansion loops, swing ells of joints shall be installed where indicated and where specified herein. Design and installation of expansion joints shall be such as to provide for the stresses and strains imposed by connected piping and vibrating equipment and by operating pressures, test pressures and temperatures.

9. Ream all pipe ends and thoroughly clean dirt, chips and foreign matter from all piping, fittings, valves and other accessories before joint connections are made.

10. Screwed joints shall be made with oil and graphite or other approved compound. Joint compound shall be applied to the male threads only and care shall be exercised to prevent compound from reaching the interior of the pipe.

11. Screwed unions, welded unions or bolted flanges shall be provided as required to permit convenient removal of equipment, valves and piping accessories from the pipe system. In concealed locations, union nuts shall be center punched to prevent loosening from vibration. Leave adequate clearances for rodding, motor lubrication, etc.

12. Copper tubing connections for water piping shall be made up with 95/5 tin antimony solder (50/50 solder not acceptable) in accordance with the recommendations of the manufacturer. Brass valves for use in copper piping 2" and larger shall have screwed or flanged ends with screwed or companion flanges and adapters to suit. Brass valves smaller than 2" may be soldered, but extreme care must be taken to prevent heat damage to valve.

13. Dielectric insulating unions or dielectric couplings shall be used wherever the adjoining materials being connected are of dissimilar material such as connections between copper tube and steel pipe.

14. Flanged joints shall be assembled with appropriate flanges, gaskets and bolting. The clearance between flange faces shall be such that the connections can be gasketed and bolted tight without imposing undue strain on the piping system. Flange faces shall be parallel and the bores concentric; gaskets shall be centered on the flange faces so as not to project into the bore. Bolting shall be lubricated before assembly to insure uniform bolt stressing. The flange bolts shall be drawn up and tightened in staggered sequence in order to prevent unequal gasket compression and deformation of the flanges. Wherever a flange with a raised face is used, the face shall be machined down to a smooth matching surface and a full face gasket shall be used.

15. Piping shall not be installed in locations subject to freezing; if in doubt, consult Engineer. Exterior lines shall have a minimum earth cover of 36 inches unless otherwise noted.

16. Eccentric reducers shall be used where required to permit proper drainage and venting of pipe lines; bushings are not permitted for this purpose. Drain valves shall be provided in all piping systems at low points and otherwise indicated. Blow off valves shall be provided in all piping at strainers where indicated hereinafter.

17. Provide pipe anchors as noted hereinbefore. Anchors shall consist of heavy steel collars welded to pipe and secured to the building structure to prevent movement of piping. All anchors shall be approved by the Architect/Engineer, before installation is started.

18. Condensate drain lines from cooling equipment shall be pitched and installed with brass plug cleanouts at each change in direction and/or at 20' intervals.

19. At each fixture and piece of equipment, provide appropriate shutoff valves and unions.

20. Materials shall be new and of the best grade and quality; workmanship shall be first class in every respect.

21. All thread shall conform to ANSI B16.3 for American Standard Taper Pipe Threads.

22. Chain or wire rope slings for handling pipe shall not be allowed unless padded to prevent marring of protective coating on pipe.

23. Lock type mechanical joints shall be made up tight, but shall allow for 1/8" contraction of the pipe at each joint.

24. Pipe shall be kept clean at all times, especially the interior and joint surfaces. When no work is in progress the pipe shall be capped or plugged to prevent the entrance of water or dirt. Before any cast iron or ductile iron pipe is laid, it shall be lightly tapped with a hammer while suspended above the ground; sound pipe will emit a clear ring sound, unsound pipe will emit a dull sound. Unsound pipe shall not be laid and shall be rejected.

25. All steel surfaces such as tie rods, flanges, bolts, nuts, etc., to be buried in the earth, shall be protected with a 1/4" minimum coating of filtrated bituminous compound after installation and prior to backfill. Protective coating shall be Sonneborn "Hydrocide Mastic", Lambers "Waterban #60M", Emulsified Asphalts "Multiseal" or equivalent. Application shall be in strict accordance with manufacturer's directions. All existing steel surfaces uncovered by excavation shall be thoroughly cleaned and treated in a like manner.

26. Plastic piping shall not be installed in any facility in a manner that would require penetration of one hour or greater fire resistive wall, ceiling or shaft. Unprotected plastic piping shall not be installed in any area that is used for the transfer of environmental air in accordance with the Kentucky State Building Code.

27. Solder joints for water systems; use 95/5 tin antimony (50/50 solder not acceptable).

28. Material shall be new and of the best grade and quality; workmanship shall be first class in every respect.

29. Soil, waste, and vent piping shall pitch 1/4" per foot where practicable, but not less than 1/8" per foot or as indicated.

30. All piping must be installed to allow proper access to equipment, access doors, valves, motors, etc.

D. Standards

1. Steel Pipe: ASTM A 120 or A 53; plain and galvanized.

2. Copper Tube: Type K, L, M; ASTM B 88.

3. Copper Tube: Type DWV; ASTM B 306.

4. Soil Pipe: ASTM A 74.

5. Welded Fittings: ANSI B 16.9.

6. Weld Flanges: ANSI B 16.5.

7. Cast Iron Screwed Fittings: ANSI B 16.4, Plain and galvanized.

8. Malleable iron screwed fittings: ANSI B 16.3.

9. Cast iron drainage fittings: ANSI B 16.22; Plain and galvanized.

10. Cast iron flanged fittings: ANSI B 16.1.

11. Wrought copper flanged fittings: ANSI B 16.1.

12. Cast bronze drainage fittings: ANSI B 16.23.

13. Cast iron soil pipe fittings; ASTM A 74.

14. Solder: Handy and Harman, United Wire and Supply and Air Reduction Company.

E. Condensate Drains

1. Condensate Drain Lines from air conditioning equipment, pumps etc., shall be Schedule 40 PVC or Type "L" copper; except piping in plenum returns and relief air plenums or to exterior must be copper.

2. Fittings to be PVC with solvent weld glued fittings; or wrought copper with 95/5 solder. Connections must be made in strict accordance with manufacturer's requirements.

3. Elbows to be long sweep type.

4. Provide "Y" cleanouts at 20' 0" intervals in mains and at all changes in direction with open ends plugged with brass screw plugs.

5. Solder shall be 95/5 tin antimony conforming to ASTM B 32, Grade 5A. (50/50 solder not acceptable).

6. Condensate piping under slab shall be standard weight cast iron (min. size of 2") with floor clean outs as indicated or at all 90 degree ells.

F. Interior Heat Pump Piping

1. Piping shall be high density polyethylene with heat fusion connections similar to exterior and geothermal piping system (except as noted below for Contractor’s option to use Aquatherm polypropylene).

2. Tubing shall be free from defects in material and workmanship. Piping shall be installed in strict accordance with pipe manufacturer's requirements.

3. ¾" through 1 ¼" shall be DR11, 160 psi; 1 ½" through 2" shall be Schedule 40, 100 psi; 3" and larger piping shall be DR 17, 100 psi.

4. See Section 15004 for pipe insulation requirements.

5. Contractor's option for interior heat pump piping.

    a. Summary

        1) This Section specifies the interior heat, fused polypropylene hydronic piping system, including associated fittings, and specialties within the building. This is in-lieu-of the above insulated heat fused polyethylene piping system.

        2) The Aquatherm Climatherm piping does not require pipe insulation.

    b. Related Sections

        1) Drawings and general provisions of the Contract, including General and Supplementary Conditions, Division 1 Specification sections apply to work of this section.

    c. Reference Documents

        1) ASTM F 2389-07 - Standard Specification for Pressure-rated Polypropylene (PP) Piping Systems

        2) CSA B137.11 - Polypropylene (PP-R) Pipe and Fittings for Pressure Applications

        3) NSF/ANSI 14 – Plastic Piping System Components and Related Materials

        4) NSF/ANSI 61 – Drinking Water Systems Components – Health Effects

    d. Definitions

        1) Definitions shall be in accordance with local mechanical codes and ASTM F 2389.

    e. Submittals

        1) Material list naming each product to be used identified by manufacturer and product number, in accordance with Section 01 30 00.

f. Quality Assurance

1) Material shall be certified by NSF International as complying with NSF 14, NSF 61, and ASTM F 2389 or CSA B137.11.

2) Material shall comply with manufacturers specifications.

3) Special Engineered products shall be certified by NSF International as complying with NSF 14.

g. Pipe And Piping Products

1) Pipe shall be manufactured from a PP-R resin meeting the short-term properties and long-term strength requirements of ASTM F 2389 or CSA B137.11. The pipe shall contain no rework or recycled materials except that generated in the manufacturer's own plant from resin of the same specification from the same raw material. All pipe shall be made in a three layer extrusion process. The piping shall contain a fiber layer (faser) to restrict thermal expansion. All pipe shall comply with the rated pressure requirements of ASTM F 2389 or CSA B137.11. All pipe shall be certified by NSF International as complying with NSF 14, NSF 61, and ASTM F 2389 or CSA B137.11.

2) Pipe shall be Aquatherm Climatherm SDR 11 with faser composite available from Aquatherm, Inc. Piping specifications and ordering information are available at www.aquathermpipe.com or phone 513-623-1924

h. Fittings

1) Fittings shall be manufactured from a PP-R resin meeting the short-term properties and long-term strength requirements of ASTM F 2389. The fittings shall contain no rework or recycled materials except that generated in the manufacturer's own plant from resin of the same specification from the same raw material. All fittings shall be certified by NSF International as complying with NSF 14, NSF 61, and ASTM F 2389 or CSA B137.11.

2) Fittings shall be Aquatherm Climatherm available from Aquatherm, Inc. Fittings specifications and ordering information are available at www.aquathermpipe.com or phone 513-623-1924.

i. Warrantee

1) Manufacturer shall warrantee pipe and fittings for 10 years to be free of defects in materials or workmanship.

2) Warrantee shall cover labor and material costs of repairing and/or replacing defective materials and repairing any incidental damage caused by failure of the piping system due to defects in materials or workmanship.

j. Valves

1) Valves with PP-R bodies shall be manufactured from a PP-R resin meeting the short-term properties and long-term strength requirements of ASTM F 2389. The valves shall contain no rework or recycled materials except that generated in the manufacturer's own plant from resin of the same specification from the same raw material.

2) Valves with brass bodies shall be manufactured in accordance with the manufacturers specifications and shall comply with the performance requirements of ASTM F 2389 or CSA B137.11.

3) Valves shall be Aquatherm Climatherm available from Aquatherm, Inc.. Valve specifications and ordering information are available at www.aquathermpipe.com.

4) Contractor can provide piping flanges and provide brass and steel valves as specified herein in-lieu-of polypropylene valves.

k. Integral Thermal And Vapor Barrier

1) The pipe with the integral thermal barrier with standard unprotected fittings shall meet the ASTM E84 and the CAN/ULC S102.2 requirements for a Flame Spread Rating of 25 and Smoke Development rating of 50.

l. Piping Applications

1) Install listed pipe materials and joining methods below in the following applications:

a) Aboveground: Polypropylene (PP-R) piping in SDR 11 based on the required minimum pressure rating and use temperature.

m. Fusion Welding Of Joints

1) Install fittings and joints using socket-fusion, elecrofusion, or butt-fusion as applicable for the fitting or joint type. All fusion-weld joints shall be made in accordance with the pipe and fitting manufacturer’s specifications and product standards.

2) Fusion-weld tooling, welding machines, and electrofusion devices shall be as specified by the pipe and fittings manufacturer.

3) Prior to joining, the pipe and fittings shall be prepared in accordance with F 2389 and the manufacturer's specifications.

4) Joint preparation, setting and alignment, fusion process, cooling times and working pressure shall be in accordance with the pipe and fitting manufacturer's specifications.

n. Valve Applications

1) Install ball valves close to main on each branch and riser serving 2 or more equipment connections and where indicated.

2) Install ball valves on inlet to each equipment item and elsewhere as indicated.

3) Install drain valve at base of each riser, at low points of horizontal runs, and where required to drain hydronic piping system.

4) Install swing check valve on discharge side of each pump and elsewhere as indicated.

5) Install ball and balancing valves in each water circulating loop; and on discharge and inlet side of each pump as detailed on Drawings.

6) Provide flanges as required if brass or steel valves are used.

o. Piping Installations

1) Install hangers and supports at intervals as specified herein.

2) Support vertical piping at each floor and as specified herein and as required by pipe manufacturer.

3) Where piping passes through fire rated wall, provide sleeve as required by piping manufacturer.

p. Inspecting and Cleaning

1) The pipes should be flushed with cold water after finishing the installation. Inspect and test piping systems following procedures of authorities having jurisdiction and as specified by the piping system manufacturer.

2) Clean and disinfect water distribution piping following procedures of the authority having jurisdiction.

6. Heat Pump Loop Piping at Heat Pumps:

   a. The heat pump piping connection to the heat pumps shall be Type “L” copper. See detail on Drawings.

7. Heat Pump Loop Piping at Base Mounted Pumps:

   a. The heat pump piping connections to the base mounted pumps shall be Schedule 40 black steel. See detail on drawings.

B. Exterior Heat Pump Piping

1. Piping shall be high density polyethylene with heat fusion connections similar to exterior and geothermal piping system.

2. Tubing shall be free from defects in material and workmanship. Piping shall be installed in strict accordance with pipe manufacturer’s requirements.

3. ¾” through 1 ¼” shall be DR11, 160 psi; 1 ½” through 2” shall be Schedule 40, 100 psi; 3” and larger piping shall be DR 17, 100 psi.

G. Relief Valve Piping

1. Piping shall be Type "L" Hard Copper.

2. Fittings shall be wrought copper or precast brass with solder joint; 95/5 tin antimony solder.

H. Unions

1. Steel pipe 2" and less; 300#; black malleable iron, screwed; ground joint.

2. Steel pipe 2 1/2" and more; 300#; black malleable iron; flanged; three part ground joint.

3. Copper pipe 2" and less; 125#; brass; solder end; ASA.

4. Copper pipe 2 1/2" and more; 150#; brass; solder end.

5. Flange unions to have proper gaskets for applicable service.

I. Welded Fittings

1. Welded Fittings ANSI B 16.9 of same materials, thickness, etc., as the pipe being jointed long radius elbows shall be used.

J. Flanges

1. Grinnell, Walworth, Tube Turns, or equivalent, with full faced gaskets heavy duty, rated for both hot and chilled water; conforming to ANSI B 16.21; bolting conforming to ASTM A307 58T or ASTM A107 flat faced for bolting to case

other steel flanges or brass flanges. Flanges above 2" in size shall be for butt welding and in sizes smaller than 2" may be threaded. Nuts shall conform to ANSI B 18.2 heavy hexagonal. Flanges shall be of same materials, weight, etc., as pipe to which they are jointed. Face dimensions shall conform to ANSI B 16.10.

K. Polyvinyl Tape

1. Johns Manville, Minnesota Mining and Mfg., Union Carbide or equivalent; similar to Johns Manville No. V 20; 0.02" thick; polyvinyl.

L. Escutcheons

1. Escutcheons shall be Beaton and Caldwell; Carpenter and Patterson; Fee and Mason or approved equivalent. Escutcheons shall be set screw type for permanent installation.

2. Exposed bare and insulated piping passing though floors, walls, or ceilings of finished rooms shall be provided with chrome plated escutcheons. Plates shall be of the split, hinged type of sufficient outside diameter to amply cover up the sleeve openings for the pipe. Beaton and Caldwell No. 10.

3. The Contractor's attention is called to the fact that most of the escutcheons will be installed around insulated pipe. It will be necessary that the plates fit snugly around the insulation and will be firmly held in place. Insulation shall not be cut or notched in any way.

4. Provide chrome plated escutcheons for hanger rods in finished ceilings. Carpenter and Patterson #182.

M. Flexible Pipe Connectors

1. Flexible heavy duty neoprene/nylon connections shall be as manufactured by Mason, Flexonic Company, Korfund, Keflex or approved equivalent, and shall be 300 lb. working pressure minimum, suitable for temperature of application. Connectors shall have flanged end connections in sizes larger than 2". Flexible connectors shall be furnished and installed at each base mounted pump connection and where indicated. Provide lengths as indicated or recommended by the manufacturer. Flexible connectors shall be equivalent to Mason Model MFTNC twin-sphere connectors.

2. Heat pump flexible flame retardant type hoses shall be stainless steel braided over a synthetic polymer liner. Hoses shall meet or exceed the ASTM-D380-83 standard, and withstand working pressures of 375 psi (1/2"), 300 psi (3/4"), 225 psi (1"), 200 psi (1¼"), 175 psi (1½") at 250 degrees F. Hoses shall meet or exceed flame retardant testing per standard UL #723, NFPA #225, ANSI 2.5, UBC 42-1, ASTM-E84A. Minimum hose length 24". Flexible hoses shall be as manufactured by Griswold, P.S.I. or Design Flow Inc.

N. Insulating Dielectric Unions and Couplings

1. Epco type GX or DX as required, Walter Vallett Co., Capitol Mfg. Co., Victaulic, or equivalent, for use in connecting dissimilar metals.

O. Refrigerant Piping and Specialties

1. Refrigerant piping shall be Type ARI hard copper with wrought copper sweat fittings. Solder joints for refrigerant systems if required; use silver brazing alloy with 1100 degree minimum melting point with approved flux; brush or wipe all joints; use nitrogen admitting method during fabrication. All 90 degree ells must be long sweep radius type.

2. Install refrigerant piping in accordance with the Safety Code for Mechanical Refrigeration and Code for Refrigerant Piping. All piping shall be sized and installed in strict accordance with the equipment manufacturer's recommendations. Submit refrigerant piping schematic drawings to Engineer for review prior to installation. Drawings must indicate all pipe sizing and refrigerant accessories. Provide refrigerant ball valves (Henry or equivalent) and refrigeration test/fill valve ports in suction and liquid lines at condensing units and cooling coils. Provide solenoid valves and expansion valves and install as directed by the unit manufacturer.

1.8 VALVES

A. Installation

1. Where required for ease of operation of valves and wherever elsewhere required by the Drawings, valves shall have extension stems.

2. All valves shall be of the same manufacturer insofar as possible.

3. In no case shall valves be installed with the stems below the horizontal.

4. Valves located above ceilings and in accessible pipe chases shall be provided with access panels.

5. Valves for water service shall be built for not less than 125 lbs. W.S.P., 200 lbs. W.O.G., 450 degrees F flanged valves shall have standard weight flanges.

6. Provide the required wrenches or handles to operate valves and cocks. A set of wrenches of handles shall be mounted on a finished plywood panel and installed in the Boiler Room where directed.

7. Brass valves for use in copper piping 1/2" and larger shall have screwed or flanged ends with screws or companion flanges and adapter to suit. Brass valves smaller than 1 1/2 inches may be soldered but extreme care must be taken to prevent heat damage to valve. Comply strictly with manufacturer's requirements.

8. Valves shall be the same size as the line in which they are installed unless otherwise noted.

9. The following paragraphs mention usually Nibco and Dezurik No.'s to establish desired quality. Comparable valves by Milwaukee, Grinnell, Crane, Kennedy, Lunkenheimer, Walworth, Jenkins, Jamesbury, Apollo, Keystone, Kunkle, Mueller, Pegler, Homestead, Red/White and Stockham will be considered equal.

B. Gate Valves

1. Gate valves 2" and smaller, Nibco No. T 134 screwed, bronze, renewable bronze disc, rising stem, 150 lbs. steam/300 lb. WOG working pressure, and union bonnet. Valves 1¼" and smaller can be sweat type valves.

2. Gate valves 2 1/2" and larger. Nibco No. F 617 0, I.B.B.M., flanged with flanged bonnet and yoke, outside screw and yoke, rising stem, 125 lbs. steam/200 lab. WOG, working pressure.

C. Globe Valves

1. Globe valves, 2" and smaller, Nibco No. T 235 Y, screwed, bronze, renewable TFE disc, rising stem, 150 lbs. steam/300 lb. WOG working pressure, and union bonnet.

2. Sizes 2 1/2" and larger Nibco No. F 718 B, I.B.B.M., flanged with flanged bonnet and yoke, outside screw and yoke, renewable bronze disc, 125 lb. steam/200 lbs. WOG working pressure.

D. Swing Check Valves

1. Check valve 2" and smaller, Nibco No. T 413 Y, screwed, bronze, swing check, renewable TFE disc, 125 lbs. steam/200 lbs. WOG, working pressure.

2. Check valve 2 1/2" and larger, Nibco No. F 918 B, I.B.B.M., flanged, with bolted cap, swing check, renewable seat and disc, 125 lbs. steam/200 lbs. WOG, working pressure.

E. Butterfly Valves

1. Butterfly valves in ANSI Class 125, 2" through 20" shall be wafer or lugged style. Valve body shall be cast iron (ASTM A-126, Class B). Lugged valves shall have a mechanically retained seat and shall provide tight shut-off on dead-end or isolation service without the use of downstream flanges. Discs shall be bronze or cast iron with electroless nickel plating or welded nickel edge. Shafts shall be 416 stainless steel and be supported on three self-lubricating bronze or TFE coated stainless steel bearings. Shaft seals and seats shall be EPDM. Valve seats shall be molded to a rigid reinforcing ring. Valves 6" and smaller shall have a 10-position locking lever handle, valves 8" and larger shall have a totally enclosed weatherproof gear operator. Valves are to be Dezurik Fig. 632/8GS or equivalent.

F. Ball Valves

1. Nibco No. T 585 70; anti blowout stem; Body shall be bronze or brass, two piece, with screwed ends. Ball shall be hard chromium plated bronze or brass. Seats, stem packing seal and thrust washer shall be RTFE. Valve handle and nut shall be cadmium or zinc plated steel, with non heat vinyl grip. Valve shall be operated from full open to full closed by turning the valve handle one quarter turn (90 degrees) and the valve handle shall indicate ball position. Valve shall be suitable for flow in either direction. Valve assembly shall be rated 150 P.S.I. SWP and 600 P.S.I. WOG, for 1/4" through 2" sizes; valves shall be full port 1/4" thru 1" and conventional port 1 1/4" thru 2".

G. Balancing Valve Flow Indicator (Plumbing Domestic Hot Water)

1. Balancing valves shall be Flowset, Accusetter, Armstrong, Gerand, or equivalent, with flow indicator and memory stop for shut off use without changing balance set point. Provide a minimum of 24" of straight run of piping on each side of balancing valve/flow indicator assembly.

H. Relief Valves

1. Provide relief valves for all pressure systems including domestic hot water heaters, boilers, storage tanks, water source heat pump loop piping as required by manufacturers, prevailing codes or insurance requirements.

2. Relief valves for domestic water heaters and storage tanks shall be combination pressure and temperature type with pressure setting of 125 psi and temperature setting of 210 degrees F.

3. Discharge these relief valves over to floor drain or as shown and noted on Drawings.

4. All relief valves shall be lever handle operated, A.S.M.E. approved as manufactured by Watts, McDonnell Miller, Kunkle, or equivalent. Coordinate relief valve setting and sizing with equipment manufacturers.

5. Water heaters and boilers shall be provided from the factory with code approved relief valves sized, located and installed in strict accordance with code and manufacturer's requirements.

6. Heat pump loop relief valve shall be equivalent to Kunkel Figure 137; size 1 1/2"; 95 psi; 1,750,000 max. btu/hr.

I. Silent Check Valves

1. Silent check valves 2" and smaller, Nibco No. T-480Y; screwed; 125 p.s.i. steam/250 p.s.i. WOG; 3 lb. stainless steel spring; bronze body; stainless steel stem; TFE disc and seat ring.

2. Silent check valves, 2 1/2" and larger, Nibco No. W-960 (wafer) or F-960 (flanged); cast iron body; type 302 stainless spring; bronze disc; Buna N bonded to bronze seat; 250 lb. W.O.G.

3. All check valves at pumps shall be silent type.

J. Gauge Cocks

1. Ashcroft No. 1092; 150 PSIG maximum working pressure; bronze; 1/4" screwed connections; tee handle.

2. All pressure gauges shall be installed with a gauge cock.

K. Pressure Reducing Valve (Water)

1. Bell and Gossett, Taco, Thrush or equivalent; brass; adjustment range set to maintain 4 PSIG in excess of pressure required to maintain a water level at highest point in system.

2. PRV for heat pump loop and boiler loop shall be each equivalent to B & G No. B7-12; brass; range 10-25 set at 18 psig.

L. Backflow Preventer for Domestic Water Service (PRZ)

1. Refer to section 15009

M. Backflow Preventer for Sprinkler Piping

1. Backflow preventer shall be similar to Watts Series 709 double check valve assembly, Hersey, Wilkins or equivalent. If isolation valves are used at the backflow preventer they must be monitored in the fire alarm system.

N. Flow Measuring Indicators and Balancing Valves

1. Flow Indicators

a. Flow indicators shall be Flowset Venturis, Armstrong Venturis, Gerand Venturis. They shall be line size unless otherwise indicated.

b. On the return side of the coil, or as shown on the mains 4" and smaller, provide a Flowset Accusetter or equivalent balancing assembly. The assembly shall include a constant orifice Flowset Venturis flow sensor with P/T ports; and connected downstream of the Venturis, a ball balancing valve with memory stop. The accuracy of the system shall be +2%. Provide a minimum of 24" straight pipe run on each side of balancing valve/flow indicator assembly.

c. For piping mains larger than 4", provide Flowset Venturis or equivalent, cast steel flow indicator with grooved or flanged connections and P/T ports. Down stream of the flow indicator, or as noted on the drawings, provide Dezurik eccentric balancing plug valve, Homestead or equivalent.

d. These balancing valves are not required at equipment locations where self-balancing valves are used.

2. Self-Balancing Constant - Flow Control Valves (For Heat Pump Units)

a. Flow control valves shall be factory calibrated, direct acting, automatic pressure compensating type. Each valve shall limit flow rates to within +5 accuracy, regardless of system pressure fluctuations. Valve control mechanism shall consist of a tamperproof, stainless steel or nickel plated brass cartridge assembly with open chambers and unobstructed flow passages. Cartridge assembly shall include a self-cleaning, spring-loaded moving cup guided at two separate points and shall utilize the full available differential pressure actuate without hysterisis or binding. Each valve to be provided with a metal tag, chain and stamped for system identification. Valves shall be provided with pressure/temperature test valves to test temperature and pressure drops across the valves. Flow control valves shall be as manufactured by Griswold Controls, Autoflow, PSI or equivalent.

b. Valve 1/2" thru 1-1/2" shall be equivalent to Griswold threaded mini Series or Auto Flow FV Series, provided complete with P/T plugs union and ball valves; 450 psi at 200 degree F. The valve pressure range shall be 2 - 32 psi.

c. Valves 2" and 2-1/2" shall be equivalent to Griswold 3542 series threaded flange type; 300 psi at 275 degree F; AISI type 300 series passivated stainless steel parts; gray-iron ASTM A126-61-T internal class 30 body material (2-32 psi).

d. Flow control valves shall be line size unless otherwise indicated and shall have set gpm flow rate as indicated on equipment water coil schedules; see Section 15012 of Specifications. Valves shall be installed on return side of coil. See details on Drawings. Provide piping reducer at heat pump piping connection as required.

O. Backflow Preventer for Heat Pump Loop and Water System

1. Backflow preventer shall be similar to Watts Series 909 reduced pressure principal backflow preventer, Hersey, Wilkins or equivalent. Provide with funnel for drain connection. See plans for line sizing unless otherwise indicated.

P. Balancing Valves

1. Balancing valves 5" and larger shall be eccentric plug valves as manufactured by Dezurik or Homestead.

a. Valves shall be of the non-lubricated eccentric type with resilient faced plugs and shall be furnished with end connections as required. Valves shall be flanged, grooved or screwed as required (Contractor's option). Flanged valves shall be faced and drilled to the ANSI 125/150 lb. standard. Screwed ends shall be to the NPT standard.

b. Valve bodies shall be of ASTM A126 Class B cast iron. Bodies in 4" and larger valves shall be furnished with a 1/8" welded overlay seat of not less than 90% pure nickel. Seat area shall be raised, with raised surface completely covered with weld to insure that the plug face contacts only nickel. Screwed-in seats shall not be acceptable.

c. Plugs shall be of ASTM A126 Class B cast iron. The plug shall have a cylindrical seating surface eccentrically offset from the center of the plug shaft. The interference between the plug face and body seat, with the plug in the closed position, shall be externally adjustable in the field with the valve in the line under pressure. Plug shall be resilient faced with isobutene/isoprene.

d. Valves shall have sleeve type metal bearings and shall be of sintered, oil impregnated permanently lubricated type 316 ASTM A743 Grade CF-8M.

e. Valve shaft seals shall be of the multiple V-ring type and shall be externally adjustable and repackable without removing the bonnet or actuator from the valve under pressure.

f. Valve pressure ratings shall be 175 PSI through 12" and 150 PSI for 14" and larger. Each valve shall be given a hydrostatic and seat test with test results being certified.

g. Manual valve 1/2" through 6" shall have lever actuators. Actuators shall clearly indicate valve position and an adjustable stop shall be provided to set closing torque and to provide seat adjustment to compensate for change in pressure differential or flow direction change. All exposed nuts, bolts and washers shall be zinc plated. Provide extension stems to ensure proper operation over pipe insulation.

h. The valves shall have 100% dead-tight shut-off without the use of sealing lubricants. Valves shall have adjustable open position memory stops.

i. Valves shall have bolted bonnet construction, allowing easy disassembly.

j. Valves shall be provided with upstream and downstream flow taps for P/T plugs.

k. A flow curve shall be shipped with each valve that is specific to that valve.

2. Balancing valves 4" and smaller shall be ball valves as specified herein. Provide valves with extension stems to ensure proper operation over pipe insulation. Valves shall have 100% dead-tight shut-off and adjustable memory stops.

Q. Pressure Reducing Valve (Domestic Water Service)

1. Refer to section 15009

1.9 MISCELLANEOUS H.V.A.C. SPECIALTIES

A. Thermometers

1. Weiss No. 9VS type vari-angle 9" mercury filled heavy duty type; Marshalltown, Ashcroft, Marsh, or equivalent, Accuracy within 2% of scale span. Brass 3 1/2" (min.) stem complete with separable socker. Stem and socket must be of adequate length to give accurate temperature readings. Install in piping system in strict accordance with manufacturer's requirements. Increase pipe sizing at thermometer as required. Range 30 to 240 degrees F. for hot water piping, and 0 120 degrees F, for heat pump loop water, unless other standard range selected upon submittal. Contractor shall adjust case for readability from floor line.

B. Pressure Gauges

1. Weiss Series UG 1, Ashcroft, Marsh, Marshalltown or equivalent. 4 1/2" dial, range selected upon submittal; with maximum pointer; brass bourdon tube and socket; 1% accuracy.

2. All pressure gauges shall be installed with lever handle gauge cock and brass straight coil siphon tube.

C. Pressure/Temperature Plugs

1. Sisco Number BNO 025, P.O. Box 197, Riverton, N.J. or approved equal. P/T plugs shall have 1/2" NPT size; brass body/cup material; Nordel Valve Core Material; 300 degrees F temperature rating.

2. Install as a minimum a P/T plug at the general location of all thermometers and pressure gauges; and at the supply and return piping of all equipment. Reference mechanical drawings for additional locations of P/T plugs.

D. Strainers

1. Strainers shall be Y type equal to Leslie, Illinois, or Mueller. Sizes 2 1/2" and larger shall be flanged; sizes 2" and smaller shall be screwed.

2. Water strainers shall be cast iron or brass, designed for 125 lb. steam/200 lbs. WOG working pressure.

3. Strainers shall have a free area of strainer screen a minimum of twice the area of the adjoining pipe. Strainer baskets shall be fabricated from stainless steel or monel sheet metal; baskets shall have 0.045" (3/64") perforations for water service.

4. Strainers shall have short nipple and ball valve provided on blow off, sized the same as blow off size. Where strainers are located more than 3' above floor, blow off line shall be offset to wall or column and extended down to 3' level and

then valve provided. Provide nipple and cap on smaller strainers, in addition to ball valve, at AHU's, FCU's and UV's for easy maintenance blow-off.

E. Manual Air Vents

1. Mains are detailed on drawings.

2. Terminal units to be Dole, Taco or equivalent. Dole No. 14A Key Air Valve.

F. Air Separator

1. Air separator shall be Thrush, Armstrong, Wheatley, Taco, or Bell & Gossett "Rolairtrol", flanged, with integral strainer. A blow down connection shall be provided with a ball valve to facilitate routine cleaning of unit. Separator shall be designed to operate at 125 psi water pressure and shall be A.S.M.E. constructed and stamped. Unit shall be line size, unless otherwise indicated. Provide air separator with high volume air eliminator similar to Thrush #720.

G. Expansion Tanks (Diaphragm Type)

1. Expansion tanks shall be Wheatley Model WPA; Taco, CA Series, Amtrol "L" Series, Bell and Gossett, Wessels or equivalent; with removable and replaceable heavy-duty butyl rubber bladder; ASME constructed, 125 PSI maximum design pressure and 240 degrees F maximum design temperature. Set air pressure in tank at 18 PSI prior to connection to system.

2. See schedule on Drawings for capacities.

H. Automatic Air Separator

1. Automatic air eliminator shall be B & G or Amtrol Model No. 720, cast iron body; 150 psi maximum working pressure; 250 degrees F maximum working temperature. Air Separator shall be insulated.

I. Automatic Air Vent

1. Automatic air vent shall be Hoffman No. 79, Amtrol, Taco or equivalent. Provide with tap at top for venting to drain.

J. Solids Separator

1. Solids separator shall be Griswold, Lakos or Metraflex.

2. Solids separator #1 shall be equivalent to Lakos Model ILB-0300, 3" size; 130 GPM at 7 psi pressure drop. One required in heat pump loop.

END OF SECTION 15003

SECTION 15004 - INSULATION

1.1 GENERAL

A. The General Conditions, Special Conditions and the applicable portions of Division 1 of the Specifications are a part of this Section.

B. The Contractor for this work shall be governed by any Alternate Bids requested insofar as they affect this work.

1.2 SCOPE

A. This work includes the furnishing of all insulation and labor, materials, equipment, etc., necessary for the proper and complete installation of insulation as shown on the Drawings and/or herein specified.

1.3 SHOP DRAWINGS

A. Shop Drawing shall be submitted on all insulation including name of manufacturer, materials of construction, manufacturer's details of installation, procedures, mastics, tape, glass cloth, molded fittings, etc. Shop drawings shall include all equipment, materials and accessories incidental to a proper and complete installation.

1.4 ACCEPTABLE INSULATING MATERIAL MANUFACTURERS

A. Insulations having the thermal and physical properties of the specific materials specified hereinafter, of any of the following manufacturers, or approved equal, are acceptable.

Armstrong-Cork	Knauf
Johns-Manville	Certain-Teed/Saint Gobain
Owens-Corning	Pittsburgh Corning
Rubatex	

B. The Architect reserves the right to determine if the proposed insulating materials of any one manufacturer are acceptable in lieu of the specific insulation selected for the following applications.

1.5 INSTALLATION

A. All workmanship shall reflect the best current practices in the trade. Installation shall be applied by an approved company regularly engaged in the application of insulation. A neat and workmanlike job will be required. No covering shall be applied to pipe lines or other mechanical equipment until they have been tested and accepted by the A/E.

B. Contours on exposed work shall be smooth and continuous. Cemented laps, flaps, bands and tapes shall be smoothly and securely pasted down; adhesives shall be liberally used in conformity with the requirements of the manufacturer.

C. Where more than one thickness of insulation is required, joints (both longitudinal and transverse) shall be staggered. All joints shall be tight and with insulation lengths tightly butted against each other. Where lengths are cut, cuts must be smooth and square and without breakage of end surfaces. Where insulation terminates at unions, equipment, etc., ends shall be neatly tapered and effectively vapor sealed where insulation is vapor sealed. All insulation shall be continuous through wall and ceiling openings and sleeves. Penciling and stove piping of pipe insulation will not be permitted.

D. On vapor sealed insulation, the vapor barrier shall be continuous over all insulation. Insulation (and vapor seal if required) shall be continuous through pipe sleeves and pipe hangers, unless otherwise specified.

E. It shall be understood that except where they deviate from specific requirements hereinafter written, all material shall be applied in strict accordance with the recommendations of the manufacturer, using their recommended mastics, clips, etc., and installation procedures.

F. Provide canvas jacket in addition to standard jacket on all exposed insulated piping (up to 6 ft. above finished floor) in Mechanical Room and size for painting. Canvas shall be 8 ounce enameling canvas attached with polyvinyl acetate adhesive.

G. Insulation shall extend through hanger and support shield for all cold water piping to be hung in horizontal. Where piping is 2-1/2" and larger, a high compression cork or wood pipe support shall be installed under pipe.

H. For vertical piping, the bracket shall fit directly to pipe and insulation shall be applied around bracket and support rod.

I. Insulation on adjacent piping to flanges shall terminate a sufficient distance back from the flange faces to permit removal of bolts. Terminate by beveling tightly into piping. Flange insulation shall extend along and overlap pipe insulation by at least 2" and shall terminate with a snug fit into pipe insulation with beveled edge. Unions on cold and chilled water shall be insulated in the same manner as flanges. Taper and seal (ground) insulation in continuous runs of vapor sealed pipe at 20 foot intervals, similarly.

J. Any piping exposed in the air stream inside an air handling unit shall be covered with 20 mil PVC jacket pipe covering and sealed watertight in strict accordance with manufacturer's requirements.

K. Insulation shall meet the following fire hazard requirements as tested under procedure ASTM E-84, NFPA 255 and UL 723.

1. Flame spread, less than 25.
2. Smoke developed, less than 50.
3. Fuel Contribution, less than 50.

1.6 ITEMS TO BE INSULATED

A. All outside air ductwork and plenums.

B. All supply and return air ductwork, unless otherwise indicated. (Exposed round supply ductwork shall be double wall no external insulation required).

C. Condensate drains.

D. Heat pump loop polyethylene supply and return piping. Heat pump loop copper/steel supply and return piping.

E. Domestic hot, cold and recirculating piping.

F. Supply and return ductwork for energy recovery units.

G. Exposed piping (waste, HW and CW) at handicapped sinks. (Provide with pre-manufactured PVC jacket).

H. Dishwasher exhaust ductwork.

1.7 REQUIRED COVERING AND APPLICATION

A. Domestic Hot and Cold Water Piping; Condensate Drain Lines; Heat Pump Polyethylene/Copper/Steel Supply and Return Piping; Hot/chilled water Supply and Return Piping,; Valve Bodies, Flanges and Fittings; Roof Drains and Horizontal Roof Leaders

1. Owens-Corning or Johns-Manville fiberglass insulation with Type AP-all purpose jacket; perm rating of .02 perms. "K" factor of .23 @ 75 degrees mean temperature. Insulation thickness shall be 1", except condensate drains shall be 1/2" thick. Jackets shall be double self-sealing lap (stapled when required) and joints sealed with vapor-proof mastic. Wrap joints with J-M Dutch Brand pressure-sensitive tape; 2" width. Fittings 2" and larger shall be made of mitered segments of insulation and vapor sealed with (2) coats of vapor barrier adhesive reinforced with glass cloth between coats. Fittings 1-1/2" and smaller shall be wrapped with two (2) coats of vapor barrier adhesive reinforced with glass cloth between coats. In addition to the above in finished areas premolded PVC fittings shall be used. Premold fittings shall be stapled in place, wrapped with 2" wide pressure sensitive tape and the edges sealed with vapor proof mastic.

2. Manufacturers offering products complying with requirements include:

Johns-Manville; Glass Fiber with Type AP Jacket

Owens-Corning; Fiberglas ASJ/SSL-11 All-Service Jacket

Certain Teed

Knauf

B. Condensate Drain Piping; Domestic Water Piping Inside Walls; Exposed Waste Piping and HW and CW Piping at Handicapped Sinks

1. Piping drops inside walls can be insulated with 1/2" Armstrong Armoflex polyethylene closed cell or equivalent insulation in-lieu-of 1" fiberglass noted above. Insulation shall be non-split type and slipped over pipe before joints are soldered together. All fittings and connections shall be factory pre-molded type and applied with factory recommended adhesive. Exposed piping (waste, HW and CW) at handicapped sinks shall have 20 mil PVC jacket.

C. Ductwork - Supply, Return and Outside Air

1. Rectangular supply, return, and outside air ductwork shall be insulated with external insulation having a minimum R-Value of 6 as noted below.

2. Ductwork listed below that is to be double wall insulated:

a. All round exposed spiral ductwork is to be double wall insulated.

3. Ductwork listed below that is to be internally insulated:

a. The first 15 feet of the supply and exhaust ductwork for the energy recovery units shall be internally insulated.

4. Ductwork listed below that is to be externally insulated:

a. All round supply, return and outside air ductwork(after the 15 feet) and dishwasher exhaust shall be externally insulated unless otherwise noted. (Exposed round double wall spiral ductwork shall not be insulated.)

Rectangular ductwork (except as noted in paragraph (3) above) shall be externally insulated.

5. Internally insulated ductwork shall be insulated as follows:

   a. Ductwork shall be internally insulated with 1" thick Owens-Corning Fiberglass Aeroflex 150 or equivalent sound absorbing duct liner, 1.5 pcf density unless otherwise indicated. Insulation shall be installed in strict accordance with the manufacturer's requirements and the described methods in the most recent edition of SMACNA's duct liner application standard. The duct sizes indicated are the net free area inside dimensions required and where ducts are internally lined, the overall metal duct dimensions shall be increased accordingly. Provide duct liner adhesive to all edges of duct liner before ductwork is assembled.

   b. All portions of duct designated to receive duct liner shall be completely covered with Aeroflex duct liner. Transverse joints shall be neatly butted and there shall be no interruptions or gaps. The black coated surface of the duct liner shall face the air stream. Duct liner shall be adhered to the sheet metal with 90% coverage of adhesive, and all exposed leading edges and all transverse joints coated with adhesive. Use only adhesives complying with ASTM C 916 and SMACNA Standards. Duct liner shall be additionally secured with mechanical fasteners (welded) which will compress the duct liner sufficiently to hold it firmly in place. Adhesive bonded pins are not allowed. Duct liner shall be cut to assure overlapped and compressed longitudinal corner joints. After installation, blow out duct system prior to occupancy to remove any cutting scraps and/or foreign material remaining in the duct.

   c. The duct liners shall not support or promote mold or fungus growth. The thermal conductivity (K) at 75 degrees F mean temperature shall be .28 BTU - in/h - ft. square - deg. F., conforming to ASTM C 518. The duct liner surface burning characteristics shall be flame spread 25 and smoke developed 50 as per UL 723.

6. Externally insulated ductwork shall be insulated as follows:

   a. Ductwork shall be externally insulated with Reflestix R-6.0 insulated having two layers of aluminum foil with polyethylene bonded for strength, and two inner layers of insulated bubbles; 5/16” thick; 1.25 oz./sq. ft. Flame and smoke 20/30.

   b. Insulation must be installed in strict accordance with insulation manufacturer's requirements. Provide pins, bands and adhesive as required. Special care must be taken on large ductwork to prevent sagging of insulation away from ductwork.

   c. Ductwork must be sealed and tested prior to installing insulation.

D. Exhaust Ductwork

1. Exhaust ductwork shall not be insulated, except as noted.

   a. All exhaust ductwork above finished ceiling serving dishwasher exhaust fan shall be insulated externally similar to supply air ductwork noted above.

b. The exhaust ductwork serving the energy recovery units shall be internally and externally insulated as noted herein.

E. Domestic Water Below Slab and to 10'-0" Outside Building

1. Piping shall be insulated with 1/2" Armstrong Armoflex polyethylene closed cell or equivalent insulation. Insulation shall be non-split type and slipped over pipe before joints are soldered together. All fittings and connections shall be factory pre-molded type and applied with factory recommended adhesive.

F. NOTE: All areas in the piping system which requires general maintenance (example: valve handles, motorized valve operators, strainers in piping, strainers in suction diffusers, access doors) shall be insulated such that maintenance functions can be made without damaging the insulation.

END OF SECTION 15004

SECTION 15011 - STARTING, TESTING AND BALANCING

1.1 STARTING, TESTING AND BALANCING THE HEATING AND AIR CONDITIONING SYSTEMS

A. General

1. This section shall include the furnishing of all labor and materials to test and balance the mechanical systems.

2. Final testing and balancing of the air and hydronic systems shall be performed by an independent AABC or NEBB certified, professional balancing organization.

3. Prior to start of balancing operation, a meeting shall be conducted at the site with all subcontractors and the HVAC design engineer present, for the purpose of coordinating the completion of all necessary work prior to starting, testing and balancing the mechanical systems.

B. Start up by the Mechanical Contractor Prior to Balance Work

1. All equipment shall be cleaned of all foreign material.

2. All water piping shall be cleaned with chemicals and thoroughly flushed with clean water until all impurities in the piping systems have been completely removed. After completion of the flushing operation, all strainers shall have their screens removed, thoroughly cleaned and reinstalled. (See Section 15012 herein on chemical cleaning of piping).

3. All equipment shall be lubricated and placed in proper working order. Drives on rotating equipment shall be checked for proper rotation and alignment. V belt drives shall be checked and adjusted for proper tension as recommended by the manufacturer. All drives shall be set for the recommended speeds. All sheaves and bearing blocks shall be checked for any loose screws or nuts.

4. Where equipment requires a change of material, it shall be filled by the Contractor with material recommended by the equipment manufacturer.

5. All controls and safety devices shall be checked to determine that they are in place and properly installed.

6. Where equipment is intended to contain fluids it shall be filled and tested for leaks as recommended by the equipment manufacturer.

C. Operational Tests by the Mechanical Contractor

1. Before starting air conditioning and ventilating fans, the plenums, etc., shall be completely cleaned of debris, foreign matter, construction dirt, etc. All dampers shall be checked and set in a full open position. The fans shall be started and run continuously for eight (8) hours at full volume. At the completion of the eight

hour run, diffusers, coils, etc., shall be opened and cleaned of any collected debris.

2. Provide baffles, if necessary, for each diffuser requiring same, to prevent excessive drafts from diffuser due to its proximity to walls, columns, lights or other obstructions.

3. Heating and Air Conditioning System Start the heating and air conditioning system at the completion of the project and adjust all equipment, controls, valves, etc., for proper operation during the first heating and cooling seasons.

4. The controls shall be calibrated and set and checked to make certain that all parts of the control system are functioning properly.

5. Upon completion of the start up procedure and prior to acceptance by the Owner, the Contractor shall complete a performance test on each system to insure that each component and the entire system is operating properly and as intended. After all systems have been verified by Contractor as to their proper operation, he shall so advise the Architect.

6. The intent of the above requirements is to insure that all equipment is operating properly within their designed capacity and is ready for final balancing.

7. The Contractor shall perform all required service and maintenance for equipment installed until the requirements of (5) and (6) above are fully complied with.

D. Balancing

1. Upon completion of the above tests and when the Contractor is satisfied that the air systems are ready for final balancing, the Engineer shall be notified.

2. Arrangements will be made for testing and balancing by an independent AABC or NEBB certified professional balancing organization. The Contractor shall provide one (1) man to accompany the balancer and make adjustments not normally provided by the balancing organization. The Balancing Contractor shall make a preliminary balance of the entire air and water system. This procedure is to determine if there are any problem areas in the systems. The Balancing Contractor shall submit this preliminary (hand written) report to the Engineer, the Mechanical Contractor, the Temperature Control Contractor and the Electrical Contractor for review. The Engineer shall then set up a meeting with all parties to solve any potential problems before final balance work and final temperature control check out and adjustments are started.

3. The final phase of the process will then be for the Balance Contractor, Control Contractor and Mechanical Contractor to work TOGETHER and do final balance work and final temperature control adjustments and check out at the same time. This process will save all parties involved many hours of duplicated work.

4. The Engineer's representative shall be notified before start of balancing. The representative may be present during all or part of the final balancing.

5. Testing and balancing and controls final adjustments must be completed prior to final acceptance and beneficial occupancy by the Owner. At substantial completion of the project the Engineer and Owner will walk thru the building with the Contractors to perform a random spot check of balance work, controls and equipment operation to insure that all work is complete.

E. Final Acceptance and Project Completion

1. Final retainage release and acceptance by the Owner will be contingent upon the satisfactory completion by the Contractor of responsibilities as set forth in the above.

2. The performance demonstration referred to above shall be scheduled in advance of the Contract completion date. Required subsequent work determined by the Architect as a result of the performance demonstration shall not be a legitimate reason for Contract time extension.

1.1 SPECIFICATION FOR FINAL BALANCING WORK

A. The final balancing of the heating, ventilating and air conditioning systems in this building shall be performed by an AABC or NEBB certified test and balance agency. Instruments used for testing and balancing of the systems shall have been calibrated within a period of six (6) months prior to balancing at this project. All final test analysis reports shall include a letter of certification listing instrumentation used.

B. Three (3) copies of the complete test reports shall be submitted to the Architect/Engineer prior to final acceptance of the project.

C. The balancing agency shall perform the following tests and compile the following information:

1. Air Systems and Distribution Balance:

a. Design Conditions

(1) CFM

(2) Static-Pressure

(3) Motor H.P.

(4) Design Outside Air

(5) Design Supply Air

(6) Design Return Air

(7) Fan R.P.M.

(8) Fan Motor Brake Horsepower

(9) Air Temperature dB/wB

b. Installed Equipment

(1) Manufacturer

(2) Size

(3) Arrange, Discharge Class

(a) Motor H.P., Volt, Phase, Cycle and Full Load Amps
Starter Heater Rating Amps

c. Field Test

(1) Fan Speed

(2) Fan Motor Operating Amperes

(3) Phase (1)____,(2)____,(3)____

(4) Fan Motor Operating Brake Horsepower

(5) Field Volts 1-2___,2-3___,1-3___

(6) Static Pressure at Outlet.

(7) Static Pressure at Inlet.

(8) Total Pressure at Inlet.

d. Velocity Test for Total Air

(1) Discharge or Suction Duct Size

(2) No. of Velocity Readings

(3) Duct Average Velocity

(4) Outside Air

(5) Return Air

(6) Supply Air

(7) Total CFM

e. Individual Outlets (grilles and/or diffusers)

(1) Supply, Return and Exhaust

(2) Each outlet shall be identified as to location and area

(3) Outlet, mfg. and type

(4) Outlet size

(5) Outlet free area, core area, or neck area

(6) Outlet factor

(7) Required ft. per min. and test resultant velocity for each outlet

(8) Required CFM and test results, each outlet

(9) Actual CFM and test results, each outlet

f. All tests shall be performed with calibrated Anemotherm Velometer, Aneomometer, Manometer and Pitot Tube or other indicated method in this Division.

g. All outlets shall be set for air pattern as required.

h. All main outside air, supply air, return air, and exhaust air shall be tested, adjusted, and set for design CFM.

i. Provide entering and leaving air temperatures at each coil. Note the date, time and O.A. temperature when readings are made.

j. Provide OA, RA, and SA temperatures (dB/wB) at each water source heat pump, chilled beam inlet, and energy recovery unit.

2. Water Systems and Water Distribution Balance

a. Water Pumps -- Design Conditions

(1) GPM

(2) Head in Feet

(3) Motor H.P.

(4) R.P.M.

b. Water Pumps (HVAC and Domestic Water) -- Installed Equipment (This Includes Domestic Water Recirculating Systems)

(1) Pump Mfg.

(2) Pump Model No.

(3) Impeller Size

(4) Head at No Flow

(5) R.P.M.

(6) Motor H.P., Volt, Phase, Cycle, and Full Load Amp. Starter Heater Rating Amps.

c. Water Pumps -- Field Tests

(1) Suction Pressure at No Flow

(2) Discharge Pressure at No Flow

(3) Suction Pressure at Full Flow

(4) Discharge Pressure at Full Flow

(5) Field Volts 1-2,____, 2-3____, 1-3____

(6) Motor Operating Amps

(7) GPM from Pump Curve or Orifice

(8) Calculated B.H.P.

3. Each Water Coil/Water Heat Pump

(1) CFM

(2) Air Static Pressure Drop Through Coil

(3) Entering and Leaving Water Temperature

(4) Entering and Leaving Water Pressure

(5) GPM

(6) Entering and Leaving Air D.B./W.B. Temperatures at Each Coil

4. Flow Indicators

(1) Mfg.

(2) Size

(3) GPM

(4) Meter Reading

(5) Pressure Reading

5. Geothermal Well Field

   a. Pressure Drop Across each circuit

   b. Entering and Leaving Water Temperature Across each circuit

   c. GPM thru each circuit

6. Mini-split heat pumps and air conditioning systems, ERU Systems, Domestic Hot Water Systems.

   a. Entering and leaving water temperature

   b. GPM through units.

   c. Entering and leaving water and air temperature thru systems.

   d. Entering and leaving supply and exhaust temperatures thru ERU's.

   e. Entering and leaving air temperatures thru Mini-Split.

7. All pumps and water elements (coils, etc.) shall be set for design GPM.

8. If requested, the balance agency shall conduct tests as listed here, in the presence of a representative of the Owner.

D. Before commencing work, verify that systems are complete and operable. Ensure the following:

1. Equipment is operable and in a safe and normal condition.

2. Temperature control systems are installed complete and operable. At final balance work, the Temperature Control Contractor and Balance Contractor must work together as described above.

3. Proper thermal overload protection is in place for electrical equipment.

4. Final filters are clean and in place. If required, install temporary media in addition to final filters.

5. Duct systems are clean of debris.

6. Correct fan rotation.

7. Fire and volume dampers are in place and open.

8. Coil fins have been cleaned and combed.

9. Access doors are closed and duct end caps are in place.

10. Air outlets are installed and connected.

11. Duct system leakage has been minimized.

12. Hydronic systems have been flushed, filled and vented.

13. Correct pump rotation.

14. Proper strainer baskets are clean and in place.

15. Service and balance valves are open.

E. Report any defects or deficiencies noted during balancing to Mechanical Contractor and the HVAC Engineer. Failure to do this will result in the report not being approved.

F. Promptly report abnormal conditions in mechanical systems or conditions which prevent system balance.

G. Beginning of work means acceptance of existing conditions. Notify the Design HVAC Engineer of completion of preliminary testing and balancing.

H. Provide instruments required for testing, adjusting and balancing operations. Make instruments available to Contracting Officer to facilitate spot checks during testing.

I. Provide additional balancing devices as required. Equipment Manufacturer to furnish additional sheaves, pulleys and belts as required for proper balancing, installed by the Mechanical Contractor.

J. Installation Tolerances At No Additional Cost To The Owner

1. Adjust air handling systems to plus or minus 10 percent for supply systems and plus or minus 10 percent for return and exhaust systems from figures indicated.

2. Adjust hydronic systems to plus or minus 10 percent of design conditions indicated.

K. Adjusting

1. Recorded data shall represent actually measured or observed condition.

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

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

4. Leave systems in proper working order, replacing belt guards, closing access doors, closing doors to electrical switch boxes and restoring thermostats to specified settings.

5. At final inspection, recheck random selections of data recorded in report. Recheck point or areas as selected and witnessed by the Owner/Engineer.

L. Air System Procedure

1. Adjust air handling and distribution systems to provide required or design supply, return and exhaust air quantities.

2. Make air quantity measurements in ducts by Pitot tube traverse of entire cross sectional area of duct.

3. Measure air quantities at air inlets and outlets.

4. Adjust distribution system to obtain uniform space temperatures free from objectionable drafts and noise.

5. Use volume control devices to regulate air quantities only to extent that adjustments do not create objectionable air motion or sound levels. Effect volume control by duct internal devices such as dampers and splitters.

6. Vary total system air quantities by adjustment of fan speeds. Provide drive changes required. Vary branch air quantities by damper regulation.

7. Provide system schematic with required and actual air quantities recorded at each outlet or inlet.

8. Measure static air pressure conditions on air supply units, including filter and coil pressure drops, and total pressure across the fan. Make allowances for 50 percent loading of filters.

9. Adjust outside air automatic dampers, outside air, return air and exhaust dampers for design conditions.

10. Measure temperature conditions across outside air, return air and exhaust dampers to check leakage.

M. Water System Procedure

1. Adjust water systems to provide required or design quantities.

2. Use calibrated Venturi tubes, orifices or other metered fittings and pressure gauges to determine flow rates for system balance. Where flow metering devices are not installed, base flow balance on temperature difference across various heat transfer elements in the system.

3. Adjust systems to provide specified pressure drops and flows through heat transfer elements prior to thermal testing. Perform balancing by measurement of temperature differential in conjunction with air balancing.

4. Effect system balance with automatic control valves fully open to heat transfer elements.

5. Effect adjustment of water distribution systems by means of balancing cocks, valves and fittings. Do not use service or shut-off valves for balancing unless indexed for balance point.

6. Where available pump capacity is less than total flow requirements or individual system parts, full flow in one part may be simulated by temporary restriction of flow to other parts.

END OF SECTION 15011

SECTION 15012 - HEATING, VENTILATING AND AIR CONDITIONING

1.1 GENERAL

A. The General Conditions, Special Conditions, and the applicable portions of Division 1 of the Specifications are a part of this Section.

1.2 SCOPE

A. Provide all labor, materials, equipment and services required for furnishing and installing all heating, ventilating, and air conditioning equipment and related items as required, specified and shown on the Drawings. Provide all required supply and return piping, condensate piping, ductwork and temperature controls for a complete and operable mechanical system.

B. The design has been based on one manufacturer as specified, changes in ductwork, electrical, piping, supports, etc., required to accommodate other units shall be performed by this Contractor at no additional expense to the Owner.

C. Warranty and Start-Up

1. All equipment manufacturers shall provide factory start-up and first year parts and labor warranty (or as noted herein).

1.3 SHOP DRAWINGS

A. Shop drawings shall be submitted on all heating and ventilating equipment including name of manufacturer, materials of construction, manufacturer's details of installation, connections to other work, fastening, supports, anchors, etc. Shop Drawings shall include all equipment accessories and attachments incidental to a proper and complete installation.

1.4 VIBRATION ISOLATORS

A. Vibration isolators shall be manufactured by Mason Industries Co., Korfund, Amber/Booth Co. or approved equal.

B. Vibration isolators for all HVAC equipment shall be the spring type, sized as recommended by Unit Manufacturer.

1.5 PUMPS

A. Base Mounted Pumps

1. General

a. The contractor shall furnish and install, as shown on the plans, pumps which are each capable of delivering the GPM when operating at a total developed head as noted below. Pumps shall be Bell & Gossett,

Thrush/Amtrol, Armstrong, Peerless, Weinman, Patterson, Flo-Fab, Paco, or equivalent.

b. The pumps shall be base mounted design, in cast iron and bronze fitted construction. The pump internals shall be capable of being serviced without disturbing piping connections or motor.

c. Each of the pumps is to be furnished with a suction diffuser of size and type as noted on the drawings. Suction diffuser shall be of the angle body type with inlet vanes and combination fan diffuser strainer orifice cylinder.

d. The impeller shall be of the enclosed type, dynamically balanced and keyed to the shaft and secured with a suitable locknut.

e. Pump seal shall be standard single mechanical seal with carbon seal ring and Ceramic seat.

f. A replaceable shaft sleeve shall be furnished to cover the wetted area of the shaft under the seal or packing.

g. The bearing frame assembly of the pump shall be fitted with regreasable ball bearings equivalent to electric motor bearing standards for quiet operation.

h. The pump and motor shall be mounted on a common baseplate of heavy structural steel design with securely welded cross members and open grouting area. A flexible coupler, capable of absorbing torsional vibration, shall be employed between the pump and motor, and it shall be equipped with a suitable coupling guard as required. The pump shall be high efficiency type for variable speed application.

i. The pump shall be factory tested, thoroughly cleaned, and painted with one coat of machinery enamel prior to shipment. A set of installation instructions shall be included with the pump at the time of shipment.

j. The pump baseplate shall be mounted to a 4 inch high reinforced concrete equipment pad which is 6 inches larger than the pump assembly all around.

B. Capacities: As shown and herein on drawings.

1.6 CHEMICAL POT FEEDER FILTER SYSTEMS

A. General

1. The new water source heat pump piping system at the High School shall be cleaned by independent chemical company such as KESCO, Marathon, Culligan or approved equipment and shall provide a written report to Engineers when system is cleaned and treated.

2. The system shall be composed of combination by-pass chemical pot feeder/filter, heavy-duty chemical alkaline cleaning solution, and corrosion inhibitor to chemically treat water system. The system and procedures are to completely remove all oil, grease and other debris from the piping system and then treat the water to help prevent corrosion. The combination feeder/filter shall have filter cartridges removed when being used to add chemical. See Drawings for connection of filters down stream of solid separator at the heat pump loop.

3. The chemical cleaning of piping and initial water treatment shall be provided by an independent chemical company. The chemical company shall certify in writing to the engineer that the piping system has been cleaned and treated per specification requirements.

B. Combination Pot Feeder/Filter

1. The by-pass shall be equivalent to Harmsco Model HIF-16; 50 GPM; 16 cartridges; 2" pipe size; 150 psi pressure rated; housing and lid shall be 304 stainless steel with EPDM gaskets and seals. See details on Drawings.

C. Provide with two (2) complete sets of reusable washable cartridge cluster filters for each feeder/filter.

1. Mount bottom of housing approximately 12" above finished floor.

D. Piping System Chemical Cleaning Solution

1. The cleaning chemical shall be Culligan crystal alkaline heavy duty industrial cleaner, Calgon BC 4 industrial cleaner, DuPont or equivalent.

2. The solution shall be prepared by carefully dissolving one (1) pound of chemical crystals in four (4) gallons hot water (140 degrees 200 degrees F.). The chemical solution shall be added to piping system at a rate of four (4) pounds of chemical crystals for each 120 gallons of water in the piping system.

3. The chemical solution is quite alkaline and should be handled similar to caustic soda. The solution must be handled with extreme caution. Follow the handling and mixing instructions of the manufacturer very carefully.

4. Once the chemical solution has been fed into the piping system, the water shall be heated to 160 degrees F (minimum) and circulated for twenty four (24) hours. Care must be taken to insure proper flow through all piping loops. After twenty four (24) hours of continuous circulation, the system water shall be completely drained down and completely flushed out with clean water and then the entire process repeated as described above.

E. Piping System Corrosion Protection

1. The corrosion inhibitor chemical shall be Culligan #C 70, Calgon CS, DuPont or equivalent. The chemical shall be a synergistic combination of sodium nitrate borax.

2. Initially, one (1) pound of corrosion inhibitor shall be added for each 50 gallons of water in the piping system. More inhibitor shall be added as needed to maintain a minimum residual of 2000 PPM.

F. Glycol

1. The piping system shall be provided with 20% solution of glycol. The glycol must be the type specifically designed for heat pump loop water systems with all required inhibitors and corrosion protection included in the solution. The glycol must be similar to Dow Chemical Dowfrost propylene glycol-based fluid. The system shall be tested every 6 months; with a report showing inhibitors present and the percent glycol in solution.

G. Test Kits

1. Provide a water test kit as manufactured by LaMotte Chemical Model #7101/PRI-DC, Kesco Standard NO2, Taylor #1510, Culligan, Calgon or equivalent. The test kit shall contain as a minimum: Nitrite Reagent 1 and 2, 0.5 g. spoon, plain glass pipet, a 5 and 10 mL glass test tube and a plastic container case with instructions. The test kit shall provide a drop count test for control of sodium nitrate. This kit shall be turned over to the Owner, (with a photocopy of transmittal sent to the Engineer of Record), so that the residual of 2000 PPM can be maintained in the piping system.

H. Water Management Program

1. Provide a water management and service program for a period of one year from start-up of the system - to include the following; initial water analysis and recommendations; system start-up assistance, training of operating personnel, periodic field service consultation; all performed by a qualified full time local representative, customer report charts and log sheets at no additional charge, plus laboratory and technical assistance.

1.7 EXHAUST FANS (EF)

A. General

1. Exhaust fans shall be furnished with separate thermal overload protection, disconnect switch as noted on schedule, backdraft dampers and 1/2" mechanical bird screen. 35 NC maximum allowable sound level at specified operation conditions.

2. Install backdraft dampers as scheduled with undue twisting which may deform damper frame.

B. Manufacturer

1. Exhaust fans shall be Cook, Greenheck, Breidert, Carnes, ACME, ILG Industries or equivalent. Greenheck catalog numbers are listed herein as design criteria. Alternate selections will be accepted provided quality, function and

characteristics are equivalent. Shop drawings shall identify and list all characteristics of each exhaust fan as scheduled herein.

C. Prefabricated 12" high curbs shall be provided for all roof fans. The Mechanical Contractor shall coordinate all curb sizes and locations with Roofing Contractor. Provide lined curbs with damper angle ledge and constructed such that fans set level. See Details on Drawings.

D. See fan schedule herein for capacities.

E. Centrifugal Roof Ventilators

1. Description: Belt-driven or direct-drive centrifugal fans, as indicated, consisting of housing, wheel, fan shaft, bearings, motor and disconnect switch, drive assembly, curb base, and accessories.

2. Housing: Removable, spun-aluminum, dome top and outlet baffle; square, one-piece, aluminum base with venturi inlet cone.

3. Fan Wheels: Aluminum hub and wheel with backward-inclined blades.

4. Belt-Driven Drive Assembly: Resiliently mounted to the housing, with the following features:

   a. Fan Shaft: Turned, ground, and polished steel drive shaft keyed to wheel hub.

   b. Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings.

   c. Pulleys: Cast-iron, adjustable-pitch motor pulley.

   d. Fan and motor isolated from exhaust air stream.

5. Accessories: The following items are required.

   a. Variable-Speed Controller: Solid-state control to reduce speed from 100 percent to less than 50 percent (for direct drive fans only).

   b. Disconnect Switch: Nonfusible type, with thermal-overload protection mounted inside fan housing, factory wired through an internal aluminum conduit.

   c. Bird Screens: Removable □-inch mesh, aluminum or brass wire.

   d. Dampers: Counterbalanced, parallel-blade, backdraft dampers mounted in curb base; factory set to close when fan stops.

   e. Roof Curbs: Galvanized steel; mitered and welded corners; 2-inch thick, rigid, fiberglass insulation adhered to inside walls; and 2-inch (50-mm) wood nailer. Size as required to suit roof opening and fan base.

F. Ceiling-Mounted Exhaust Fan

1. Description: Centrifugal fans designed for installing in ceiling or in-line, for in-line applications. Unit shall have automatic backdraft damper, and be rated for continuous operation.

2. Housing: Galvanized steel lined with acoustical insulation.

3. Fan Wheel: Centrifugal wheels directly mounted on motor shaft. Fan shrouds, motor, and fan wheel shall be removable for service.

4. Grille: White polymeric, louvered grille with flange or intake and thumbscrew attachment to fan housing.

5. Electrical Requirements: Junction box for electrical connection on housing and receptacle for motor plug-in.

6. Variable-Speed Controller: Solid-state control to reduce speed from 100 percent to less than 50 percent. Required if noted on the Drawings.

7. Accessories: Manufacturer's standard wall cap and transition fittings, all ventilator schedule for size and additional requirements.

G. In-Line Exhaust Fan

1. Fan shall be duct mounted, direct or belt driven as scheduled centrifugal square inline.

2. Fan shall be listed Underwriters Laboratories (UL 705) and UL listed for Canada (CSA Standard 113 – M1984). Fan shall bear the AMCA certified ratings seal for sound and air performance.

3. The fan shall be of bolted construction utilizing corrosion resistant fasteners. Housing shall be minimum 18 gauge steel with integral duct collars. Bolted access doors shall be provided on three sides, sealed with closed cell neoprene gasketing. Housing shall be pre-drilled to accommodate universal mounting feet for vertical or horizontal installation. Unit shall bear an engraved aluminum nameplate and shall be shipped in ISTA certified transit tested packaging.

4. Wheel shall be centrifugal backward inclined, constructed of 100% aluminum, including a precision machined cast aluminum hub. An aerodynamic aluminum inlet cone shall be provided for maximum performance and efficiency. Wheel shall be balanced in accordance with AMCA standard 204-96, balance quality and vibration levels for fans.

5. Motor shall be heavy duty type with permanently lubricated sealed bearings and furnished at the specified voltage, phase and enclosure.

6. See Schedule on Drawings for capacities.

1.8 ELECTRIC HEATERS

A. General

1. Section Includes:

a. Wall, unit and ceiling heaters with propeller fans and electric-resistance heating coils.

b. Acceptable Manufacturers

i. Markel, Chromalox, Berko or equivalent.

2. Submittals

a. Product Data: Include rated capacities, operating characteristics, furnished specialties, and accessories for each product indicated.

b. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

i. Plans, elevations, sections, and details.

ii. Location and size of each field connection.

iii. Equipment schedules to include rated capacities, furnished specialties, and accessories.

c. Field quality-control test reports.

d. Operation and maintenance data.

3. Quality Assurance

a. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

b. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1-2004, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

c. ASHRAE/IESNA 90.1-2004 Compliance: Applicable requirements in ASHRAE/IESNA 90.1-2004, Section 6 - "Heating, Ventilating, and Air-Conditioning."

B. Products

1. Electric Wall Heater – (EH-02)

a. General

i. Contractor shall supply and install heavy-duty, wall-mounted forced-air electric wall heater of the wattage, voltage and phase as indicated on the plans. The heater shall so be designed to provide an even distribution of heated air to the space by drawing return air in the perifery of the heater across the element which shall then be discharged from the center section of the heater by means of an electric motor and axial flow fan blade. Provide with unit mounted disconnect.

ii. Heaters shall surface mounted or recessed as noted on Drawings.

b. Enclosure

i. Heater front shall withstand with less than 1/16" permanent distortion 10.8 ft. Lbs impact and 400 lbs. Static force applied to an 8 sq. in. area at center grille location. The combination return and supply grille assembly shall be constructed of 1/16" x 3/8" rounded edge horizontal steel louvers which shall be spaced for maximum opening of 1/4". Louvers shall be welded at every intersection to three evenly spaced 1/16" diameter vertical members and completely framed in a heavy gauge natural anodized aluminum extrusion. Front assembly shall be attached to the chassis by hidden tamper-resistant (Allen-head) machine screws. All other parts shall be 16 ga. steel zinc coated both sides finished in a high glass bronze colored baked enamel.

c. Motor

i. Motor shall be a permanently lubricated unit bearing, totally enclosed, shaded pole type with impedance protection. Motors shall operate no more than 1400 RPM and shall be the same voltage as the heater. A protective shield shall surround the motor to separate return air from heated air.

d. Performance

i. Heater shall perform as indicated in schedule.

e. Elements

i. Element assemblies shall consist of two or three corrosion resistant steel sheathed type elements mechanically bonded to common corrosion resistant steel fins. Each sheathed element shall consist of helically coiled nickel chromium alloy resistant wire completely embedded in and surrounded by magnesium oxide, enclosed and swedged into corrosion resistant steel sheaths. Elements shall have 2" cold conductor pins extended

into the sheath and shall have a density of no more than 60 watts per inch.

f. Thermal Overload

i. Heaters shall be equipped with a thermal overload which disconnects elements and motor in the event normal operating temperatures are exceeded. For safety, if opened due to abnormal temperatures, thermal overload shall remain open until manually reset by turning heater off for five minutes. Automatic reset thermal overloads which allow the element to continue to cycle under abnormal conditions will not be accepted.

g. Approval

i. Heaters shall be Underwriters' Laboratories listed. Heaters shall conform to Underwriters' Laboratories, Inc. standard 1025. Paragraphs 31.20, 31.21, 31.22, and 31.23, and shall not be required to have any "CAUTION" marking on the front of the heater. Heaters not conforming to these paragraphs will not be acceptable.

ii. Heater shall be controlled by integrally mounted thermostats. Thermostats shall be heavy-duty, hydraulic type with a range of 40 degrees F to 80 degrees F and with remote sensing bulb placed in the return air. Thermostats shall be electrically rated at least 125% of heater rating. Thermostats shall also act as a disconnect by breaking all ungrounded conductors in the OFF position. Thermostat control knob shall be covered by a 16 ga. tamper-proof access place to prevent adjustment by unauthorized personnel.

h. Capacities

i. See schedule for capacity and voltage.

2. Electric Ceiling Heater (ECH-01,02)

a. General

i. Contractor shall supply and install heavy-duty, ceiling-recessed forced-air electric ceiling heater of the wattage, voltage and phase as indicated on the plans. The heater shall so be designed to provide an even distribution of heated air to the space by drawing return air in the periphery of the heater across the element which shall then be discharged from the center section of the heater by means of an electric motor and axial flow fan blade. Provide with unit mounted disconnect.

ii. Heaters shall be recessed mounted as noted on Drawings.

b. Enclosure

i. Heater front shall withstand with less than 1/16" permanent distortion 10.8 ft. Lbs impact and 400 lbs. Static force applied to an 8 sq. in. area at center grille location. The combination return and supply grille assembly shall be constructed of 1/16" x 3/8" rounded edge horizontal steel louvers which shall be spaced for maximum opening of 1/4". Louvers shall be welded at every intersection to three evenly spaced 1/16" diameter vertical members and completely framed in a heavy gauge natural anodized aluminum extrusion. Front assembly shall be attached to the chassis by hidden tamper-resistant (Allen-head) machine screws. All other parts shall be 16 ga. steel zinc coated both sides finished in a high glass bronze colored baked enamel.

c. Motor

i. Motor shall be a permanently lubricated unit bearing, totally enclosed, shaded pole type with impedance protection. Motors shall operate no more than 1400 RPM and shall be the same voltage as the heater. A protective shield shall surround the motor to separate return air from heated air.

d. Performance

i. Heater shall perform as indicated in schedule.

e. Elements

i. Element assemblies shall consist of two or three corrosion resistant steel sheathed type elements mechanically bonded to common corrosion resistant steel fins. Each sheathed element shall consist of helically coiled nickel chromium alloy resistant wire completely embedded in and surrounded by magnesium oxide, enclosed and swedged into corrosion resistant steel sheaths. Elements shall have 2" cold conductor pins extended into the sheath and shall have a density of no more than 60 watts per inch.

f. Thermal Overload

i. Heaters shall be equipped with a thermal overload which disconnects elements and motor in the event normal operating temperatures are exceeded. For safety, if opened due to abnormal temperatures, thermal overload shall remain open until manually reset by turning heater off for five minutes. Automatic reset thermal overloads which allow the element to continue to cycle under abnormal conditions will not be accepted.

g. Approval

i. Heaters shall be Underwriters' Laboratories listed. Heaters shall conform to Underwriters' Laboratories, Inc. standard 1025. Paragraphs 31.20, 31.21, 31.22, and 31.23, and shall not be required to have any "CAUTION" marking on the front of the heater. Heaters not conforming to these paragraphs will not be acceptable.

ii. Heater shall be controlled by remote thermostat provided by the Temperature Controls Contractor

h. Capacities

i. See schedule on Drawings for capacity and voltage.

3. Electric Unit Heater (EH-01)

a. General

i. Furnish and install unit heaters with heating and air delivery capacities as shown on following schedule. The cabinet shall be made of 18 gauge die formed, furniture grade steel. Individual adjustable louvers with 30 ☐ downward s to provide desired control of discharge air. All metal surfaces of the ceasing shall be phosphate coated to resist corrosion and finished in baked enamel. Mounting brackets designed for either ceiling or wall swivel mounting shall be furnished. Heater to be of the draw-through air flow design to eliminate element hot spots and extend design life.

b. Enclosure

i. The electric heating bank shall consist of metal sheath heating elements. The elements shall have a copper clad steel sheath for strength and corrosion resistance, and aluminum fins for faster heat transfer. Automatic reset thermal over-heat protection shall be of the linear capillary type wired for instantaneous de-energizing in case of thermal overload. Heating bank to have protective air inlet louvers.

c. Motor

i. Motors shall be of the totally enclosed, continuous heavy-duty all-angle operation equipped with built-in thermal overload protection.

d. Fans

i. Fans shall be aluminum, directly connected to fan motor, designed specifically for unit heater application.

ii. Fan voltage control transformers shall be standard for temperature control.

e. Controls

i. All controls shall have pig tails and spade terminals for ease of wiring. All heaters shall be pro-vided with power disconnect switches (factory installed). Provide unit mounted thermostats.

f. Approval

i. All heaters shall be U.L. listed and meet the requirements of the National Electrical Code. See schedule herein.

1.9 VARIABLE SPEED PUMPING SYSTEMS (FOR PUMPS PU-1 & PU-2)

A. Section Includes:

1. Full size cabinet with 2 ABB drives each rated for 30 hp at 460/3ph/60 hz.

2. Variable Speed Pumping Package

3. Pump Control Cabinet

4. Pump Control Panel

5. Adjustable Frequency Drives

6. Adjustable Frequency Drive Bypass

7. Sensor Transmitters

8. Isolation Transformer

9. Sequence of Operation

B. References

1. Hydraulic Institute

2. ANSI - American National Standards Institute

3. NEMA - National Electrical Manufacturers Association

4. UL - Underwriters Laboratories. Inc.

5. ETL - Electrical Testing Laboratories

6. CSA - Canadian Standards Association

7. NEC - National Electrical Code

8. ISO - International Standards Organization

9. IEC - International Electrotechnical Commission

C. Submittals

1. Submittals shall include the following:

2. System summary sheet

3. Sequence of operation

4. Shop drawing indicating dimensions, required clearances and location and size of each field connection

5. Power and control wiring diagrams

6. System profile analysis including variable speed pump curves and system curve. The analysis shall also include pump, motor and AFD efficiencies, job specific load profile, staging points, horsepower and kilowatt/hour consumption.

7. Pump data sheets

   a. Submittals must be specific to this project. Generic submittals will not be accepted.

D. Quality Assurance

1. The pumping package shall be assembled by the pump manufacturer. An assembler of pumping systems not actively engaged in the design and construction of centrifugal pumps shall not be considered a pump manufacturer. The manufacturer shall assume "Unit Responsibility" for the complete pumping package. Unit responsibility shall be defined as responsibility for interface and successful operation of all system components supplied by the pumping system manufacturer.

2. The manufacturer shall have a minimum of 20 years experience in the design and construction of variable speed pumping systems.

3. All functions of the variable speed pump control system shall be tested at the factory prior to shipment. This test shall be conducted with motors connected to AFD output and it shall test all inputs, outputs and program execution specific to this application.

4. The manufacturer shall be fully certified by the International Standards Organization per ISO 9001. Proof of this certification shall be furnished at time of submittal.

5. The manufacturer shall carry a minimum product liability insurance of $5,000,000.00 per occurrence.

6. Manufacturer shall be listed by Underwriter's Laboratories as a manufacturer of packaged pumping systems.

7. Bidders shall comply with all sections of this specification relating to packaged pumping systems. Any deviations from this specification shall be bid as a voluntary alternate clearly defined in writing. If no exceptions are noted, the supplier or contractor shall be bound by these specifications.

E. Acceptable Manufacturers

1. Subject to compliance with these specifications, the following manufacturers shall be acceptable:

a. ITT Bell & Gossett

b. Syncro Flo

c. Systecom

d. Armstrong

e. Patterson

f. Taco

F. Manufactured Units

1. Furnish and install as shown on the plans a Powersav Variable Speed Pumping System model number 55D4 2P020 DAC as manufactured by ITT Bell & Gossett or approved equal.

2. The control system shall include as, a minimum, the programmable logic pump controller, adjustable frequency drives and remote sensor/transmitters as indicated on the plans. Provide additional items as specified or as required to properly execute the sequence of operation.

3. The variable speed pump logic controller, adjustable frequency drive(s) and AFD bypass circuitry shall be mounted in a NEMA 1 enclosure. Unit shall be pre-wired at the factory to permit a single point incoming power connection. Where multiple compartment enclosures are used, each compartment shall be isolated from other compartments.

4. The pump control cabinet shall have sufficient ventilation via the use of intake and exhaust fans. The package shall be suitable for operation within an ambient

temperature range of 0 to 40 degrees C. There shall be a fan hood over the top outlet exhaust fan.

5. The control cabinet shall be designed and fabricated in compliance with construction code 508 of Underwriters Laboratories, Inc. The entire cabinet shall be listed by and bear the ETL label. All components within the panel shall be UL listed or recognized.

6. A door interlocked disconnect switch shall be provided for each equipment compartment housing line voltage components.

7. The cabinet shall also include a main power disconnect switch for de-powering the entire package. This switch shall be interlocked with the power distribution compartment.

G. Components

1. Pump Logic Controller

a. The Technologic pump logic controller assembly shall be listed by and bear the label of Underwriter's Laboratory, Inc. (UL). (Canadian Standards Association (CSA) listing available upon request.) The controller shall meet Part 15 of FCC regulations pertaining to class A computing devices. The controller shall be specifically designed for variable speed pumping applications.

b. The variable speed pump controller shall function to a proven program that safeguards against damaging hydraulic conditions including:

i. Motor Overload

ii. Pump Flow Surges

iii. Hunting

c. End of Curve Protection: The pump logic controller shall be capable of protecting the pumps from hydraulic damage due to operation beyond their published end-of-curve through a factory pre-programmed algorithm. This feature requires an optional flow meter for activation.

d. The pump logic controller shall be capable of staging and de-staging pumps based on an Efficiency Optimization Program to provide the lowest kW draw. This optimization program requires an optional flow meter, kW meter, and system differential pressure sensor for activation.

e. The pump logic controller shall be capable of accepting 5 discrete analog inputs from zone sensor/transmitters as indicated on the plans. Analog input resolution shall be 12-bit minimum, and the controller shall scan each analog input a minimum of once every 100 milliseconds. Use of a multiplexer for multiple sensor inputs is not acceptable. All

sensor/transmitter inputs shall be individually wired to the pump logic controller for continuous scan and comparison function. All analog inputs shall be provided with current limit circuitry to provide short circuit protection and safeguard against incorrect wiring of sensors.

f. The pump logic controller will select the analog input signal that deviates the most from its setpoint. This selected signal will be used as the command feedback input for a closed loop hydraulic stabilization function to minimize hunting. The hydraulic stabilization program shall utilize a proportional-integral-derivative control function. The proportional, integral and derivative values shall be user-adjustable over an infinite range. The scan and compare rate that selects the command setpoint and process variable signal shall be continuous and automatically set for optimum performance. Each sensor shall be scanned at least once every 100 milliseconds.

g. The pump controller shall be capable of controlling 2 pumps in parallel as described in the sequence of operation section.

h. The pump logic controller shall be self-prompting. All messages shall be displayed in plain English. The following features shall be provided: Multi-fault memory and recall On-screen help functions LED pilot lights and switches Soft-touch membrane keypad switches

i. The variable speed pumping system shall be provided with a user friendly operator interface complete with membrane switches and numeric keypad. Display shall be no less than four lines with each line capable of displaying up to twenty characters. The human interface panel shall display the following values:

    i. Flow in GPM (requires optional flow meter)

    ii. Pump On/Off Status

    iii. Pump % Speed

    iv. Individual Alarm Conditions

    v. Troubleshooting Diagnostics

    vi. User-adjustable parameters such as alternation, PID, setpoints, etc.

j. A data-logging feature shall be provided as a function of the pump logic controller. The Alarm log shall include the last 20 alarms with date/time stamp. The Pump data log shall display individual pump run timers and pump cycle counters. A Signal log shall be provided to display the maximum and minimum values with date/time stamps for each process variable and flow, when optional flow meter is provided. The Signal log shall also be capable of displaying the cumulative value of kilowatt-

hours for each pump and of system minimum and maximum flow along with individual counter reset capability.

k. The Logic controller shall incorporate a Flash Memory for saving and reloading customized settings. These field determined values shall be permanently retained in Flash memory for automatic reloading of the site specific setup values in the event of data corruption due to external disturbances. The Controller shall also employ a sensor setup copy feature.

l. The pump controller shall be capable of communicating with the Building Automation System (BAS) by both hard-wired and serial communications.

m. The following communication features shall be provided to the BAS in "hardwired" form via 4-20ma analog signals and digital outputs:

i. Remote system start/stop (dry contact supplied by BAS)

ii. Failure of any system component (qty. 1, relay output from pump controller)

iii. Process variable (qty. 4 4-20ma analog output supplied by pump controller)

iv. AFD speed (qty. 1, 0-10VDC analog output supplied by pump controller)

v. Optional: Pump on/off status (qty. 2 relay output supplied by pump controller)

n. The following communication features shall be provided to the Building Automation System via an RS-485 port (optional hardware required) utilizing Johnson Controls Metasys N2, Modicon's Modbus, BACnet Class II MSTP, Profibus, Trane Tracer or Allen-Bradley Data Highway protocol:

i. All sensor process variables

ii. Individual zone setpoints

iii. Individual pump failure

iv. Individual pump on/off status

v. Individual AFD on/off status

vi. AFD speed

vii. Individual AFD Failure

viii. AFD bypass status (if automatic)

ix. Individual sensor failure

o. The pump logic controller shall be a Bell & Gossett Technologic 5500. Enclosure shall be NEMA 1.

2. Adjustable Frequency Drive

a. The adjustable frequency drive(s) shall be pulse width modulation (PWM) type, microprocessor controlled design, AFD shall be capable of operating in voltage ranges of 200 to 240V and 380 to 480V AC, +/- 10%, three phase; at frequencies of 48 to 63 Hz. Unit shall be the ABB ACH 550 Series manufactured by ABB Drives & Power Products.

b. The AFD, including all factory-installed options, shall have UL and UL approval.

c. Enclosure shall be NEMA 1 ventilated for installation as a wall mounted or freestanding unit, depending on the amp rating. Drive shall be equipped with an input disconnect switch, which can be locked in the open position for safety during maintenance, and fuses to protect against ground faults.

d. An electronic manual bypass option shall be available to enable the operator to select normal or manual bypass of the drive. The electronic bypass includes two contactors. One contactor is the bypass contactor that connects the motor directly to the incoming power line in the event that the drive is out of service. The other is the drive output contactor that disconnects the drive from the motor when the motor is operating in the bypass mode. The drive output contactor and the bypass contactor are electrically interlocked to prevent "back feeding."

e. AFD shall utilize a full wave rectifier to convert three phase AC to a fixed DC voltage. Power factor shall remain above 0.98 regardless of speed or load. AFDs employing power factor correction capacitors shall not be acceptable.

f. Insulated gate bipolar transistors shall be used in the inverter section to convert to fixed DC voltage to a three phase, adjustable frequency, AC output.

g. The output switching frequency shall be selectable at 4 or 8 kHz. AFDs with an operable carrier frequency above 10 kHz shall not be acceptable.

h. An internal line reactor (5% impedance) shall be provided to lower harmonic distortion of the power line and to increase the fundamental power factor.

i. The AFD shall be suitable for elevations to 3300 feet above sea level without de-rating. Maximum operating ambient temperature shall not be less than 104°F. AFD shall be suitable for operation in environments up to 95% non-condensing humidity.

j. The AFD shall be capable of displaying the following information in plain English via an alphanumeric display:

i. Output Frequency

ii. Output Voltage

iii. Motor Current

iv. Kilowatts per hour

v. Fault identification with text

vi. Percent torque

vii. Percent power

viii. RPM

k. All AFDs shall be warranted for a period of 24 months from date of substantial completion. This warranty shall cover parts, labor, travel time, and expenses.

3. Automatic AFD Bypass

a. Variable speed pumping system shall be equipped with an ITT Bell & Gossett automatic bypass.

b. Bypass shall consist of a main power disconnect with ground fault protection, a pair of interlocked contactors and a motor overload relay. All are to be mounted in a NEMA 1 enclosure.

c. Automatic bypass shall operate as described in the sequence of operation.

4. Sensor / Transmitters

a. Provide four (4) ITT Bell & Gossett ST-102R field mounted differential pressure sensor transmitter(s) as indicated on the plans. Unit shall transmit an isolated 4-20mA dc signal indicative of process variable to the pump logic controller via standard two wire 24 DC system. Unit shall have stainless steel wetted parts with two 0.25" male NPT process connections. It shall be protected against radio frequency interference and shall have a watertight, NEMA 4 electrical enclosure capable of withstanding 2000 PSI static pressure with a 0.5" NPT conduit connection. Accuracy shall be within 0.25% of full span.

b. Provide one (1) ITT Bell & Gossett ST-104 field mounted flow sensor transmitter as indicated on the plans. Unit shall transmit an isolated 4-20 mA dc signal indicative of process variable to the pump logic controller via standard two wire 24 Vdc system. Unit shall consist of an insertion probe and separately mounted transmitter. The unit shall be accurate to within 1% of flow rate from 1 to 30 fps and shall withstand a static pressure of 200 PSI with negligible change in output.

5. Sequence of Operation for D4 with End of Curve Protection Program

a. The system shall consist of a Technologic pump logic controller, multiple pump/AFD sets with manual and automatic alternation and pump staging with across the line bypasses for each pump.

b. The pumping system shall start upon the closure of customer's contact when the pump logic controller Mode of Operation selector switch is in the REMOTE position.

c. When the pump logic controller selector switch is in the LOCAL position, the pumping system shall operate automatically.

d. Sensor/transmitters shall be provided as indicated on the plans.

e. Each sensor/transmitter shall send a 4-20mA signal to the pump logic controller, indicative of process variable condition.

f. The pump logic controller shall compare each signal to the independent, engineer/user determined set points.

g. When all set points are satisfied by the process variable, the pump speed shall remain constant at the optimum energy consumption level. If the input from the flow sensor indicates that the operating pumps are approaching the end of curve point, the controller shall automatically stage on lag pumps as required to bring all pumps back to an acceptable operating point.

h. The Technologic pump logic controller shall continuously scan and compare each process variable to its individual set point and control to the least satisfied zone.

i. If the set point cannot be satisfied by the designated lead pump, the pump logic controller shall initiate a timed sequence of events to stage a lag pump.

j. The lag pump shall accelerate resulting in the lead pump(s) decelerating until they equalize in speed.

k. Further change in process variable shall cause the pumps to change speed together.

l. When the set point criteria can be safely satisfied with fewer pumps, the Technologic pump logic controller shall initiate a timed de-stage sequence and continue variable speed operation.

m. As the worst case zone deviates from set point, the pump logic controller shall send the appropriate analog signal to the AFD to speed up or slow down the pump/motor.

n. The operation of the pumps in the failure mode shall be started through the pump logic controller and a Bell & Gossett Type IV across the line bypass.

o. When in the "AUTOMATIC" mode, the pump(s) shall operate through the AFD(s) being controlled by a signal generated by the pump logic controller.

p. In the event of a system differential pressure failure, due to a pump, AFD, overload fault, the pump logic controller shall automatically initiate a timed sequence of events to start the remaining pump/AFD set(s) in the variable speed mode. A message on the display shall indicate the fault, pump/motor, or AFD. Subsequent failures shall initiate a timed sequence of events to the variable speed mode as available.

q. In the event of all AFD faults, all pumps shall be automatically started across the line.

r. When in the "BYPASS" mode, the selected pump(s) shall be able to be operated across the line at constant speed with motor overload protection. A solid red light shall signal this condition. All pumps shall be locked out of the variable speed mode.

s. In the event of an overload fault while in the "BYPASS" mode, the selected pump shall be locked out.

t. In the event of the failure of a zone sensor/transmitter, its process variable signal shall be removed from the scan/compare program. Alternative zone sensor/transmitters, if available, shall remain in the scan/compare program for control.

u. The zone number corresponding to the failed sensor/transmitter shall be displayed on the operator interface of the pump logic controller.

v. In the event of failure to receive all zone process variable signals, the AFD shall maintain 100% speed; reset shall be automatic upon correction of the zone failure.

w. PUMP, AFD, OVERLOAD fault shall be continuously scrolled through the display on the operator interface of pump logic controller until the fault has been corrected and the controller has been manually reset.

H. Installation

1. Install equipment in accordance with manufacturer's instructions.

2. The contractor shall align the pump and motor shafts to within the manufacturer's recommended tolerances prior to system start-up.

3. Power wiring, as required, shall be the responsibility of the electrical contractor. All wiring shall be performed per manufacturer’s instructions and applicable state, federal and local codes.

4. Control wiring for remote mounted switches and sensor / transmitters shall be the responsibility of the controls contractor. All wiring shall be performed per manufacturer’s instructions and applicable state, federal and local codes.

I. Demonstration

1. The system manufacturer or factory trained representative shall provide start-up of the packaged pumping system. This start-up shall include verification of proper installation, system initiation, adjustment and fine tuning. Start-up shall not be considered complete until the sequence of operation, including all alarms, has been sufficiently demonstrated to the owner or owner's designated representative. This jobsite visit shall occur only after all hook-ups, tie-ins, and terminations have been completed and signed-off on the manufacturer's start-up request form.

2. The system manufacturer or factory trained representative shall provide on-site training for owner's personnel. This training shall fully cover maintenance and operation of all system components.

3. The system manufacturer must have a complete HVAC training program available for owner's personnel. The training sessions shall take place at the manufacturer's facility and cover all aspects of HVAC system design, service and operation.

1.10 SPLIT DUCTLESS SYSTEMS

A. Capacity Range: 1.6 to 3.0 Ton Nominal

B. System Description:

1. The heat pump air conditioning system shall be a Mitsubishi Electric MXZ-B variable capacity multi-zone series. The system shall consist of two (2), three (3), or four (4) slim silhouette, compact, wall and/or floor mounted indoor fan coil sections with digital wireless remote controller, and/or ceiling suspended, ceiling recessed and/or low to mid profile ducted indoor units with a wired, wall mounted remote controller connected to a compact horizontal discharge outdoor unit which shall be of an inverter driven heat pump design.

2. Indoor unit model numbers shall be:

a. Ceiling Recessed; PLA-A**BA, SLZ-KA**NA

b. Ducted; SEZ-KD**NA

c. Outdoor unit model number will be MXZ-4B36NA (2:1, 3:1 or 4:1) multi-zone systems.

C. Quality Assurance:

1. The system components shall be tested by a Nationally Recognized Testing Laboratory (NRTL) and shall bear the ETL label.

2. All wiring shall be in accordance with the National Electrical Code (N.E.C.).

3. The units shall be rated in accordance with Air-conditioning Refrigeration Institute's (ARI) Standard 240 and bear the ARI Certification label.

4. The units shall be manufactured in a facility registered to ISO 9001 and ISO 14001, which is a set of standards applying to product and manufacturing quality and environmental management and protection set by the International Standard Organization (ISO).

5. A dry air holding charge shall be provided in the indoor section.

6. System efficiency shall meet or exceed 15.5 SEER when part of a multi system (2:1 / 3:1 / 4:1).

D. Delivery, Storage and Handling

1. Unit shall be stored and carefully handled according to the manufacturer's recommendations.

2. The wireless remote controller shall be shipped inside the carton and packaged with the indoor unit and shall be able to withstand 105°F storage temperatures and 95% relative humidity without adverse effect.

E. Approved Manufacturers:

1. Basis of Design is Mitsubishi Mr. Slim. Other approved manufacturers as listed below. Any manufacturers not approved must submit performance and design data to engineer for review minimum 10 days in advance of bid date.

F. Approved Manufacturers:

1. Mitsubishi Mr. Slim

2. LGE

3. Daikin

G. Warranty

1. The units shall have a manufacturer's parts and defects warranty for a period five (5) years from date of installation. The compressor shall have an extended warranty of seven (7) years from date of installation. If, during this period, any part should fail to function properly due to defects in workmanship or material, it shall be replaced or repaired at the discretion of the manufacturer.

2. Provide one year labor warranty from date of substantial completion.

3. Manufacturer shall have over 29 years of continuous experience in the U.S. market.

H. Outdoor Units:

1. General:

a. The MXZ-B outdoor units shall be specifically designed to work with the MSZ-GE, MSZ-FE, MFZ-KD, SEZ-KD and SLZ-KA family of indoor units, as well as with the PLA-A18BA, PLA-A24BA, PCA-A24KA and PEAD-A24AA indoor models. The outdoor unit shall be completely factory assembled, piped and wired. Each unit shall be run tested at the factory prior to shipment.

2. Unit Cabinet:

a. The casing shall be fabricated of galvanized steel, Bonderized, finished with an electrostatically applied, thermally fused acrylic or polyester powder coating for corrosion protection. Assembly hardware shall be cadmium plated for weather resistance.

b. Cabinet color shall be Munsell 3Y 7.8/1.1.

c. Two (2) mild steel mounting feet, traverse mounted across the cabinet base pan, welded mount, providing four (4) slotted mounting holes shall be furnished. Assembly shall withstand lateral wind gust up to 155 MPH to meet applicable weather codes.

3. Fan:

a. The unit shall be furnished with a direct drive, high performance propeller type fan.

b. The condenser fan motor shall be a variable speed, direct current (DC) motor and shall have permanently lubricated bearings.

c. Fan speed shall be switch automatically according to the number of operating indoor units and the compressor operating frequency.

d. The fan motor shall be mounted with vibration isolation for quiet operation.

e. The fan shall be provided with a raised guard to prevent contact with

moving parts.

f. The outdoor unit shall have horizontal discharge airflow.

4. Outdoor unit sound level shall not exceed:

Model	Cooling	Heating
MXZ-4B36NA	54 dB(A)	57 dB(A)

5. Coil:

a. The outdoor unit coil shall be of nonferrous construction with lanced or corrugated plate fins on copper tubing.

b. The coil shall be protected with an integral guard.

c. Refrigerant flow from the outdoor unit to the indoor units shall be independently controlled by means of individual electronic linear expansion valves for each indoor unit.

d. Outdoor unit shall be pre-charged with sufficient R-410a refrigerant for up to one hundred and thirty-one (131) feet of refrigerant piping.

e. All refrigerant lines between outdoor and indoor units shall be of annealed, refrigeration grade copper tubing, ARC Type, meeting ASTM B280 requirements, individually insulated in twin-tube, flexible, closed-cell, CFC-free (ozone depletion potential of zero), elastomeric material for the insulation of refrigerant pipes and tubes with thermal conductivity equal to or better than 0.27 BTU-inch/hour per Sq Ft / °F, a water vapor transmission equal to or better than 0.08 Perm-inch and superior fire ratings such that insulation will not contribute significantly to fire and up to 1” thick insulation shall have a Flame-Spread Index of less than 25 and a Smoke-development Index of less than 50 as tested by ASTM E 84 and CAN / ULC S-102.

f. All refrigerant connections between outdoor and indoor units shall be flare type.

6. Compressor:

a. The compressor shall be a high performance, hermetic, inverter driven, variable speed, dual rotary type manufactured by Mitsubishi Electric Corporation.

b. The compressor motor shall be direct current (DC) type equipped with a factory supplied and installed inverter drive package.

c. The outdoor unit shall be equipped with a suction side refrigerant accumulator.

d. The compressor will be equipped with an internal thermal overload.

e. The compressor shall be mounted to avoid the transmission of vibration.

7. Manifold:

a. The outdoor unit shall have manifold connections providing a separate set of flared fittings for each indoor unit per the table below:

Port Connections	A	B	C	D
MXZ-4B36NA	¼ " Liquid ; 1/2" Gas	¼ " Liquid ; 3/8" Gas	¼ " Liquid ; 3/8" Gas	¼ " Liquid ; 3/8" Gas

[Some indoor unit combinations may require port adapters for proper connection]

8. Piping Requirements:

a. The outdoor unit must have the ability to operate within the following refrigerant piping and height limitations without the need for line size changes, traps or additional oil.

9. Piping Lengths:

Refrigerant Piping Data	Length to each indoor unit	Total piping length
MXZ-4B36NA	82 feet (Max)	230 feet (Max)

10. Height Differential:

Model	Indoor unit above outdoor unit	Indoor unit below outdoor unit
MXZ-4B36NA	49 feet (Max)	33 feet (Max)

11. Electrical:

a. The unit electrical power shall be 208/230 volts, 1-phase, 60 hertz.

b. The unit shall be capable of satisfactory operation within voltage limits of 198 volts to 253 volts.

c. The outdoor unit shall be controlled by the microprocessors located in the indoor unit and in the outdoor unit communicating system status, operation, and instructions digitally over A-Control – a system directing that the indoor unit be powered directly from the outdoor unit using a 3-wire, 14 ga. AWG connection plus ground.

12. The outdoor unit shall be equipped with Pulse Amplitude Modulation (PAM)

compressor inverter drive control for maximum efficiency with minimum power consumption.

I. Ceiling Recessed SLZ-KA**NA Indoor Unit

1. The SLZ shall be a four-way cassette style indoor unit that recesses into the ceiling with a ceiling grille. The indoor unit shall be factory assembled, wired and run tested. Contained within the unit shall be all factory wiring, piping, electronic modulating linear expansion device, control circuit board and fan motor. The unit shall have a self-diagnostic function, 3-minute time delay mechanism, an auto restart function, an emergency operation function and a test run switch. Indoor unit and refrigerant pipes shall be charged with dehydrated air before shipment from the factory.

2. Unit Cabinet:

   a. The cabinet shall be a compact 22-7/16” wide x 22-7/16” deep so it will fit within a standard 24” square suspended ceiling grid.

   b. The cabinet panel shall have provisions for a field installed filtered outside air intake.

   c. Four-way grille shall be fixed to bottom of cabinet allowing two, three or four-way blow.

3. Fan:

   a. The indoor fan shall be an assembly with a turbo fan direct driven by a single motor.

   b. The indoor fan shall be statically and dynamically balanced to run on a motor with permanently lubricated bearings.

   c. The indoor fan shall consist of three (3) speeds, Low, Mid, and High.

   d. The indoor unit shall have an adjustable air outlet system offering 4-way airflow, 3-way airflow, or 2-way airflow.

   e. The auto air swing vanes shall be capable of automatically swinging up and down for uniform air distribution.

4. Filter:

   a. Return air shall be filtered by means of a long-life washable filter.

5. Coil:

   a. The indoor coil shall be of nonferrous construction with smooth plate fins on copper tubing.

   b. The tubing shall have inner grooves for high efficiency heat exchange.

c. All tube joints shall be brazed with phos-copper or silver alloy.

d. The coils shall be pressure tested at the factory.

e. A condensate pan and drain shall be provided under the coil.

f. The unit shall include a condensate lift mechanism that will be able to raise drain water 19-3/4” inches above the condensate pan.

g. Both refrigerant lines to the SLZ indoor units shall be insulated.

h. Cassette shall be equipped with integral condensate lifting device.

6. Electrical:

a. The unit electrical power shall be 208/230 volts, 1-phase, 60 hertz.

b. The system shall be capable of satisfactory operation within voltage limits of 187-228 volts (208V/60Hz) or 207-253 volts (230V/60Hz).

7. Controls:

a. The control system shall consist of a minimum of one microprocessor on each indoor unit and one on the outdoor unit, interconnected by single non-polar two-wire cables. Field wiring shall run directly from the indoor unit to the wall mounted controller with no splices. The microprocessor located in the indoor unit shall have the capability of monitoring return air temperature and indoor coil temperature, receiving and processing commands from the wired controller, providing emergency operation and controlling the outdoor unit. The control voltage from the wired controller to the indoor unit shall be 12/24 volts, DC. The control signal between the indoor and outdoor unit shall be pulse signal 24 volts DC. Up to two wired controllers shall be able to be used to control one unit.

b. For A-Control, a three (3) conductor 14 ga. AWG wire with ground shall provide power feed and bi-directional control transmission between the outdoor and indoor units. . If code requires a disconnect mounted near the indoor unit, a TAZ-MS303 3-Pole Disconnect shall be used – all three conductors must be interrupted.

c. The system shall be capable of automatic restart when power is restored after power interruption. The system shall have self-diagnostics ability, including total hours of compressor run time. Diagnostics codes for indoor and outdoor units shall be displayed on the wired controller panel.

J. Remote Controller

1. Remote controller needs to be ordered separately from the unit.

K. Wired Remote Controller (PAR-21MAA)

1. The Wired Remote Controller (PAR-21MAA) shall be approximately 5” x 5” in size and white in color with a light-green LCD display. The PAR-21MAA shall support a selection from multiple languages (Spanish, German, Japanese, Chinese, English, Russian, Italian, or French) for display information. There shall be a built-in weekly timer with up to 8 pattern settings per day. The controller shall consist of an On/Off button, Increase/Decrease Set Temperature buttons, a Cool/Auto/Fan/Dry mode selector, a Timer Menu button, a Timer On/Off button, Set Time buttons, a Fan Speed selector, a Ventilation button, a Test Run button, and a Check Mode button. The controller shall have a built-in temperature sensor. Temperature shall be displayed in either Fahrenheit (°F) or Celsius (°C), and Temperature changes shall be by increments of 1°F (0.5°C). The PAR-21MAA shall have the capability of controlling up to a maximum of 16 systems, as a group with the same mode and set-point for all, at a maximum developed control cable distance of 1,500 feet (500 meters).

2. The basic functions are:

Wired Remote Controller (PAR-21MAA)	
Item	Description
Number of Units Controllable	16 units as 1 group
ON/OFF	Run and stop operation
Operation Mode	Switches between Cool/Dry/Auto/Fan/Heat.
Temperature Setting (Range and modes depend on connected unit model)	Sets the setpoint temperature in the following range Cool/Dry: 67°F-87°F Heat: 63°F-83°F Auto: 67°F-83°F
Fan Speed Setting (Range and modes depend on connected unit model)	Hi/Mid-2/Mid-1/Low/Auto
Air Flow Direction Setting (Air flow direction settings depend on the unit model)	Air flow direction angles 100%-80%-60%-40%, Swing.
Weekly Scheduler	ON/OFF/Temperature setting can be done up to 8 times one day in the week. The time can be set by the 1-minute interval.

Wired Remote Controller (PAR-21MAA)	
Item	Description
Operating Conditions Display	Setpoint and room temperature. Sensing can be done at the remote controller or the indoor unit depending on the indoor unit dipswitch setting Liquid, discharge, indoor and outdoor pipe temperatures LEV opening pulses, sub cooling and discharge super heat Compressor Operating Conditions: Running current, frequency, input voltage, On/Off status and operating time
Error	When an error is currently occurring on an air conditioner unit, the afflicted unit and the error code are displayed
Ventilation Equipment	Up to 16 indoor units can be connected to an interlocked system that has one LOSSNAY unit. LOSSNAY items that can be set are “Hi”, “Low”, and “Stop”. Ventilation mode switching is not available.
Auto Lock Out Function	Setting/releasing of simplified locking for remote control buttons can be performed. Locking of all buttons Locking of all buttons except ON/OFF button

a. The microprocessor located in the indoor unit shall have the capability of sensing return air temperature and indoor coil temperature, receiving and processing commands from the wireless or a wired controller, providing emergency operation and controlling the outdoor unit.

b. Indoor units shall be equipped with an optional “i-see® Sensor” kit, providing i-See® Sensor technology providing uniform temperature detection and automatically response to adjust the set temperature to provide uniform comfort from floor to ceiling.

L. Ceiling Recessed PLA-A**BA Indoor Unit:

1. General:

a. The indoor unit shall be a space-saving ceiling-recessed cassette type, factory assembled, wired and run tested prior to shipment. Contained within the indoor unit shall be all factory wiring, piping, control circuit board, fan, and fan motor. The unit , in conjunction with the wired, wall mounted controller shall have a self-diagnostic function, 3-minute restart time delay mechanism, an auto restart function, an emergency / test

operation. Indoor unit shall be charged with dry air before shipment from factory.

2. Unit Cabinet:

   a. The cabinet shall be formed from galvanized sheet metal coated with high-density foam insulation. Cabinet shall be for recessed mounting and provided with four (4) corner mounting supports behind removable corner pockets in Grille assembly allowing adjustment of mounting height from front of unit.

   b. The cabinet panel shall have provisions for a field installed filtered outside air intake.

   c. There shall be a knock-out to provide a branch air duct for conditioning a secondary space.

   d. There shall be an optional multi-function casement which will mount between the unit cabinet and the Grille assembly to provide a second field installed filtered outside air intake and provide a mount for a high-efficiency filter element.

   e. A separate grill assembly shall be attached to the front of the cabinet to provide supply air vanes in four directions and a center mounted return air section. The four-way grill shall be fixed to bottom of cabinet allowing two, three or four-way blow. The grill vane angles shall be individually adjustable from the wired remote controller to customize the airflow pattern for the conditioned space. Grill assembly color shall be white, Munsell number 6.4Y 8.9/0.4.

3. Fan:

   a. The indoor fan shall be an assembly with a turbo fan propeller, direct driven by a single motor and shall be statically and dynamically balanced to run on a motor with permanently lubricated bearings.

   b. The indoor unit shall have an adjustable air outlet system offering 4-way airflow, 3-way airflow, or 2-way airflow with switches that can be set to provide optimum airflow based on ceiling height and number of outlets used.

   c. The indoor unit vanes shall have 5 fixed positions and a swing feature that shall be capable of automatically swinging the vanes up and down for uniform air distribution.

   d. The vanes shall have an Auto-Wave selectable option in the heating mode that shall randomly cycle the vanes up and down to evenly heat the space. If specified, the grill shall have an optional i-see® sensor kit installed – sensor function described in System Control Section.

e. The indoor fan shall consist of five (5) speed settings, Low, Mid1, Mid2, High and Auto. The fan shall have a selectable Auto fan setting that will adjust the fan speed based on the difference between controller set-point and space temperature.

4. Filter:

a. Return air shall be filtered by means of an easily removable, long life, washable filter. [An optional high-efficiency shall be installed in the multi-function casement].

5. Coil:

a. The indoor unit coil shall be of nonferrous construction with pre-coated aluminum strake fins on copper tubing. The tubing shall have inner grooves for high efficiency heat exchange.

b. The heat exchanger shall have a modified fin shape that reduces air resistance for a smoother, quieter airflow. All tube joints shall be brazed with PhosCopper or silver alloy. The coils shall be pressure tested at the factory.

c. A condensate pan with drain connections shall be provided under the coil. The unit shall also include a built-in, automatic condensate lift mechanism that will be able to raise drain water 33 inches (84 cm) above the condensate pan. The lift mechanism shall be equipped with a positive acting liquid level sensor to shut down the indoor unit if liquid level in the drain pan reached maximum level.

d. Both refrigerant lines between the indoor unit and outdoor unit shall be fully insulated.

e. Cassette shall be equipped with integral condensate lift mechanism.

6. Electrical:

a. The indoor unit electrical power shall be 208 / 230 volts, 1-phase, 60 hertz.

b. The system shall be capable of satisfactory operation within voltage limits of 198 volts to 253 volts.

c. The system shall be equipped with A-Control – a system allowing each indoor unit to be powered and controlled directly from the outdoor unit using a 14 gauge (AWG) 3-wire connection plus ground providing both primary power and integrated, bi-directional, digital control signal without additional connections.

d. The indoor unit shall not have any supplemental or back-up heating elements.

7. Control:

a. The control system shall consist of a minimum of one microprocessor on each indoor unit and one on the outdoor unit, interconnected by single non-polar two-wire cables. Field wiring shall run directly from the indoor unit to the wall mounted controller with no splices. The microprocessor located in the indoor unit shall have the capability of monitoring return air temperature and indoor coil temperature, receiving and processing commands from the wired controller, providing emergency operation and controlling the outdoor unit. The control voltage from the wired controller to the indoor unit shall be 12/24 volts, DC. The control signal between the indoor and outdoor unit shall be pulse signal 24 volts DC. Up to two wired controllers shall be able to be used to control one unit.

b. For A-Control, a three (3) conductor 14 ga. AWG wire with ground shall provide power feed and bi-directional control transmission between the outdoor and indoor units. . If code requires a disconnect mounted near the indoor unit, a TAZ-MS303 3-Pole Disconnect shall be used – all three conductors must be interrupted.

c. The system shall be capable of automatic restart when power is restored after power interruption. The system shall have self-diagnostics ability, including total hours of compressor run time. Diagnostics codes for indoor and outdoor units shall be displayed on the wired controller panel.

M. Remote Controllers

1. All remote controllers need to be ordered separately from the unit.

N. Wired Remote Controller (PAR-21MAA)

1. The Wired Remote Controller (PAR-21MAA) shall be approximately 5” x 5” in size and white in color with a light-green LCD display. The PAR-21MAA shall support a selection from multiple languages (Spanish, German, Japanese, Chinese, English, Russian, Italian, or French) for display information. There shall be a built-in weekly timer with up to 8 pattern settings per day. The controller shall consist of an On/Off button, Increase/Decrease Set Temperature buttons, a Cool/Auto/Fan/Dry mode selector, a Timer Menu button, a Timer On/Off button, Set Time buttons, a Fan Speed selector, a Ventilation button, a Test Run button, and a Check Mode button. The controller shall have a built-in temperature sensor. Temperature shall be displayed in either Fahrenheit (°F) or Celsius (°C), and Temperature changes shall be by increments of 1°F (0.5°C). The PAR-21MAA shall have the capability of controlling up to a maximum of 16 systems, as a group with the same mode and set-point for all, at a maximum developed control cable distance of 1,500 feet (500 meters).

2. The basic functions are same as above

a. The microprocessor located in the indoor unit shall have the capability of sensing return air temperature and indoor coil temperature, receiving and processing commands from the wireless or a wired controller, providing emergency operation and controlling the outdoor unit.

b. Indoor units shall be equipped with an optional "i-see® Sensor" kit, providing i-See® Sensor technology providing uniform temperature detection and automatically response to adjust the set temperature to provide uniform comfort from floor to ceiling.

O. SEZ-KD**NA Ducted Indoor Units

1. General:

a. The indoor unit shall be factory assembled, wired and run tested. Contained within the unit shall be all factory wiring, piping, control circuit board, fan and fan motor. The unit shall have a self-diagnostic function, 3-minute time delay mechanism, and an auto restart function. Indoor unit shall be charged with dry air before shipment from factory.

2. Unit Cabinet:

a. The cabinet shall be low profile, ceiling-concealed ducted not to exceed 7-7/8" in depth.

3. Fan:

a. The indoor unit fan shall be an assembly with one Sirocco fan direct driven by a single motor.

b. The indoor fan shall be statically and dynamically balanced to run on a motor with permanently lubricated bearings.

c. The indoor fan shall consist of three (3) speeds, High, Mid, and Low.

d. The indoor unit shall have a ducted air outlet system and ducted return air system.

4. Filter:

a. Return air shall be filtered by means of a standard factory installed return air filter.

5. Coil:

a. The indoor coil shall be of nonferrous construction with smooth plate fins on copper tubing.

b. The tubing shall have inner grooves for high efficiency heat exchange.

c. All tube joints shall be brazed with PhosCopper or silver alloy.

d. The coils shall be pressure tested at the factory.

e. A condensate pan and drain shall be provided under the coil.

f. The unit shall be provided with an integral condensate lift mechanism able to raise drain water 21 inches above the condensate pan.

g. Both refrigerant lines to the indoor units shall be insulated.

6. Electrical:

a. The unit electrical power shall be 208/230 volts, 1 phase, 60 hertz.

b. The system shall be capable of satisfactory operation within voltage limits of 187-228 volts (208V/60Hz) or 207-253 volts (230V/60Hz).

7. Controls:

a. The indoor unit shall perform Self-diagnostic Function and Check Mode switching.

b. The system shall be capable of automatically restarting and operating at the previously selected conditions when the power is restored after power interruption.

P. Remote Controllers

1. All remote controllers need to be ordered separately from the unit.

Q. Wired Remote Controller (PAR-21MAA)

1. The Wired Remote Controller (PAR-21MAA) shall be approximately 5” x 5” in size and white in color with a light-green LCD display. The PAR-21MAA shall support a selection from multiple languages (Spanish, German, Japanese, Chinese, English, Russian, Italian, or French) for display information. There shall be a built-in weekly timer with up to 8 pattern settings per day. The controller shall consist of an On/Off button, Increase/Decrease Set Temperature buttons, a Cool/Auto/Fan/Dry mode selector, a Timer Menu button, a Timer On/Off button, Set Time buttons, a Fan Speed selector, a Ventilation button, a Test Run button, and a Check Mode button. The controller shall have a built-in temperature sensor. Temperature shall be displayed in either Fahrenheit (°F) or Celsius (°C), and Temperature changes shall be by increments of 1°F (0.5°C). The PAR-21MAA shall have the capability of controlling up to a maximum of 16 systems, as a group with the same mode and set-point for all, at a maximum developed control cable distance of 1,500 feet (500 meters).

2. The basic functions are same as above.

a. The microprocessor located in the indoor unit shall have the capability of sensing return air temperature and indoor coil temperature, receiving and processing commands from the wireless or a wired controller,

providing emergency operation and controlling the outdoor unit.

1.11 ENERGY RECOVERY UNITS (ERU-01, 02)

A. General

1. Provide outside air unit as manufactured by Valent or pre-approved equal.

2. Other Approved Manufacturers: Desert Aire and Aaon.

3. Project is based on the specified equipment. Any additional costs associated with using alternate manufacturer's equipment shall be borne by the installing contractor or equipment provider.

B. Warranty

1. Unit shall subject to manufacturer's standard warranty for the following periods:

2. Overall unit, 12 months from substantial completion but no more than 18 months from shipment.

3. Compressors, 60 months substantial completion but no more than 66 months from shipment.

4. Energy recovery wheel, 60 months from substantial completion but no more than 66 months from shipment.

5. One year labor warranty from substantial completion.

C. Casing Construction

1. Unit shall be constructed for outdoor installation on a roof curb, framing, or concrete pad.

D. Base

1. Base rails shall be constructed of a minimum of 10 gage galvanized steel with 16 gage integral floor pan.

2. Base shall have a minimum 4" overhang over the top of a roof curb to prevent water infiltration.

3. All floor seams shall have a raised rib joint.

4. There shall be no penetrations through the floor of the unit within the perimeter of the curb except for duct openings and utility chases.

5. Penetrations through the floor shall have a ½" raised rib around each opening.

E. Options

1. Base pan shall be insulated with ½" closed-cell neoprene liner.

F. Panels

1. Casing shall be constructed with minimum 2-inch, foam-injected, double-wall panels.

2. Individual panels shall be constructed so that they are thermally broken (there shall be no metal-to-metal contact between the interior and exterior sheet metal of each panel).

3. Interior side of panel shall be 22 gage G-90 galvanized steel.

4. Exterior side of panel shall be 22 gage painted steel rated for 1000 hours in accordance with ASTM B117 and ASTM D1654.

G. Insulation

1. Insulation shall be 2 lb/ft3 foam insulation with an average R-value of 6 per inch.

2. Insulation water absorption must be no more that 0.038 lb/ft per ASTM D 2842 and show "no growth" per ASTM G21 biocide testing.

3. No insulation shall be exposed to the air stream.

4. Fiberglass insulation is not acceptable due to possibility of sloughing and moisture retention.

H. Access doors

1. Access doors shall be provided for access to all components requiring regular maintenance or inspection.

2. Access doors shall have a minimum of two quarter-turn compression latches with adjustable catches.

3. Access door construction shall be identical to unit casing.

4. Interior side of access doors shall be 22 gage G-90 galvanized steel.

5. Exterior side of panel shall be 22 gage painted steel rated for 1000 hours in accordance with ASTM B117 and ASTM D1654.

6. Access doors shall be sealed with a full-perimeter gasket constructed of Mylar-encased low-density foam.

I. Insulation

1. Insulation of shall be 2 lb/ft3 foam insulation with an average R-value of 6 per inch.

2. Insulation water absorption must be no more that 0.038 lb/ft per ASTM D 2842 and show "no growth" per ASTM G21 biocide testing.

3. No insulation shall be exposed to the air stream.

4. Fiberglass insulation is not acceptable due to possibility of sloughing and moisture retention.

5. Weatherhood with bird screen shall be provided on outside air inlet.

6. Roof shall be pitched with a minimum ½" roof overhang around the perimeter of the unit.

J. BLOWERS/MOTORS

1. Blowers

a. Fan assemblies shall be direct-drive without the use of belts or adjustable sheaves.

b. Manufacturer shall provide a variable frequency drive for each fan section.

c. Variable frequency drive shall be mounted, wired, and programmed by the manufacturer.

d. Variable frequency drive shall be located in an enclosed compartment outside of the supply or exhaust air stream.

e. Fan wheels shall have backward inclined blades constructed out of corrosion-resistant, fiber-reinforced polyamide.

f. Fan wheels shall have backward inclined blades constructed of welded aluminum.

g. Fan wheel shall be tested in accordance to AMCA 210.

2. Motors

a. Fan motor shall be VFD rated, ODP type, EPACT compliant.

b. Fan motor shall be of premium efficiency (PE).

K. DAMPERS

1. Motorized dampers

a. Provide OA, EA and RA bypass dampers.

2. Construction

a. Frame shall be constructed of a 16 gage galvanized steel hat-channel.

b. Blades shall be constructed of 16 gage galvanized steel strengthened by three longitudinal 1 inch deep “vee” grooves.

c. Blades shall be symmetrical relative to its axle pivot point.

d. Axle bearings shall be synthetic sleeve-type and rotate inside extruded holes in the damper frame.

e. Blade seals shall be extruded vinyl permanently bonded to the appropriate blade edges.

f. Frame shall include flexible stainless steel compression-type jamb seals.

g. Modulating spring-return actuators shall be provided by the factory, installed on the damper, and wired to the control center.

h. Damper leakage shall be no more than 5 cfm/sq.ft. at 1 in.wg static pressure.

L. FILTERS

1. Outdoor air filters

a. Outdoor air filter rack shall accommodate factory-provided 2" aluminum filters.

b. Filter sections shall be accessible through a 2" foam-injected, double-wall, hinged access door with quarter-turn latches.

2. Supply air filters

a. Supply air filter rack shall accommodate 2" MERV 8 filters.

b. Filter sections shall be accessible through a 2" thick, foam-injected, double-wall, hinged access door with quarter-turn latches.

3. Return air filters

a. Return air filter rack shall accommodate factory-provided 2" aluminum filters.

b. Filter sections shall be accessible through a 2" thick, foam-injected, double-wall, hinged access door with quarter-turn latches.

M. ENERGY RECOVERY – ENTHALPY WHEEL

1. Energy recovery shall be an integral part of unit from the manufacturer.

2. No field assembly, ducting, or wiring shall be required with energy recovery

option.

3. Energy recovery media shall be accessible through a 2" thick, foam-injected, double-wall, hinged access door with quarter-turn latches.

4. Wheel construction

   a. Energy recovery shall be provided through a total enthalpy wheel providing sensible and latent energy transfer.

   b. Energy recovery wheel shall be constructed of lightweight polymer substrate with permanently-bonded silica gel desiccant.

   c. Energy recovery wheel cassette shall be mounted perpendicular to the base of the unit.

   d. Individual pie-shaped wheel sections shall be removable from wheel cassette for maintenance.

   e. Wheel bearings shall be selected to provide an L-10 life in excess of 400,000 hours.

   f. Rim shall be continuous rolled stainless steel and the wheel shall be connected to the shaft by means of taper locks.

   g. Energy wheel cassette shall include seals, drive motor and drive belt.

   h. Latent energy shall be transferred entirely in the vapor phase.

   i. The energy recovery cassette shall be an Underwriters Laboratories Recognized Component for electrical and fire safety.

   j. The wheel drive motor shall be an Underwriters Laboratory Recognized Component and shall be mounted in the cassette frame and factory wired to main ventilator disconnect.

   k. Thermal performance shall be certified by the wheel manufacturer in accordance with ASHRAE Standard 84, Method of Testing Air-to-Air Heat Exchangers and ARI Standard 1060, Rating Air-to-Air Energy Recovery Ventilation Equipment.

N. COOLING - WATER-SOURCE HEAT-PUMP

1. Unit shall be provided with factory piped, charged, and tested packaged water source heat pump direct expansion refrigeration system.

2. All refrigeration systems 13 nominal tons and above shall be equipped with two stages of capacity control, each on an independent refrigerant circuit.

3. Refrigeration system shall include microprocessor-based head pressure control logic to maintain refrigerant pressures by actively modulating water flows

(Active Head Pressure Control).

4. Thermal expansion valves

    a. Refrigeration system shall be provided with thermal expansion valve (TXV) incorporating adjustable superheat.

5. Evaporator coil

    a. Coil shall be rated in accordance to ARI standards and pressure tested for 250 psi working pressure.

    b. Coil shall be a minimum of 4 rows deep.

    c. Refrigeration systems with more than one circuit shall have interlaced evaporator coils.

    d. Coil casing shall be constructed of 16 gage galvanized steel.

    e. Coil tubes shall be constructed of 1/2" diameter, 0.016" thick seamless copper tubing.

    f. Coil fins shall be constructed of 0.0060" thick aluminum.

6. Drain pan

    a. Drain pan shall be constructed of a minimum of 18 gage 201 stainless steel.

    b. Drain pan shall be double-sloped to ensure condensate removal from unit.

    c. Drain pan shall extend a minimum of 8” past the evaporator coil to ensure condensate retention.

7. Modulating hot-gas reheat

    a. Hot-gas reheat coil shall be separated from the evaporator coil by a minimum of 6” in the direction of airflow to prevent the re-evaporation of condensate, provide room for coil cleaning, and allow control system to monitor evaporator coil leaving air temperature.

    b. Hot-gas reheat coil shall be constructed entirely of aluminum.

    c. Hot-gas reheat shall be controlled through a factory-supplied modulating control valve.

8. Compressors

    a. Compressors shall be hermetic scroll type and include the following items:

b. Suction and discharge service valves.

c. Reverse rotation protection.

d. Oil level adjustment.

e. Oil filter.

f. Rotary dirt trap.

g. Short cycling control.

h. High and low pressure limits.

i. Crankcase heaters.

j. Compressors shall be installed in an isolated compartment separate from supply airflow, return airflow, microprocessor controller, non-fused disconnect, compressor relays, fan motor VFD, and all other electrical components inside the unit.

k. Compressors shall be installed using manufacturer's recommended rubber vibration isolators.

l. Lead refrigeration circuit shall utilize Digital Scroll™ compressor capable of 10:1 turndown.

9. Water-to-refrigerant heat exchanger

a. Each independent refrigerant circuit shall be provided with a coaxial water-to-refrigerant heat exchanger.

10. Options

a. Supply fan inlet cone for airflow monitoring

b. Supply Fan modulation for duct static pressure.

c. Exhaust fan modulation for space pressure control.

d. Enthalpy economizer.

e. Filter differential pressure switches and gages.

f. Return air smoke detector.

g. Active Head Pressure Control

h. Refrigeration sightglasses.

i. Heat wheel rotation sensor.

j. One set of extra filters of each type.

11. Electrical

a. Units shall be factory wired with a single point power connection.

b. Units shall be wired according to NEC and listed per ETL.

c. ETL listing shall cover all components of the ventilator and not be limited to the control panel.

d. All major electrical components shall be UL listed.

e. Unit shall be constructed with an integral control center isolated from supply airflow, exhaust airflow, compressors, and heating elements.

f. The following items shall be provided and wired within the control center by the factory:

g. Non-fused disconnect.

h. Sub-circuit fusing.

i. Low voltage transformers.

j. Control circuit fusing.

k. Terminal block.

l. Fan motor variable frequency drives.

m. Electrical panel must house all high voltage components such as terminal blocks, variable frequency drives, and fuse blocks.

12. Options

a. Control panel shall include a factory supplied and mounted 115V GFCI convenience outlet receptacle with a 12A circuit breaker. Outlet shall be powered by factory.

b. Unit shall include a factory supplied, mounted, and wired phase and voltage monitor.

c. Factory mounted disconnect with 90 Amp circuit breaker.

13. Controls

a. Units shall include factory supplied, mounted, wired, and tested stand-alone microprocessor controls.

b. Microprocessor controller shall be factory-programmed for discharge air

control and use an internal 7-day time clock.

c. Microprocessor controller shall be mounted in a weather-proof enclosure and accessible without exposing the operator to high voltage wiring or having to turn off or circumvent the main disconnect.

d. Microprocessor controller shall include local liquid crystal display (LCD) for user interface.

e. The following sensors shall be factory supplied, mounted, and wired inside the unit:

i. Outdoor air humidity sensor.

ii. Outdoor air temperature sensor.

iii. Evaporator coil leaving air temperature sensor.

iv. Supply air filter pressure monitoring.

v. Energy wheel rotation sensor.

f. The following devices shall be factory supplied but ship loose and require field installation and wiring:

i. Supply air temp temperature sensor.

ii. Space static pressure sensor.

iii. Duct static pressure sensor.

iv. Smoke detectors.

v. Microprocessor controller shall include BACnet IP or LonTalk (FTT-10A) communications for building management system interface.

vi. Provide local LCD with 6 foot cable.

14. Factory Verification Testing

a. Unit shall be run tested prior to shipment from the factory.

b. Factory run test report shall be provided at the request of the engineer, contractor, or owner.

15. Testing Procedures

a. Unit shall be subjected to and pass a dielectric (hipot) test.

b. All motorized dampers shall be cycled one full stroke while installed in

the unit using the factory-provided motorized actuators.

16. Supply fan

    a. Visually inspect ramp-up, ramp-down, and rotation direction of fan when enabled.

    b. Verify fan pressure proving switch operation.

    c. Measure and record current draw through supply fan motor(s).

17. Exhaust fan

    a. Visually inspect ramp-up, ramp-down, and rotation direction of fan when enabled.

    b. Verify fan pressure proving switch operation.

    c. Measure and record current draw through exhaust fan motor(s).

18. Energy recovery wheel.

    a. Visually inspect energy recovery wheel cassette is free to rotate within cassette.

    b. Visually inspect energy recovery belt drive mechanism.

    c. Enable energy recovery wheel motor and ensure proper rotation.

    d. Measure and record current draw through energy recovery wheel motor.

19. Refrigeration system

    a. Measure and record subcooling and superheat on circuit A with hot-gas reheat valve closed (0%) after 15 minutes of steady-state operation.

    b. Measure and record subcooling and superheat on circuit A with hot-gas reheat valve open (100%) after 15 minutes of steady-state operation.

    c. Measure and record subcooling and superheat on circuit B after 15 minutes of steady-state operation.

    d. Test report shall be included with unit and available from the factory upon request.

1.12 WATER SOURCE HEAT PUMP UNITS

A. General

1. Section Includes

a. Water-Source Heat Pumps.

b. Controls.

c. Accessories.

2. Basis of design is Trane, acceptable manufacturers include: Climate Master and Water Furnace.

B. References

1. AHRI 13256 - Water-Source Heat Pump Equipment.

2. ANSI/UL 559 - Standard for Heat Pumps.

3. CSA C22.2 No. 186.1 Central Forced Air Unitary Heat Pumps with or without Electric Resistance Heat.

4. AHRI 260 - Sound rating of ducted air moving and conditioning equipment.

C. Submittals

1. Submit unit performance data including: capacity, nominal and operating performance.

2. Submit Mechanical Specifications for unit and accessories describing construction, components and options.

3. Submit shop drawings indicating overall dimensions as well as installation, operation and service clearances. Indicate lift points and recommendations and center of gravity. Indicate unit shipping, installation and operating weights including dimensions.

4. Submit data on electrical requirements and connection points. Include recommended wire and fuse sizes or MCA, sequence of operation, safety and start-up instructions.

5. Submit operation and maintenance data including manufacturer's descriptive literature, operating instructions, installation instructions, and maintenance and repair data to include parts list and wiring diagrams.

D. Delivery, Storage and Handling

1. Deliver, store, protect, and handle products per manufacturer's recommendations.

2. Comply with manufacturers installation instructions for rigging, unloading and transporting units.

3. Protect unit from physical damage. Leave factory shipping covers in place until installation.

E. Warranty

1. Provide Whole Units Parts Warranty for the duration of one year from substantial completion. Warrant that all products are free from defects in material and workmanship and have the capacities and ratings set forth in manufacturer's catalogs and bulletins.

2. Provide one year labor warranty.

F. Qualifications

1. Manufacturer: Company specializing in manufacturing the products specified in this section with minimum fifteen years documented experience.

G. Products

H. Vertical Ground/Water Source Heat Pumps

1. Cabinet: Provide unit factory assembled and pre-wired consisting of: galvanized steel cabinet with 1/2" fiberglass on interior, discharge duct collar and return collar with filter rack to accommodate 1" or 2" thick throwaway filters.

2. Sound Power Data: Sound power data must not exceed the following requirements to ensure quiet unit operation. Sound power level in dB re 1 pW. Acoustical data obtained in accordance with AHRI 260. Note: Acoustical data based on high blower speed.

3. 1/2 - 5 Ton Horizontal Units with Standard Static Motors at the 125 Hz Octave Band.

	Duct Disch.	Inlet+Case	Case	Duct Inlet
6MBH-15MBH	68	63	62	70
18MBH-30MBH	78	66	65	70
36MBH-42MBH	74	71	67	71
48MBH-60MBH	78	73	71	72

4. If sound power data cannot be met, sound attenuation shall be applied as a standard feature in the product design. The sound reduction package shall include vibration isolation to the compressor and water-to-refrigerant coil, discharge line muffler, compressor blanket, 16-gauge access panels, neoprene gasketing on all access panels, and 1" insulation on the interior of the unit. Unit manufacturer shall provide, at their expense, a mock-up unit to be approved by owner representative.

I. Refrigeration System

1. Compressor: The unit shall include a compressor. External vibration isolation shall be provided by mounting devices located underneath the mounting base of the compressor. Thermal overload protection shall be provided.

2. 7.5 and 10 Ton units shall have high efficient dual compressors or single compressors with unloading.

3. Water-to-Refrigerant Heat Exchanger: The water-to-refrigerant heat exchanger shall be of a high quality co-axial coil for maximum heat transfer. The copper coil shall be deeply fluted to enhance heat transfer and minimize fouling and scaling. The coil shall have a working pressure of 450 psig on the refrigerant side and 400 psig on the water side.

4. Reversing Valve: The reversing valve shall be a pilot operating sliding piston type with replaceable encapsulated magnetic coil. This valve shall be energized in cooling.

5. Tubing: The refrigerant tubing shall be of 99% pure copper. This system shall be free from contaminants and conditions such as drilling fragments, dirt, and oil. All refrigerant and water lines shall be insulated with an elastomeric insulation that has a 3/8" thick wall wherever air is introduced to the assembly.

6. Refrigerant Metering: The equipment shall be provided with a thermal expansion valve (TXV). Capillary tubes may only be used if unit manufacturer provides water-regulating valve.

7. Schraeder Connections: The refrigerant access ports shall be factory supplied on the high and low pressure sides for easy refrigerant pressure or temperature testing.

8. Air-to-Refrigerant Coil: The air-to-refrigerant coil shall contain copper tubes mechanically expanded into evenly spaced aluminum fins. All coils are to be leak tested. The proof must be performed at 450 psi operating pressure and the leak test at 125 psi operating pressure with helium. In addition, the tubes are to be completely evacuated of air prior to shipment. The refrigerant coil distributor assembly shall be of orifice style with round copper distributor tubes. The tubes shall be sized consistently with the capacity of the coil. Suction headers shall be fabricated from rounded copper pipe.

9. Electrical: The factory tested and installed control panel shall contain all necessary devices to allow heating and cooling operation of the equipment to occur from a remote wall thermostat or zone sensor. These devices shall be as follows:

10. 24 VAC contactor for compressor control.

11. 18 pole terminal strip located inside the control panel behind the service access panel. This terminal strip shall be used for low voltage (thermostat/zone sensor) connections.

12. An electrically operated safety lockout relay shall help prevent cycling of the

compressor during adverse conditions of operation. This device shall be reset either at the remote thermostat/zone sensor, or by cycling power to the unit.

13. A high pressure switch shall help protect the compressor against operation at refrigerant system pressure in excess of 395 psig.

14. A low pressure switch shall help prevent compressor operation under low charge or catastrophic loss of charge situations.

15. Controls: Unit controls shall be factory-wired, factory-tested, and factory-commissioned. Each WSHP shall be controlled by a communicating DDC controller. Additionally, this controller shall have resident WSHP control logic. The controller shall provide the features listed below:

    a. 24 VAC Energy Limiting Class II, 75 VA breaker type transformer (minimum) with integral circuit breaker for component safety.

    b. Random start of all water source heat pumps

    c. Fan status and filter timer.

    d. Low water temperature sensor.

    e. Ability to control to four setpoints: occupied, occupied standby, occupied bypass (timed-override), and unoccupied.

    f. The unit controller shall receive the following commands from the Building Management System: mode (occupied and unoccupied), demand limiting sequence, emergency shutdown, and time-of-day scheduling.

    g. Provide field service interface for diagnostic and troubleshooting purposes.

16. Specific diagnostics (not general alarm) shall be communicated to the Building Management System:

    a. Space setpoint.

    b. Discharge air temperature.

    c. Leaving water temperature.

    d. Unit alarms with manual reset include: high pressure, low pressure, and condensate overflow.

    e. Unit alarms with automatic reset include: fan and filter status and low water temperature.

    f. Zone thermostat with one setpoint and override button

g. Building Management System: Interface control module to Building Management System to be furnished and mounted by the water source heat pump manufacturer. Through this interface module, all Building Management functions (specified in Building Management section) shall be performed. See Building Automation and Automatic Temperature Control system specifications. The interface module with necessary controls and sensors shall all be factory mounted (not field mounted). The only field connection to Building Management System shall be a single communication link.

J. 1/2 - 5 Ton Motor and Fan Assembly:

1. All fan motors shall be three speed high efficiency PSC, wired on the high speed tap. The motor shall have permanently lubricated and sealed bearings. All motors shall have internal thermal overload protection.

2. High external static pressure motors to be provided as scheduled.

3. The fan assembly shall be arranged for back, left, or right discharge. The discharge must also be capable of being changed in the field.

4. Removal of the motor and fan wheel shall be made with the assistance of a factory provided orifice ring assembly. This assembly shall attach the wheel and motor to the fan housing providing single side service access.

K. 10 Ton Motor and Fan Assembly:

1. All fan motors shall incorporate a belt driven motor selection.

2. Adjustable motor sheave and blower drive assemblies shall allow a greater variation in external static pressures. The motors shall be capable of providing external static pressure as scheduled.

3. Access to the blower motor is provided through the back of the unit by way of two panels, and/or through a side access panel if adjustment to the motor belt or drive assembly are needed.

4. Drain Pan: The drain pan shall be constructed of corrosion resistant material and insulated to prevent sweating. The bottom of the drain pan shall be sloped on two planes which pitches the condensate to the drain connection. When the unit is installed per the installation manual, the drain pan shall be designed to leave puddles no more than 2" in diameter, no more than 1/8" deep, for no longer than 3 minutes following step 3 of the following test. The test steps are:

5. Temporarily plug the drain pan.

6. Fill the drain pan with 2" of water or the maximum allowed by the drain pan depth, whichever is smaller.

7. Remove the temporary plug.

8. Filters: Standard filter that ships with unit is a 1" thick throwaway.

9. Provide extra set of filters.

10. Provide condensate overflow switch.

L. Execution

1. Examination

2. Verify that required utilities are available, in proper location, and ready for use.

3. Beginning of installation means installer accepts existing surfaces.

M. Installation

1. Install in accordance with manufacturer's instructions.

2. Locate units as indicated, level and shim units, and anchor to structure.

3. Protect units with protective covers during balance of construction.

4. Provide units with shut-off valve on supply and lockshield balancing valve on return piping. If not easily accessible, extend vent to exterior surface of cabinet for easy servicing.

N. Cleaning

1. Clean work.

2. After construction is completed, including painting, clean exposed surfaces of units. Vacuum clean coils and inside of cabinets.

3. Touch-up marred or scratched surfaces of factory-finished cabinets, using finish materials available from manufacturer.

4. Install new filters.

END OF SECTION 15012

SECTION 15012A - EARTH COUPLED GROUND LOOP PIPING SYSTEM

1.1 GENERAL

A. Scope

1. Furnish all material, equipment and labor and perform all operations required to drill and backfill bore holes and install closed loop piping for earth coupled applications as specified in these sections and indicated on the plans. This work shall include all piping from wells, underground mains, vault, 1” PVC electric conduit to vault, valves and extend piping mains and conduit into building mechanical room. Provide piping flanges 18” above mechanical room floor. See Drawings.

B. Related Work

1. Related work listed hereinafter is for reference guide only and is not intended to define limits of work necessary for complete installation:

a. Section 15002: Pipe Trenching and Backfilling

2. There will be one (2) test wells on site. Contractor shall attempt to incorporate the test well into final layout of Geothermal Well-field.

NOTE: No well system shall be backfilled until all piping and connections are reviewed by the Engineer or Architect’s representative. Provide sweeping 90° elbows in 1” piping at top of bore holes.

a. Section 15012: HVAC

C. Submittals

1. Submit piping schedule showing manufacture, pipe or tube weight, pressure rating, fitting type and joint type for each piping system. Submit manufacturer's mechanical data for valves. Submit drilling logs of each borehole. Submit total cubic yards of backfill in each borehole.

1.2 SUBMITTALS

A. Closed Loop Piping

1. Closed loop piping shall be high density polyethylene piping and fittings with heat fused joints for earth coupled heat pump applications.

2. Tubing shall be free from defects in material and workmanship.

3. 1” thru 1 1/4” piping shall be DR11, 160 PSI; 1 1/2” thru 2” shall be Schedule 40, 100 PSI; 3” and larger piping shall be DR 17,100 psi.

B. Warranty

1. Entire ground loop piping system shall be warranted for ten (10) years from date of Substantial Completion against any leakage or failure.

1.3 QUALIFICATIONS

A. Bore Holes

1. The ground loop piping Contractor must have a minimum of five (5) years experience in installation in earth coupled ground loop piping systems. The Geothermal Contractors must be approved by Architect/ Engineer prior to bidding. All fees and licenses required for this contractor will be paid by the Contractor.

B. Piping and Headers

1. Contractor shall hold a Certification of Qualification provided by the pipe manufacturer who is recognized by International Ground Source Heat Pump Association as a qualified trainer certifying that the Contractor is knowledgeable, qualified and proficient in performing the fusion welding process. Use only thoroughly trained and experienced workmen completely familiar with polyethylene piping and heat fusion joining.

C. Acceptable Bidders

1. All bidders for earth coupled/ground loop system must have Architect/Engineer approval prior to bidding the project.

2. The list of approved well drillers and/or earth coupled/ground loop system contractors for this project is as follows:

a. Geothermal Contractors:

i. Moses Drilling Company

ii. Eastern Well & Pump, Inc.

iii. Geothermal Earthworks, Inc.

iv. Geothermal Systems, Inc.

v. M&W Drilling

vi. E&E Drilling

vii. Stafford Drilling

viii. Withers Geothermal Drilling

ix. Geothermal Solutions

3. Any well drillers and/or earth coupled/ground loop system contractors not on approved list must submit their qualifications seven (7) days (minimum) prior to bidding.

1.4 PERFORMANCE

A. Bore Hole and Headers

1. Minimum bore hole diameter shall be 6 inches.

2. Minimum bore depth shall be as shown on the drawings.

3. All bore holes for a unit to be completed, backfilled and tested prior to trenching for headers. Bore holes which cannot be used because of voids or caverns are to be abandoned in accordance with the applicable plugging and abandoning of wells procedures.

4. The assembled bore hole piping shall be pressure tested at 90 psi prior to installing in the bore hole. After pipe is placed in bore hole, hydrostatic test to 90 psi for 3 hours. After pipe passes hydrostatic test, backfill as follows:

   a. The bore holes shall be backfilled with a 50%/50% mixture of #9 crushed limestone and manufactured sand and the top 25 feet of the bore holes shall be capped with Bentonite. All backfill will be in accordance with local regulating authority. Extreme care must be taken to insure NO bridging of the backfill or the bore holes. The piping shall be installed in the borehole, tested immediately and backfilled immediately. Borehole cuttings cannot be used for backfill of the boreholes. The cuttings can be used as part of the backfill for lateral mains.

5. From the well headers, provide 60-inch minimum cover until inside the grade beam. Terminate piping as shown on the Drawings. Provide temporary loop connection of the supply and return mains inside the building so that the piping system can be tested and flushed properly. Hydrostat pressure test to 90 psi for each heat pump ground loop for six (6) hours.

6. Backfill the trench after placing 6-inches of manufactured sand on, around and under the header pipe. Backfill with same material removed from trench, free of rocks. Trace tape shall be installed 24-inches below finished grade in all header piping trenches. Note: Backfill under paved areas shall be compacted dense grade from the 6” of manufactured sand to the underside of paving. Provide 12 gauge coated copper trace wire at all lateral piping runs adjacent to lateral piping at bottom of ditch.

7. Final connections of ground loop piping to heat pump loop piping inside the building will be performed by the Mechanical Contractor at a future date.

8. Ground loop piping and final flushing, purging and filling of the ground loop system will be performed by the ground loop piping Contractor. Purging and flushing equipment must be capable of filtering ground loop water and be

capable of reversing direction of water flow in the ground loop system without disconnecting the purge unit from the system. Once the geothermal piping loop system is purged and pressure tested, the entire system shall be sealed off to protect the system.

9. Unit prices shall include both permanent steel casing and removable casing. Refer to Unit Prices, attachment to Form of Proposal, Division 0.

10. SPECIAL CARE must be taken to insure that there are no voids in the hole. (The well hole cuttings can be used for horizontal header piping backfill only). All backfill must be in strict accordance with local regulating authority.

11. A pre-installation meeting will be held with the Geothermal Subcontractor, Owner, Engineer and Architect's Representative. The test well reports will be reviewed, location and lay-out of the wells and vault reviewed, routing of the header piping and pipe testing will be discussed.

12. Prior to backfill of the header distribution piping, the Contractor shall provide as-built "Record Drawings" showing the exact location and depth of all exterior geothermal loop piping and the exact location of each geothermal well. The Contractor shall provide GPS coordinates for each vertical well.

1.5 GEOTHERMAL WELL FIELD PIPING VAULT

A. General

1. This specification designates the requirements for the geothermal vault (valve pit) including internal pipe, fittings, and valves. The packaged system shall be similar to custom made Atlantis heavy duty polyethylene vault. At contractor's option, a concrete vault may be submitted. Install vault in strict accordance with manufacturer's requirements.

B. External Shell

1. The external shell shall be constructed of high density polyethylene flat stock having a cell classification of 345444 with a UV stabilizer of C. All materials used shall have a minimum thickness of 1". Internal and external seams are heat welded using high density polyethylene welding rods having a cell classification of 345444C. All seams are nitrogen tested. Walls to be 72" high, with a 30" manhole with ladder. The manhole lid is connected with 8-3/8" stainless steel counter sunk bolts. Lid to have 5000 pound load bearing capacity. Provide vault with sump pit and sump pump. See plumbing drawings and specification for sump pump (SP-3) requirements. Provide 1" conduit from vault to where geothermal piping mains are terminated in building. See Drawings. Coordinate all work with Plumbing Contractor and Electrical Contractor.

C. Internal Bracing

1. Bracing shall be spaced at a maximum of 30” and constructed of a minimum of 1” thick high density polyethylene flat stock heat welded to the external shell with high density polyethylene welding rods.

D. Internal Piping

1. Piping shall be constructed of CPChem Performance Driscoplex 5300 Climate Guard TM High Density Polyethylene DR 15.5 pipe having a cell classification of 345444 with a UV stabilizer of C. This internal pipe is constructed in an offset, over and under, model for supply and return lines. All joints to be heat fused. The entire piping system to be tested using 150 psi nitrogen. The main supply and return pipe to be shipped with cap butt welded to pipe. All pipe penetrating the vault walls shall be DR 11 and heat welded to the external shell.

E. Fittings

1. P/T Plugs shall be constructed of solid brass and have a dual seal core of Nordel, Good up to 350 degrees F for water. Plugs shall be rated zero leakage from vacuum 1000 psig and are capable of receiving a pressure or temperature probe.

2. Butterfly Valve shall be constructed of a cast iron body, 416 stainless steel stem with a lever shut off system.

3. 90 Degree Elbows shall be molded out of high density polyethylene resins in accordance with the requirements of ASTM 3261.

4. Branch and Service Saddles shall be molded out of high density polyethylene resins in accordance with the requirements of ASTM 3261.

5. Provide integral circuit setters near the header on the return line for each loop.

6. Provide test/flushing ports on circuit in vault.

F. Installation

1. The vault shall be lowered into a pit 105” deep with a 6” bed of #57 gravel. Once the vault is in place, concrete is poured 36” deep and 12” thick around the vault to balance buoyancy pressure and allow for anchoring. Install sump pump, float controls and 1 ¼” polyethylene discharge piping. See details on Drawings. The Contractor shall confirm all vault sizes and piping layouts.

END OF SECTION 15012A

SECTION 15013 - AIR DISTRIBUTION

1.1 DUCTWORK AND ACCESSORIES

A General

1. The General Conditions, Special conditions and the applicable portions of Division 1 of the Specifications are a part of this Section.

B Scope

1. This work includes the furnishing of all labor, materials, equipment, etc. necessary for the proper and complete installation of ductwork and accessories as shown on the Drawings and/or herein specified.

C Shop Drawings

1. Shop drawings shall be submitted on all ductwork accessories including name of manufacturer, materials of Construction, Manufacturer's details of installation, connections to other work, fastening, supports, anchors, etc. Shop Drawings shall include all equipment accessories and attachments incidental to a proper and complete installation.

2. Shop drawings shall be submitted, as a minimum, on the following items: flexible connections, manual dampers, damper quadrants, splitter dampers, inspection door and latches; turning vanes, control dampers, fire dampers (include sleeve installation instructions per manufacturer recommendations); flexible ductwork.

D Quality Control

1. Provide all materials, labor accessories, etc., for the fabrication and installation of all ducts and sheet metal work as shown on the Drawings and/or as specified herein. Where construction methods for various items are not indicated on the Drawings or specified herein. Where construction methods for various items are not indicated on the Drawings or specified herein all such work shall be fabricated and installed in strict accordance with the recommended methods, metal gauges, hanging procedures, access door and accessory installations, etc., as outlined, the latest edition of NFPA Pamphlet No. 90A, SMACNA's Duct Manual and Sheet Metal construction for Ventilating and Air Conditioning System, SMACNA's Duct Manual for high velocity systems, and the Manual of Recommended practice of Industrial Ventilation published by the American conference of Governmental Industrial Hygienists. These references and Plate Numbers shall be used by the Engineer for required sheet metal thicknesses and final acceptance of methods of fabrication, hanging accessories, etc. all equipment furnished by manufacturers shall be installed in strict accord with their recommended methods.

E Miscellaneous Materials, Accessories and Requirements

1. Flexible Connections

a. Provide Dyro-Dyne, Ventfabrics, U.S. Rubber or equivalent conforming to NFPA Pamphlet 90A; neoprene coated glass fabric; 20 oz. for low pressure ducts secured with ship locks. Provide at all duct connections to fans, air handling units, etc.

2. Manual Dampers

a. Dampers in round ductwork shall be similar to Ruskin Model MDR525, Whiz Air, Creative Metals, Louvers and Dampers, American Warming, Cesco or equivalent round manual balancing damper; frame 20 gauge galvanized steel; blade 20 gauge galvanized steel; 3/8" axle shaft extending thru both sides of ductwork and factory mounted heavy duty locking hand quadrant; bearings shall be brass, stainless steel or molded synthetic on both sides of ductwork.

b. Dampers in rectangular ductwork 12" in depth or less similar to Ruskin Model MD25 manual balancing damper; frame 20 gauge galvanized steel; blade 20 gauge galvanized steel; 3/8" square axle shaft extending thru both sides of ductwork and factory mounted heavy duty locking hand quadrant; bearings shall be brass, stainless steel or molded synthetic on both sides of ductwork.

c. Dampers in rectangular ductwork of greater than 12" in depth shall be similar to Ruskin Model MD35 round manual balancing damper; frame 16 gauge galvanized steel; blade 16 gauge galvanized steel; 3/8" square axle shaft extending thru both sides of ductwork and factory mounted heavy duty linkage and locking hand quadrant; bearings shall be brass, stainless steel or molded synthetic on both sides of ductwork.

d. Comparable dampers as manufactured by Cesco, Arrow, Dowco, Air Balance, Creative Metals, Louvers and Dampers or equivalent.

3. Damper Quadrants

a. Quadrants shall have indicators showing open and closed positions, and shall be Ventfabrics, "Ventlock".

b. Dampers with shaft length 12" or less - No. 620 for base ductwork and No. 637 for insulated ductwork.

c. Dampers with shaft length longer than 12" - No. 637.

4. Splitter Dampers

a. Fabricate from 16-gauge steel with a hemmed leading edge; trailing edge shall be pivoted on a rod or hinges; install in accordance with the latest

edition of SMACNA Low Velocity Manual. Secure rod to leading edge of damper and extend rod through side of ductwork using Ventlok No. 603 ball joint bracket with set screw.

5. Miscellaneous Accessories

   a. Test openings with covers, latches, hardware, locking devices, etc., shall be installed as recommended by SMACNA and/or as indicated. Test openings shall be placed in the inlet and discharge of all centrifugal type fans and fan sections of air handling units at the end and middle of all main trunk ducts and where indicated.

6. Turns

   a. Turning vanes shall be installed in low pressure duct in all square turns and where indicated and shall be fabricated as recommended by SMACNA or shall be Barber- Colman Company, Titus, Airturns, or equivalent. No projecting edges will be permitted inside ducts. Air extractors shall be utilized at each supply diffuser face where the take-off to the diffuser is at a 90 degree angle. Radius elbows shall be made with the radius of the center line of the duct equivalent to 1.5 times the width of the duct; where a smaller radius is required use guide vanes.

7. Control Dampers

   a. Provide any automatic control dampers not supplied by others; install all dampers. Dampers to have blade/weather seals.

8. Crossbreaking

   a. Crossbreak all low pressure ducts in excess of 18" in width or depth and internally lined ducts over 18" shall be constructed of hemmed S Slip, or 1 inch bar slips on 5'-0" centers according to SMACNA Plate No. 7.

9. Duct Hanging

   a. All duct hangers in direct contact with galvanized duct shall be galvanized steel.

   b. Where ducts are situated in unconditioned areas and are required to have insulation with a vapor sealed facing, the ducts shall be supported on trapeze hangers. The hangers shall be spaced far enough out from the side of the duct to permit the duct insulation to be placed on the duct inside the trapeze. Under no circumstances shall duct hangers penetrate the vapor sealed facing.

   c. All other duct hangers may be directly attached to ducts. Ducts shall be hung by angles or straps as listed in the following schedule. Rods, straps or angles may be used in trapeze hangers. hangers shall be in accordance with the following schedule, except that there shall be no

less than one set of hangers for each section of ductwork. Ductwork shall not be hung or supported from metal deck.

d. Where elbows or tees are installed for changes in direction, hangers shall be provided. No ductwork shall rest on the Building structural system.

Cross-Sectional Area	Hanger Strap	Hanger Angle	Hanger Rod	Hanger Set Spac. Maximum
0.1.5 sq. ft.	1"x22 ga.	1"x1"x1/8"	3/8"	8'0"
1.6-3.0 sq. ft.	1"x22 ga.	1"x1"x1/8"	3/8"	8'0"
3.1-6.0 sq. ft.	1-1/2"x18ga	1"x1"x1/8"	1/2"	8'0"
6.1 sq. ft. & larger	2"x18 ga.	1-1/2"x1-1/2"x1/8"	1/2"	6'-0"

e. Where trapeze hangers are used, the bottom of the duct shall be supported on angle sized as follows (for round cuts, the angle shall conform to the bottom 120° of the duct).

Dia. of Duct	Width of Duct	Bottom Angle Sizes
0" - 34"	0" - 30"	1"x1"x1/8"
35" & larger	31" - 48"	1-1/2"x1-1/2"x1/8"
35"	49" - 72"	1-1/2"x1-1/2"x3/16"

f. All hangers shall be sufficiently cross- braced to eliminate, in the opinion of the Architect, excessive sway. Whatever ductwork contains filter sections, coils, fans or other heavy equipment (excluding registers, grilles, diffusers, splitter dampers, etc.) such equipment shall be hung independently of the ductwork, with rods or angles of sizes adequate to support the load.

10. Special Duct Hanging Conditions

a. In the event ductwork interferes with suspended ceiling support hangers, provide cross members from hangers affected. These cross members shall be of reinforcing steel or furring channels and shall run under ductwork in question from which additional ceiling hangers shall be supported.

11. Duct Sizes

a. Duct sizes indicated on Drawings are net free areas required. Internally lined ducts where required shall be increased in size to fully compensate for internal insulation thickness.

12. Plenums

a. Plenums shall be sturdily constructed with structural iron stiffeners as required to insure a vibration free system.

13. Ductwork Access Doors

a. Ductwork access doors shall be installed at the locations and of sizes shown on the Drawings and as required for all equipment access. Hardware for doors shall be Ventfabrics, Young Regulator Company, United Sheet Metal, Kees, Air Balance, Buckley or Ruskin equivalent to Ventfabrics, "Ventlok" as follows:

(1) Small doors (16" maximum side, or smaller) shall have No. 100 Latches.

(2) Large Doors (18" side or Larger) shall have No. 310 latches.

b. Where doors are installed in insulated ductwork, doors shall be of double panel construction, insulated internally with a minimum of 1" glass fiber insulation, and set flush with outside surface of duct insulation.

14. Fire Dampers

a. Furnish and install at all ductwork penetrations through fire rated ceilings, walls and floors; and at all locations as shown on the Drawings and/or specified, U.L. labeled fire dampers as manufactured by United Sheet Metal, Air Balance Incorporated, Ruskin and Sterling Corporation, Cesco, Creative Metals, United Air, Nailor Industries or equivalent. Fire Dampers shall be installed in strict accordance to Manufacturer's instructions and recommendations. All U.L. Labeled Fire Dampers shall have a 1-1/2 hour fire protection rating and conform to NFDA 90A, Paragraph 905 in one (1) hour rated walls; and two (2) hour (minimum) rated dampers in two (2) hour walls.

b. Fire dampers for round ductwork shall be United Sheet Metal Model U-200S (Fire Resistive Floors) and Model U-200G (Fire Resistive Partitions); type "C" round oval duct shall have Type "C" oval.

c. The wall opening must be larger than the damper by 1/8" for each linear foot in height and width of damper to allow for thermal expansion. The folded blade assembly must always be positioned at the top when the damper is placed in the wall opening. The damper should be positioned in the opening so the horizontal clearance is equally divided at both sides of the damper.

d. Retaining angles to be attached to damper sleeves as recommended by the fire damper manufacturer. Retaining angles shall not be attached to the wall. They should not be welded together at the corners of the damper. The duct must not be continuous through the wall opening, but must connect to the damper sleeve on either side of the wall according to U.L. Standard 555, "Fire Dampers". Fire damper sleeve shall be a minimum of 18 gauge galvanized steel.

e. United Type A dampers shall be used in low pressure rectangular ductwork or used for the protection of openings where there is no ductwork, as these dampers comply with NFPA No. 80; mounted in sleeve as required by manufacturer. Medium pressure ductwork shall have Type "B" dampers.

f. The fusible link assembly shall be designed so that a second fusible link may be placed beside the first link for back-up purposes.

g. Low pressure Rectangular Duct shall be connected to the fire damper flanges and/or to sleeve with S- Slip Type joints.

h. Dampers shall be compatible with firewalls, partitions, or ducts within which they are to be installed. They shall be complete with 165oF fusible link and link retainer; except fusible links at mechanical room penetrations shall be 180 degrees F.

i. If fire dampers are accessible through grilles or registers, duct access openings will not be required.

j. Detailed installation instructions shall be provided by the manufacturer and this contractor shall install dampers in strict accordance with those details.

k. Fire dampers shall be sized and installed to fit directly to sheet metal duct sizes, not for inside dimensions of internal insulation.

F Low Pressure Air Distribution Ductwork

1. Sheet Metal Duct (Rectangular and Round)

a. All low pressure supply, return, outside air and exhaust air ductwork for the air distribution systems shall be galvanized sheet steel complying with ASTM A-527, lock forming quality; with G90 zinc coating in accordance with ASTM A-525. Provide internal insulation as specified in Insulation Section of this Specification and/or as indicated on the Plans.

b. Provide paint grip primer on exposed ductwork in janitor receiving area for field painting.

c. Sheet metal duct drops to diffusers, registers and/or grilles shall be connected to duct collar with sheet metal screws 3" c/c.

2. Round Spiral Ductwork

a. All exposed round ductwork shall be low pressure round spiral ductwork; and shall be double wall perforated as manufactured by Semco, Eastern United, Libdab or equivalent. Furnish and install per SMACNA standards. Provide with paint grip primer for field painting.

G Grease Duct Specification

1. Furnish single-wall, factory built, grease duct for use with Type I kitchen hoods, which conforms to the requirements of NFPA-96. Products shall be ETL listed to UL-1978 and CAN/ULC-S662 for venting air and grease vapors from commercial cooking operations as described in NFPA-96.

2. The duct wall shall be constructed of .036 and .047 thick stainless steel and be available in diameters 8" through 24".

3. All supports, fan adapters, hood connections, fittings and expansion joints required to install grease duct shall be included.

4. Roof penetrations shall comply with listed clearance to combustibles, see "Clearance to Combustibles" guide for details. The grease duct will terminate at the fan adapter plate, will be fully welded to the fan adapter plate and the fan adapter plate will be fastened to the curb using a suitably sized fastener provided by others; see page 12 of the "Installation, Operation and Maintenance Manual" for details.

5. Grease duct joints shall be held together by means of formed vee clamps and sealed with 3M Fire Barrier 2000+. Screws used to secure the vee clamps shall be of the hex-head type with flanged stops and tapered "lead in" threads for easy starting. Nuts shall be retained by means of a free-floating cage to allow easy alignment.

6. Single-Wall Grease Duct shall be installed in accordance with the manufacturer's "Installation, Operation and Maintenance Manual", ETL listing and state and local codes.

7. Grease duct installed outside of the building shall be protected against accidental damage or vandalism.

8. Support vertically installed grease duct from the building structure using rigid structural supports. Anchor supports to the structure by welding or bolting steel expansion anchors or concrete inserts. Support horizontally installed grease duct from the building structure using above method. 1/2" Threaded rod and saddles may also be used for the support of horizontal grease duct.

9. Fans shall be supported independently from the grease duct sections. Protect grease duct from twisting or movement caused by fan torque or vibration.

H Flexible Duct (Low Pressure)

1. Provide where indicated on Drawings flexible ductwork of a type suitable for the application as hereinafter indicated. The duct must comply with the latest NFPA Bulletin 90A and be listed as Class 1 connector or duct material; duct connections and terminations shall be per manufacturer's directions. U.L. Standard 181 where applicable. Flexible duct shall be as manufactured by Wiremold, United, Clevaflex, Flexmaster, Thermaflex, Omni or equivalent.

2. Ductwork shall be equivalent to Wiremold type WK airtight polyester core with galvanized wire helix; 1-1/2", 3/4 lb. density fiberglass insulation blanket, and aluminized reinforced vapor barrier (no vinyl).

3. Flexible ducts shall be installed with joints made using approved metal banding methods as detailed on the Drawings. Pan-duit straps or similar fastening products are not acceptable. Ducts shall be limited to 5' in length.

I Duct Sealer

1. All joints and connections in the entire supply, return, outside air and exhaust sheet metal ductwork systems (except exposed round spiral ductwork) shall be sealed with a top quality grade of high pressure duct sealer. Duct sealer shall be similar to Hardcast Inc. IG-601 iron grip, United or R.V. Money "Money Saver Sealer;" U.L. listed; zero flame spread, fuel contribution and smoke development.

1.2 AIR DISTRIBUTION DEVICES

A General

1. The General Conditions, Special Conditions and the applicable portions of Division 1 of the Specifications are a part of this Section.

B Scope

1. This work includes the furnishing of all air distribution devices and labor, materials and equipment, etc., necessary for proper and complete installation of all air distribution devices as shown on the Drawings and/or herein specified.

2. The work of this Section consists of providing all labor, materials, equipment, and services for the fabrication or installation of all diffusers, grilles, louvers, intakes, discharges, and appurtenances in connection with heating, ventilating and air conditioning. Alternate selections will be accepted provided quality, function and characteristics are equal. Shop drawings shall identify and list all characteristics of each device as scheduled herein.

C Registers, Grilles, and Diffusers

1. General

a. Registers, grilles and diffuser shall be one manufacturer. Model numbers specified are Krueger and are for design criteria only. Manufacturers offering products complying with requirements include:

Krueger	Hart & Cooley	Metal Aire
Anemostat	Reliable Metals	Nailor Industries
Titus	Carnes	Price
Tuttle & Bailey		

b. Provide required mounting frames, supports and attachments to mount registers, grilles and diffuser in ceilings, walls, floor or exposed conditions. Install surface mounted units without gap between unit and mounting surface. Lay-in units shall rest evenly on ceiling channels or frames. Install registers, grilles and diffusers in symmetrical pattern consistent with ceiling systems, lighting fixtures, ceiling speakers and sprinkler heads where included.

c. Maintain maximum sound level of 30 NC at specified air flow.

d. Painted finishes shall be factory baked enamel unless otherwise specified. Primer coat finish shall be factory applied. Protect finish in shipping cartons until ready for installation.

e. Volume dampers shall be opposed blade, adjustable type with tight linkage and blade movement. Provide 2" extension on control rod to extend beyond insulation.

f. All ceiling supply diffusers shall be adjustable air flow type with removable core.

2. Capacities and Finish

a. See schedule herein and on Drawings.

D Exterior Louvers

1. Louvers

a. Louvers shall be United Enertech, Ruskin, Vent Products, Reliable, Greenheck, Construction Specialties (C/S), Airstream, Airolite, Arrow, Creative Metals, Air Balance, Cesco or equivalent. Louvers shall be constructed of .125" extruded aluminum walls and blades, (unless otherwise indicated), arranged to prevent entrance of driving rain. Furnish with 1/2" mesh aluminum bird screen mounted interior and compatible sill. Coordinate each louver with surrounding wall conditions prior to ordering louver. Louvers shall be furnished and installed by Mechanical Contractor. All louvers shall be installed recessed 3/8" from exterior wall surface. See Schedule for capacities, sizes, etc. Louvers shall be supplied with factory baked enamel finish, color as selected by Architect.

2. Capacities and Finish

a. See schedule on drawings.

END OF SECTION 15013

SECTION 15014 - CONTROLS

PART 1 - GENERAL

1.1 DESCRIPTION

A. The Facility Management System (FMS) consists of a web based, high-speed peer-to-peer network of Building Controllers residing on an owner provided Local Area Network (LAN) based on ISO 8802-3 (Ethernet) Physical/Data Link layer protocol. This is the same LAN that the existing FMS Central Server and workstations resides on. Building Controllers shall communicate via Annex J of ANSI / ASHRAE™ Standard 135-2004.

B. The new Facility Management Systems (FMS) must integrate seamlessly into the existing Trane Tracer ES FMS utilizing Annex J of ASHRAE Standard 135-2004 (BACnet). This integration must include all software licenses, graphics, programming, and data bases while providing full functionality from the Trane Tracer ES system. Graphics must duplicate the existing graphics in form and functionality. The object oriented database for the new system shall adhere to the existing system's naming convention.

C. Each Building Controller shall perform communications to a network of Custom Application and Application Specific Controllers utilizing LonTalk™ or BACnet/mstp protocol. All Custom Application and Application Specific Controllers shall be LonMark™ certified or BTL listed.

D. The FMS shall be an open architecture, enterprise-level multiple building control system as indicated on the drawings and described in the specifications. All system communications should be transparent, meaning that any user of the FMS does not need to know the details of system architecture and operation.

E. The FMS shall provide a web-based Graphical User Interface (GUI) and be designed to integrate multiple BACnet-based systems, collect, store and display historical data, and provide enterprise-wide or multiple building facilities management capabilities from a central database.

F. An Open DataBase Connectivity (ODBC) or Structured Query Language (SQL) compliant server database is required for all system database parameter storage. This data shall reside on a supplier-installed server for all database access. Systems requiring proprietary database and user interface programs shall not be acceptable.

G. The FMS Contractor shall work with the owner's IT department to secure the appropriate system hardware, software, network drops, and addresses and ensure network compatibility.

H. All work described in this section shall be installed, wired, circuit tested and calibrated by factory certified technicians qualified for this work and in the regular employment of or subcontracted by the FMS Contactor. The FMS Contractor shall have a minimum rated qualification of 15 years of installation experience with the controls manufacturer and shall provide documentation in the bid and submittal package verifying longevity of the installing company's relationship with the manufacturer. Supervision, calibration and checkout of the system shall be by the employees of the FMS Contractor. The FMS Contractor shall have an in place support facility within 75 miles of the site with technical staff, spare parts inventory and all necessary test and diagnostic equipment.

1. System Installer Qualifications

a. The System Installer shall have an established working relationship with the FMS contractor of not less than three years.

b. The System Installer must be trained and certified by the FMS Contractor as to their ability perform all necessary duties required for the proper installation of the controls equipment and wiring. The System Installer shall present for review the certification of completed training, including the hours of instruction upon request.

c. The installer shall have an office within 100 miles of the project site and provide 24-hour response in the event of a customer call.

I. The FMS Contractor shall supply a Portable Operator Terminal, all necessary software, and interfaces to provide for the uploading/downloading of Custom Application Controller and Application Specific Controllers databases and programs, monitoring of all LonMark™ Standard Network Variables Types (SNVTs) including display of all bound SNVTs, monitoring and overrides of all controller physical input/output points, and editing of controller resident time schedules.

J. The FMS Contractor shall furnish all labor, materials, system engineering, programming, and service necessary for a complete and operating temperature control system as described. Equipment and labor not specifically referred to herein or on the plans, that is required to meet the functional intent, shall be provided without additional cost to the owner.

K. Controls Contractor is responsible for power to all controls panels.

1.2 SUBMITTALS

A. The FMS Contractor shall provide shop drawings and manufacturers' standard specification data sheets on all hardware and software to be provided. No work may begin on any segment of this project until the Engineer and Owner have reviewed submittals for conformity with the plan and specifications. [Six (6)] copies are required. All shop drawings shall be provided to the Owner electronically as .dwg or .dxf file formats.

B. Quantities of items submitted shall be reviewed by the Engineer and Owner. Such review shall not relieve the contractor from furnishing quantities required for completion.

C. Provide the Engineer and Owner, any additional information or data which is deemed necessary to determine compliance with these specifications or which is deemed valuable in documenting the system to be installed.

D. Submit the following within 30 days of contract award:

1. A complete bill of materials of equipment to be used indicating quantity, manufacturer and model number.

2. A schedule of all control valves including the valve size, model number (including pattern and connections), flow, CV, pressure rating, and location.

3. A schedule of all control dampers. This shall include the damper size, pressure drop, manufacturer and model number.

4. Provide manufacturers cut sheets for major system components. When manufacturer's cut sheets apply to a product series rather than a specific product, the data specifically applicable to the project shall be highlighted or clearly indicated by other means. Each submitted piece of literature and drawings shall clearly reference the specification and/or drawing that the submittal is being submitted to cover. Include:

a. Centralized server hardware and software

b. Building Controllers

c. Custom Application Controllers

d. Application Specific Controllers

e. Operator Interface Computer(s) as specified

f. Configuration and service software programs

g. Portable Operator Workstation(s) or Service software PCs as specified

h. Auxiliary Control Devices

i. Proposed control system riser diagram showing system configuration, device locations, addresses, and cabling

j. Detailed termination drawings showing all required field and factory terminations. Terminal numbers shall be clearly labeled

k. Points list showing all system objects, and the proposed English language object names

l. Sequence of operations for each system under control. This sequence shall be specific for the use of the Control System being provided for this project

m. Provide a BACnet Product Implementation Conformance Statement (PICS) for each BACnet device type in the submittal

n. Color prints of proposed graphics with a list of points for display

E. Approved Control System Contractors And Manufacturers

1. Approved Control System Contractors and Manufacturers:

Manufacturer Name	Product Line	Contractor Name
Trane	Tridium	Harshaw Trane
Automated Logic	Tridium	Innerspace
Siemens	Tridium	Siemens

a. The above list of manufacturers applies to centralized server software, operator workstation configuration tool software, building controller software, the custom application programming language, Building Controllers, Custom Application Controllers, and Application Specific Controllers. All other products specified herein (i.e., sensors, valves, dampers, and actuators) need not be manufactured by the above manufacturers.

2. Project Record Documents. Upon completion of installation submit three (3) copies of record (as-built) documents. The documents shall be submitted for approval prior to final completion and include:

a. Project Record Drawings. These shall be as-built versions of the submittal shop drawings. One set of electronic media including CAD .DWG or .DXF drawing files shall also be provided.

b. Testing and Commissioning Reports and Checklists

3. Operating and Maintenance (O & M) Manual. These shall be as-built versions of the submittal product data. In addition to that required for the submittals, the O & M manual shall include:

   a. Names, address and 24-hour telephone numbers of Contractors installing equipment, and the control systems and service representative of each.

   b. Operators Manual with procedures of operating the control systems including logging on/off, alarm handling, producing point reports, trending data, overriding computer control, and changing set points and other variables.

   c. Programming Manual with a description of the programming language including syntax, statement descriptions including algorithms and calculations used, point database creation and modification, program creation and modification, and use of the editor.

   d. Engineering, Installation and Maintenance Manual(s) that explains how to design and install new points, panels, and other hardware; preventative maintenance and calibration procedures; how to debug hardware problems; and how to repair or replace hardware.

   e. A listing and documentation of all custom software created using the programming language including the point database. One set of magnetic media containing files of the software and database shall also be provided.

   f. One set of electronic media containing files of all color-graphic screens created for the project.

   g. Complete original issue documentation, installation, and maintenance information for all third party hardware provided including computer equipment and sensors.

   h. Complete original issue media for all software provided including operating systems, programming language, operator workstation software, and graphics software.

   i. Licenses and warranty documents for all equipment and systems.

   j. Recommended preventive maintenance procedures for all system components including a schedule of tasks, time between tasks, and task descriptions.

4. Training Materials: The Contractor shall provide a course outline and training material for all training classes at least six weeks prior to the first class. The Owner reserves the right to modify any or all of the training course outline and training materials. Review and approval by Owner and Engineer shall be completed at least 3 weeks prior to first class.

1.3 QUALITY ASSURANCE

A. Codes and Standards: Meet requirements of all applicable standards and codes, except when more detailed or stringent requirements are indicated by the Contract Documents, including requirements of this Section.

   1. Underwriters Laboratories: Products shall be UL-916-PAZX listed.

   2. National Electrical Code -- NFPA 70.

3. Federal Communications Commission -- Part J.

4. ANSI/ASHRAE™ 135-2004 (BACnet)

5. ANSI/EIA/CES 709.1 (LonTalk™)

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. Bids by wholesalers and non-franchised contractors shall not be acceptable.

D. The system manufacturer shall, as a minimum, manufacture and supply the Custom Application Controller, Application Specific Controller, and Graphical User Interface.

E. All work described in this section shall be installed, wired, circuit tested and calibrated by factory certified technicians qualified for this work and in the direct employment of the temperature control system manufacturer.

F. The FMS Contractor shall have a full service facility within 75 miles of the project that is staffed with engineers trained in integrating interoperable systems and technicians fully capable of providing BACnet and LonWorks instructions and routine emergency maintenance service on all system components.

G. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

H. Comply with NFPA 90A, “Installation of Air Conditioning and Ventilation Systems”.

I. Comply with National Electric Code, UL-916 Energy Management Systems, LonMark™, ULC, FCC Part 15, subpart J, Class B Computing Devices.

J. Comply with Annex J of ANSI/ASHRAE™ Standard 135-2004 and ANSI/EIA/CEA Standard 709.1 LonTalk™ protocol for DDC system control components.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Factory-Mounted Components: Where control devices specified in this Section are indicated to be factory mounted on equipment, arrange for shipping of control devices to equipment manufacturer.

B. System Software: Updates to the latest version of software at Project completion.

1.5 WARRANTY AND MAINTENANCE

A. All components, system software, and parts furnished and installed by the FMS Contractor shall be guaranteed against defects in materials and workmanship for 1 year of substantial completion unless extended warranty by owner or mfg is greater then one year. Labor to repair, reprogram, or replace these components shall be furnished by the FMS Contractor at no charge during normal working hours during the warranty period. Materials furnished but not installed by the FMS Contractor shall be covered to the extent of the product only. Installation labor shall be the responsibility of the trade contractor performing the installation. All corrective software modifications made during warranty periods shall be updated on all user documentation and on user and manufacturer archived software disks. The Contractor shall respond to the owner’s request for warranty service within forty-eight (48) hours standard working hours. Emergency service shall be available within twenty-four (24) hours.

B. The FMS Contractor shall provide remote critical alarm monitoring and phone support for a period of one year. Upon receipt of critical alarms, the FMS Contractor shall remotely investigate the alarm and notify the owner of possible causes and solutions. The FMS Contractor shall also provide telephone support by a factory trained technician who has immediate access to all relevant documentation including operations and maintenance manuals and design drawings. Critical alarm monitoring and telephone support shall be provided between the hours of 8:00 am to 5:00 pm, Monday through Friday excluding Holidays.

1.6 OWNERSHIP OF PROPRIETARY MATERIAL

A. The Owner shall sign a copy of the manufacturer's standard software and firmware licensing agreement as a condition of this contract. All software licensing shall be made to the Owner not the FMS Contractor or vendor, and such license shall grant use of all programs and application software to owner as defined by the manufacturer's license agreement, but shall protect manufacturer's rights to disclosure of trade secrets contained within such software. All software shall be capable of adding other manufacture licensed vendors if of the same firmware. All project developed software, control software and documentation shall become the property of the owner. These include, but are not limited to project graphic images, record drawings, project database, project specific application programming code, and all other associated documentation. Any and all required IDs, passwords, and software keys for access to any component or software program shall be provided to the owner.

B. All project developed hardware and software shall become the property of the Owner. These include but are not limited to:

1. Project graphic images,
2. Record drawings,
3. Project database,
4. Job-specific application programming code.
5. All software, software licenses and software keys.
6. All documentation.

1.7 CONTRACTOR'S QUALIFICATIONS AND BASIC REQUIREMENTS

A. The FMS herein specified shall be fully integrated and installed as a complete package by the FMS Contractor. The System shall include all wiring, piping, installation supervision, calibration, adjustments, and checkout necessary for a complete and fully operational system. Work shall be installed under the supervision of a project manager with a minimum of 10 years experience.

B. Qualified Contractors:

1. Contractors shall be subject to full compliance with the requirements of the Drawings, sequences of operation, points lists and specifications. Interested contractors in bidding this work shall submit a pre-bid package 10 days prior to bidding for pre-approval. Pre-approved status will be documented via addenda prior to the bid date.

C. The FMS Contractor shall coordinate with other Trade Contractors regarding the location and size of pipes, equipment, fixtures, conduit, ducts, openings, switches, outlets, and so forth, in order to eliminate any delays in the progress of the job.

D. The FMS Contractor shall have a minimum of 15 years experience with the complete, turnkey installation of Facility Management systems of similar size and technical complexity. The FMS Contractor shall provide a list of five comparable projects that have FMS with the features as specified for this project. These projects must be on-line and functional.

1.8 INSTRUCTION AND ADJUSTMENT

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

B. Instruction manuals shall be furnished covering the function and operation of the control system on the project for use by the operating personnel.

1. FMS Operators : On-site instruction consisting of four (4) four hour (4) sessions shall be provided to completely familiarize operating personnel with the sequence of operations, digital controller software configurations, Object oriented database, Network Controller software configurations, system graphics and FMS network map.

2. Return Training: The FMS Contractor shall include in the bid two (2) additional four (4) hour sessions on site that may be on different dates during the one year warranty period for additional training or program changes to adjust building for unforeseen sequences of operation.

PART 2 - PRODUCTS

2.1 SECTION INCLUDES

A. Materials

B. Communication

C. Operator Interface

D. Application and Control Software

E. Building Controllers

F. Custom Application Controllers

G. Application Specific Controllers

H. Input/Output Interface

I. Auxiliary Control Devices

2.2 MATERIALS

A. All products used in this installation shall be new, currently under manufacture, and shall be applied in similar installations for a minimum of 1 year. The installation shall not be used as a test site for any new products unless explicitly approved by the Owner’s representative in writing. Spare parts shall be available for at least 5 years after completion of this contract.

2.3 COMMUNICATION

A. This project shall comprise of a network utilizing high-speed BACnet over IP communications between the Central Server, Building Controllers and the Operator PC Workstations

B. LonTalk™, BACnet/mstp, or Zigbee Certified sub-networks shall be used for communications between Building Controllers, Custom Application Controllers and Application Specific Controllers.

C. All Building Controllers shall have a communications port to allow for communications with other building controllers, service software PCs, and the centralized server. The connection shall be an Ethernet network interface node. Service software connections at a building controller may be optionally provided through an RS-232 port for Point to Point connection.

D. All database values (i.e., points, software variable, custom program variables) of any one building controller shall be readable by any other building controller on the internetwork. An operator/installer shall not be required to set up any communications services to perform internetwork value passing.

2.4 OPERATOR INTERFACE

A. Operator Interface. Owner will access BAS daily operations through use of any designated workstations setup through system security functions. PC hardware shall be provided by the owner and must meet the standards described in section B below. Each workstation shall be able to access all operator-level information in the system through use of a standard Microsoft Internet Explorer web browser. These workstations shall reside on the enterprise-wide network as the central server and building controllers.

B. Operator Workstation Components.

1. PCs shall include Microsoft Windows XP or Windows 7 and Internet Explorer 6.0 SP1 or higher

2. Furnish all required serial, parallel, and network communication ports, and all cables for proper system operation. Each PC shall include a minimum 17", color monitor with 1024 x 768 screen resolution.

C. Central Server Components.

1. The existing FMS server shall be reused

D. System Software

1. System Graphics. The operator interface shall provide graphically-oriented web pages as designated.

a. Provide a method for the operator to easily move between graphic displays on the screen.

b. The system must dynamically generate and serve web pages based on standard or custom web page templates in combination with content derived from the database in any building control panel.

c. Dynamic points shall include analog and binary values, dynamic text, static text, and animation files. Graphics shall have the ability to show animation of equipment.

d. Navigation shall be primarily through floor plan graphics. FMS contractor must provide custom 3-D color floor plan graphics shaded by scheduled zone.

e. Equipment graphics must also be 3-D and include animations for status of fans.

2. Engineering Units. Allow for selection of the desired engineering units (i.e. Inch pound or SI) in the system. Unit selection shall be able to be customized by user to select the desired units for each measurement.

3. Site Management

a. The system must allow for grouping of the many sites in an enterprise in a logical manner.

b. The system shall provide a search function to allow users to search for sites or groups of sites by name or partial names.

c. The system must provide the necessary means to add, remove, and manage sites.

E. System Applications

1. The central server shall serve operator interface web pages and provide off-line storage of system information. Provide the following applications within the system.

a. Automatic System Database Save and Restore. The central server shall store on the hard disk backup tables of data including trends, alarms, custom settings and user profiles. This data shall be backed up once a day. This database shall be updated whenever a change is made in the system. The storage of this data shall be automatic and not require operator intervention.

b. Manual Database Save and Restore. A system operator with the proper password clearance shall be able to archive the database manually at any time.

c. System Configuration. The central server shall serve web pages as the interface for configuring the operator-level functions of the system. A user with proper security shall be able to configure the system to allow for future changes or additions.

d. On-Line Help and Training. Provide a context sensitive, on line help system to assist the operator in operation and editing of the system. On-line help shall be available for all system functions and shall provide the relevant data for that particular screen. Additional help shall be available through the use of hypertext links onscreen.

e. Security. The system shall support state-of-the-art encryption between server and web browser. Web browser interface shall utilize Secure Socket Layer SSLv3 encryption technology. Web server shall utilize TLS encryption. Server security shall accommodate a minimum of 1000 individually password protected users. Each user shall be assigned a user name and password and security level. User names and passwords shall be case sensitive and able to have up to 32 characters. User security shall be set up through the web browser as an administrative function. Each user will be assigned to a security level. Security levels shall be hierarchical in nature – the higher security levels have all rights of lower levels. There shall be at least four (4) user security levels corresponding to user roles. A System Administrator shall be able to define the data view and edit capabilities for each security level. Users shall be

automatically logged off of the system after a specified period of inactivity.

f. System Diagnostics. The system shall automatically monitor the operation of all workstations, network connections, building management panels, and controllers. The failure of any device shall be annunciated to the operator.

g. Alarm Management - The central server shall provide the following alarm handling functions:

1) Receiving alarms from each building panel.

2) The central server shall store specified alarms in an alarm log database.

3) Displaying an alarm log.

4) Forward alarms via e-mail as specified by the user.

5) Alarm sorting and/or filtering by alarm and/or site attribute.

6) Store alarm data in a standard format accessible to a user-specified peer database/server.

7) Storing and purging the alarm log.

8) Provide a means of acknowledging and deleting alarms from the viewable alarm log(s).

9) Provide a printer-friendly format for printing alarm logs.

h. Alarm and Event Log. The operator shall be able to view all logged system alarms and events from any location in the system. An operator with the proper security level may acknowledge and clear alarms. All that have not been cleared by the operator shall be archived to the hard disk on the central server.

i. Trend Logs. The operator shall be able to define a trend log for any data in the system. This definition shall include interval, start-time, and stop-time. Trend intervals of 1, 5, 15, 30, and 60 minutes as well as user-defined intervals shall be selectable. The system operator shall be able to determine how many samples are stored in each trend. Trend data shall be sampled and stored on the Building Controller panel, then harvested and be archived on the central server hard disk. Additionally, provide the capability to sample directly from the building controller database to the central server. Trend data shall be able to be viewed and printed from the operator interface web pages. Trends must be viewable in a text-based format or graphically. Trends shall also be storable in a tab delimited ASCII format for use by other industry standard word processing and spreadsheet packages, and be exportable to a file for use in other software tools, available in a non-proprietary file format to be used by another database.

j. 10. Dynamic Graphical Trending. The system shall have the ability to display collected data in a graphical chart. Trend viewing capabilities shall include the ability to show up to 5 points on a chart. Each data point trend line shall be an individual color. Trend data shall be able to

be stored indefinitely on the central server, based on server storage capacity and data archiving practices.

k. Object and Property Status and Control. Provide a method for the operator to view, and edit if applicable, the status of any object and property in the system.

l. Reports and Logs. Provide a reporting function that presents the system operator stored data in either a table format, as a chart, or as a report that can be printed. Data in a table format shall list the data values as well as a date and time stamp. Allow the user to present data log pages of a collection from a single piece of equipment or a building panel summary. Provide the ability to view data points on a static graph or configured for a specified length of time. The system shall be capable of storing trend data in a database, and providing an interface to allow for retrieval of data by network peer servers and databases.

F. Workstation Applications Editors. The system web user interface shall support dedicated screens for editing of control system applications. The application programs shall be executed at the appropriate controller panels.

G. Scheduling. An editor for an enterprise-wide scheduling application shall be provided. Provide a method by which a system operator can make permanent changes to one or many building schedules without the need to repeat any steps. The system shall provide temporary changes to one or more schedules at one or more building locations.

1. Manual Control and Override. Provide a means of manually controlling analog and binary output points.

2. Air System Equipment Coordination. Provide a control application and user interface pages that summarize the monitoring and control functions that group together and coordinates the operation of air handling equipment and associated VAV boxes as specified in the sequence of operations. For each air system, status pages shall include:

a. System mode of the air handling system

b. Listing and assignment of the associated air handler and VAV boxes

c. AHU supply air cooling and heating setpoints

d. AHU minimum, maximum and nominal static pressure setpoints

e. VAV box minimum and maximum flow

H. Custom Application Programming. Provide software configuration tools installed on operator PCs and/or Portable Operator's Terminals as designated to create, modify, and debug custom application programming. The operator shall be able to create, edit, and download custom programs at the same time that all other system applications are operating. The system shall be fully operable while custom routines are edited, compiled, and downloaded.

2.5 APPLICATION AND CONTROL SOFTWARE

A. Furnish the following applications software for building and energy management. All software applications shall reside and run in the system controllers. Editing of applications shall occur at operator workstations served web-based user interface pages.

B. Scheduling. Provide the capability to schedule each object or group of objects in the system. Each of these schedules shall include the capability for start, stop, and optimal start actions. When a group of objects are scheduled together, provide the capability to define advances and delays for each member.

C. Optimal Start. The scheduling application shall support an optimal start algorithm. This shall calculate the thermal characteristics of a zone and start the equipment prior to occupancy to achieve the desired space temperature at the specified occupancy time. The algorithm shall calculate separate sets of heating and cooling rates for zones that have been unoccupied for less than and greater than 24 hours. Provide the ability to modify the start algorithm based on outdoor air temperature. Provide an early start limit in minutes to prevent the system from starting before an operator determined time limit.

D. Maintenance Management. The system shall monitor equipment status and generate maintenance messages based upon user designated run time, starts, and/or calendar date limits.

E. PID Control. A PID (proportional-integral-derivative) algorithm with direct or reverse action and anti-wind-up shall be supplied. The algorithm shall calculate a time-varying analog value used to position an output or stage a series of outputs. The controlled variable, set-point, and PID gains shall be user-selectable. The setpoint shall optionally be chosen to be a reset schedule.

F. Timed Override. A standard application shall be utilized to enable/disable temperature control when a user selects on/cancel at the zone sensor, workstation, or the operator display. The amount of time that the override takes precedence will be selectable from the workstation.

G. Staggered Start. This application shall prevent all controlled equipment from simultaneously restarting after a power outage. The order in which equipment (or groups of equipment) is started; along with the time delay between starts shall be user-selectable.

H. Anti-Short Cycling. All binary output points shall be protected from short cycling. This feature shall allow minimum on-time and off-time to be selected.

2.6 BUILDING CONTROLLERS

A. General. Provide System Controllers to provide the performance specified in section 1 of this division. Each of these panels shall meet the following requirements.

1. The System Automation System shall be composed of one or more independent, standalone, microprocessor based System Controllers to manage the global strategies described in System software section.

2. The System Controller shall have sufficient memory to support its operating system, database, and programming requirements.

3. The controller shall provide a USB communications port for connection to a PC

4. The operating system of the Controller shall manage the input and output communications signals to allow distributed controllers to share real and virtual point information and allow central monitoring and alarms.

5. Controllers that perform scheduling shall have a real time clock.

6. Data shall be shared between networked System Controllers.

7. The System Controller shall utilize industry recognized open standard protocols for communication to unit controllers.

8. The System Controller shall continually check the status of its processor and memory circuits. If an abnormal operation is detected, the controller shall:

   a. Assume a predetermined failure mode.

   b. Generate an alarm notification.

   c. Create a retrievable file of the state of all applicable memory locations at the time of the failure.

   d. Automatically reset the System Controller to return to a normal operating mode.

B. Communications. Each System Controller shall reside on the Enterprise wide network, which is same high-speed network as the workstations. The Enterprise wide network will be provided by the owner and supports the Internet Protocol (IP). Local connections of the System Controller shall be on ISO 8802-3 (Ethernet). Each System Controller shall also perform routing to a network of Custom Application and Application Specific Controllers) [Optional – Each System Controller shall perform communications to a network of Custom Application and Application Specific Controllers using LonTalk FTT-10 and LonMark profiles and/or use BACnet MSTP as prescribed by the BACnet standard to perform communications to a network of Custom Application and Application Specific Controllers..]

   1. Alternate: Wireless equipment controllers and auxiliary control devices shall conform to:

      a. IEEE 802.15.4 radios to minimize risk of interference and maximize battery life, reliability, and range.

      b. Operating range shall be a minimum of 200 feet; open range shall be 2,500 ft. (762 m) with less than 2% packet error rate.

      c. To maintain robust communication, mesh networking and two-way communications shall be used to optimize the wireless network health.

      d. Certifications shall include FCC CFR47 - RADIO FREQUENCY DEVICES - Section 15.247 & Subpart E

      e. Shall be ZigBee Building Automation Certified to allow wireless integration with products from multiple suppliers.

      f. Wireless Comm Interface certifications shall include:

         1) TFP-13651127 - Canada Compliance

         2) UL 916 - Energy Management Equipment

         3) UL 94 - The Standard for Flammability of Plastic Materials for Parts in Devices and Appliances: 5 VA flammability rating

         4) UL 873 - Temperature regulating and indicating equipment

         5) ZigBee Building Automation, BACnet Tunnelling Device

C. Environment. Controller hardware shall be suitable for the anticipated ambient conditions. Controller used in conditioned ambient shall be mounted in an enclosure, and shall be rated for operation at -40 C to 50 C [-40 F to 122 F].

2.7 CUSTOM APPLICATION CONTROLLERS

A. General. Provide Custom Application Controllers to provide the performance specified in section 1 of this division. Each of these panels shall meet the following requirements.

1. The Controller shall have sufficient memory to support its operating system, database, and programming requirements.

2. Controllers that perform scheduling shall have a real time clock.

3. The operating system of the Controller shall manage the input and output communications signals to allow distributed controllers to share real and virtual point information and allow central monitoring and alarms.

4. The Controller shall continually check the status of its processor and memory circuits. If an abnormal operation is detected, the controller shall assume a predetermined failure mode, and generate an alarm notification.

5. Custom application controllers shall communicate using LonTalk, BACnet MSTP, or Zigbee.

B. Environment. Controller hardware shall be suitable for the anticipated ambient conditions.

1. Controller used in conditioned ambient shall be mounted in IP 20 type enclosures, and shall be rated for operation at 0 C to 50 C [32 F to 120 F].

2. Controllers used outdoors and/or in wet ambient shall be mounted within IP 56 type waterproof enclosures, and shall be rated for operation at -40 C to 70 C [-40 F to 158 F].

C. Memory. The Controller shall maintain all BIOS and programming information in the event of a power loss for at least 72 hours.

D. Immunity to power and noise. Controller shall be able to operate at 90% to 110% of nominal voltage rating and shall perform an orderly shutdown below 80% nominal voltage.

2.8 APPLICATION SPECIFIC CONTROLLERS

A. General. Application specific controllers (ASC) are microprocessor-based DDC controllers, which through hardware or firmware design are dedicated to control a specific piece of equipment. They are not fully user programmable, but are customized for operation within the confines of the equipment they are designed to serve.

1. Each ASC shall be capable of stand-alone operation and shall continue to provide control functions without being connected to the network.

2. Each ASC will contain sufficient I/O capacity to control the target system.

B. Environment. The hardware shall be suitable for the anticipated ambient conditions.

1. Controller used in conditioned ambient spaces shall be mounted in IP 20 type rated enclosures. Controllers located where not to be disturbed by System activity (such as above ceiling grid), may be provided with plenum-rated enclosures and non-enclosed wiring connections for plenum cabling. All controllers shall be rated for operation at 0 C to 50 C [32 F to 120 F].

2. Controllers used outdoors and/or in wet ambient shall be mounted within IP 56 type waterproof enclosures, and shall be rated for operation at -40 C to 65 C [-40 F to 150 F].

C. Memory. The Application Specific Controller shall maintain all BIOS and programming information in the event of a power loss for at least 90 days.

D. Immunity to Power and noise. Controller shall be able to operate at 90% to 110% of nominal voltage rating and shall perform an orderly shutdown below 80%.

E. Transformer. Power supply for the ASC must be rated at minimum of 125% of ASC power consumption, and shall be fused or current limiting type.

2.9 INPUT/OUTPUT INTERFACE

A. Hard-wired inputs and outputs may tie into the system through Building, Custom, or Application Specific Controllers.

B. All input points and output points shall be protected such that shorting of the point to itself, another point, or ground will cause no damage to the controller. All input and output points shall be protected from voltage up to 24V of any duration, such that contact with this voltage will cause no damage to the controller.

C. Binary inputs shall allow the monitoring of on/off signals from remote devices. The binary inputs shall provide a wetting current of at least 12 mA to be compatible with commonly available control devices.

D. Pulse accumulation input points. This type of point shall conform to all the requirements of Binary Input points, and also accept up to 3 pulses per second for pulse accumulation, and shall be protected against effects of contact bounce and noise.

E. Analog inputs shall allow the monitoring of low voltage (0-10 Vdc), current (4-20 mA), or resistance signals (thermistor, RTD). Analog inputs shall be compatible with, and field configurable to commonly available sensing devices.

F. Binary outputs shall provide for on/off operation. Terminal unit and zone control applications may use 2 outputs for drive-open, drive-close (tri-state) modulating control.

G. Analog outputs shall provide a modulating signal for the control of end devices. Outputs shall provide either a 0-10 Vdc or a 4-20 mA signal as required to provide proper control of the output device.

2.10 AUXILIARY CONTROL DEVICES

A. Motorized dampers, unless otherwise specified elsewhere, shall be as follows:

1. Damper frames shall be 16 gauge galvanized sheet metal or 1/8" extruded aluminum with reinforced corner bracing.

2. Damper blades shall not exceed 8" in width or 48" in length. Blades are to be suitable for medium velocity performance (2,000 fpm). Blades shall be not less than 16 gauge.

3. Damper shaft bearings shall be as recommended by manufacturer for application.

4. All blade edges and top and bottom of the frame shall be provided with compressible seals. Side seals shall be compressible stainless steel. The blade seals shall provide for a maximum leakage rate of 10 CFM per square foot at 2.5" w.c. differential pressure.

5. All leakage testing and pressure ratings will be based on AMCA Publication 500.

6. Individual damper sections shall not be larger than 48" x 60". Provide a minimum of one damper actuator per section.

B. Control dampers shall be parallel or opposed blade types as scheduled on drawings.

C. Electric damper/valve actuators.

1. The actuator shall have electronic overload or digital rotation sensing circuitry to prevent damage to the actuator throughout the rotation of the actuator.

2. Where shown, for power-failure/safety applications, an internal mechanical, spring return mechanism shall be built into the actuator housing.

3. All rotary spring return actuators shall be capable of both clockwise and counter clockwise spring return operation. Linear actuators shall spring return to the retracted position.

4. Proportional actuators shall accept a 0-10 VDC or 0-20 mA control signal and provide a 2-10 VDC or 4-20 mA operating range.

5. All non-spring return actuators shall have an external manual gear release to allow manual positioning of the damper when the actuator is not powered. Spring return actuators with more than 60 in-lb. torque capacity shall have a manual crank for this purpose.

6. Actuators shall be provided with a conduit fitting and a minimum 1m electrical cable and shall be pre-wired to eliminate the necessity of opening the actuator housing to make electrical connections.

7. Actuators shall be Underwriters Laboratories Standard 873 listed.

8. Actuators shall be designed for a minimum of 60,000 full stroke cycles at the actuator's rated torque.

D. Control Valves

1. Control valves shall be two-way or three-way type for two-position or modulating service as scheduled or shown.

2. Close-off (differential) Pressure Rating: Valve actuator and trim shall be furnished to provide the following minimum close-off pressure ratings:

a. Water Valves:

1) Two-way: 150% of total system (pump) head.

2) Three-way: 300% of pressure differential between ports A and B at design flow or 100% of total system (pump) head.

b. Steam Valves: 150% of operating (inlet) pressure.

3. Water Valves:

a. Body and trim style and materials shall be per manufacturer's recommendations for design conditions and service shown, with equal percentage ports for modulating service.

b. Sizing Criteria:

1) Two-position service: Line size.

2) Two-way modulating service: Pressure drop shall be equal to twice the pressure drop through heat exchanger (load), 50% of the pressure difference between supply and return mains, or [5] psi, whichever is greater.

3) Three-way Modulating Service: Pressure drop equal to twice the pressure drop through the coil exchanger (load), [5] psi maximum.

4) Valves 1/2" through 2" shall be bronze body or cast brass ANSI Class 250, spring loaded, Teflon packing, quick opening for two-position service. Two-way valves to have replaceable composition disc, or stainless steel ball.

5) 2-1/2" valves and larger shall be cast iron ANSI Class 125 with guided plug and Teflon packing.

c. Water valves shall fail normally open or closed as scheduled on plans or as follows:

1) Heating coils in air handlers - normally open.

2) Chilled water control valves - normally closed.

3) Other applications - as scheduled or as required by sequence of operation.

4) Zone valves shall be sized to meet the control application and they shall maintain their last position in the event of a power failure.

4. Steam Valves:

a. Body and trim materials shall be per manufacturer's recommendations for design conditions and service. Linear ports for modulating service.

b. Sizing Criteria:

1) Two-position service: pressure drop 10% to 20% of inlet psig.

2) Modulating service 15 psig or less: pressure drop 80% of inlet psig.

3) Modulating service 16 to 50 psig: pressure drop 50% of inlet psig.

4) Modulating service over 50 psig: pressure drop as scheduled on plans.

E. Binary Temperature Devices

1. Low-Voltage Space Thermostats shall be 24 V, bimetal-operated, mercury-switch type, with either adjustable or fixed anticipation heater, concealed setpoint adjustment, 13°C-30°C (55°F-85°F) setpoint range, 1°C (2°F) maximum differential, and vented cover.

2. Line-Voltage Space Thermostats shall be bimetal-actuated, open-contact type or bellows-actuated, enclosed, snap-switch type or equivalent solid-state type, with heat anticipator, UL listing for electrical rating, concealed setpoint adjustment,

13°C-30°C (55°F-85°F) setpoint range, 1°C (2°F) maximum differential, and vented cover.

3. Low-Limit airstream thermostats shall be UL listed, vapor pressure type. Element shall be at least 6 m (20 ft) long. Element shall sense temperature in each 30 cm (1 ft) section and shall respond to lowest sensed temperature. Low-limit thermostat shall be manual reset only.

F. Temperature Sensors

1. Temperature sensors shall be Resistance Temperature Device (RTD) or Thermistor.

2. Duct sensors shall be rigid or averaging as shown. Averaging sensors shall be a minimum of 1.5m [5 feet] in length.

3. Immersion sensors shall be provided with a separable stainless steel well. Pressure rating of well is to be consistent with the system pressure in which it is to be installed.

4. Space sensors shall be equipped with set-point adjustment, override switch, display, and/or communication port as shown on the drawings.

5. Provide matched temperature sensors for differential temperature measurement. Differential accuracy shall be within 0.1 C [0.2 F].

6. ALTERNATE: Wireless Zone Sensors

a. To check for proper operation, wireless zone temperature sensors shall include a signal strength and battery condition indicators on the zone sensor display or using LED’s on non-display models.

b. To allow local troubleshooting without specialized tools, error codes shall be displayed on the digital display through a blinking pattern on the non-display models. Error codes shall include: not associated, address to 000, improper software configuration, input voltage too high, or general sensor failure. Codes shall be indicated on inside of sensor back cover.

c. To support use by the physically impaired, the wireless zone sensor shall be a minimum font size of 12 points, and the LCD model shall be readable in low light conditions.

d. The wireless zone sensor shall include a readily visual indication of battery condition. The battery indication lights shall flash periodically for a minimum of 5 days to indicate the need for battery replacement prior to failure.

e. To ensure proper system performance, the wireless zone sensors shall automatically determine when the space temperature is rapidly changing. When the space temperature is readily changing, the space temperature shall be transmitted at least once each 30 seconds. The maximum time between transmissions shall be 15 minutes. Zone temperature sensing accuracy shall be +/- 0.5F (+/- 0.28C).

f. The wireless zone sensor battery life shall provide at least 5 years life under normal operating conditions and must be readily available size AA, 1.5V.

G. Humidity Sensors

1. Duct and room sensors shall have a sensing range of 20% to 80% with accuracy of ±5% R.H.

2. Duct sensors shall be provided with a sampling chamber.

3. Outdoor air humidity sensors shall have a sensing range of 20% to 95% R.H. It shall be suitable for ambient conditions of -40° C to 75° C [-40° F to 170° F].

4. Humidity sensor's drift shall not exceed 1% of full scale per year.

H. Static Pressure Sensors

1. Sensor shall have linear output signal. Zero and span shall be field-adjustable.

2. Sensor sensing elements shall withstand continuous operating conditions plus or minus 50% greater than calibrated span without damage.

3. Water pressure sensor shall have stainless steel diaphragm construction, proof pressure of 150 psi minimum. Sensor shall be complete with 4-20 mA output, required mounting brackets, and block and bleed valves. Mount in location accessible for service.

4. Water differential pressure sensor shall have stainless steel diaphragm construction, proof pressure of 150 psi minimum. Over-range limit (DP) and maximum static pressure shall be 3,000 psi. Transmitter shall be complete with 4-20 mA output, required mounting brackets, and five-valve manifold. Mount in a location accessible for service.

I. Low Limit Thermostats

1. Safety low limit thermostats shall be vapor pressure type with an element 6m [20 ft] minimum length. Element shall respond to the lowest temperature sensed by any one foot section.

2. Low limit shall be manual reset only.

J. Carbon Dioxide (CO_2) Sensors

1. Carbon Dioxide sensors shall measure CO_2 in PPM in a range of 0-2000 ppm. Accuracy shall be +/- 3% of reading with stability within 5% over 5 years. Sensors shall be duct or space mounted as indicated in the sequence of operation.

K. Flow Switches

1. Flow-proving switches shall be either paddle or differential pressure type, as shown.

2. Paddle type switches (water service only) shall be UL listed, SPDT snap-acting with pilot duty rating (125 VA minimum). Adjustable sensitivity with NEMA 1 Type enclosure unless otherwise specified.

3. Differential pressure type switches (air or water service) shall be UL listed, SPDT snap-acting, pilot duty rated (125 VA minimum), NEMA 1 Type enclosure, with scale range and differential suitable for intended application, or as specified.

4. Current sensing relays may be used for flow sensing or terminal devices.

L. Relays

1. Control relays shall be UL listed plug-in type with dust cover. Contact rating, configuration, and coil voltage suitable for application.

2. Time delay relays shall be UL listed solid-state plug-in type with adjustable time delay. Delay shall be adjustable plus or minus 200% (minimum) from set-point shown on plans. Contact rating, configuration, and coil voltage suitable for application. Provide NEMA 1 Type enclosure when not installed in local control panel.

M. Transformers and Power Supplies

1. Control transformers shall be UL listed, Class 2 current-limiting type, or shall be furnished with over-current protection in both primary and secondary circuits for Class 2 service.

2. Unit output shall match the required output current and voltage requirements. Current output shall allow for a 50% safety factor. Output ripple shall be 3.0 mV maximum Peak-to-Peak. Regulation shall be 0.10% line and load combined, with 50 microsecond response time for 50% load changes. Unit shall have built-in over-voltage protection.

3. Unit shall operate between 0° C and 50° C.

4. Unit shall be UL recognized.

N. Current Switches

1. Current-operated switches shall be self-powered, solid state with adjustable trip current. The switches shall be selected to match the current of the application and output requirements of the DDC system.

O. Local Control Panels

1. All indoor control cabinets shall be fully enclosed NEMA 1 Type construction with hinged door, and removable sub-panels or electrical sub-assemblies.

2. Interconnections between internal and face-mounted devices shall be pre-wired with color-coded stranded conductors neatly installed in plastic troughs and/or tie-wrapped. Terminals for field connections shall be UL listed for 600-volt service, individually identified per control/interlock drawings, with adequate clearance for field wiring. Control terminations for field connection shall be individually identified per control drawings.

3. Provide on/off power switch with over-current protection for control power sources to each local panel.

PART 3 - EXECUTION

3.1 SECTION INCLUDES:

A. Examination

B. Protection

C. General Workmanship

D. Field Quality Control

E. Wiring

F. Fiber Optic Cable

G. Installation of Sensors

H. Flow Switch Installation

I. Actuators

J. Warning Labels

K. Identification of Hardware and Wiring

L. Controllers

M. Programming

N. Cleaning

O. Training

P. Acceptance

3.2 EXAMINATION

A. The project plans shall be thoroughly examined for control device and equipment locations, and any discrepancies, conflicts, or omissions shall be reported to the Architect/Engineer for resolution before rough-in work is started.

B. The contractor shall inspect the site to verify that equipment is installable as shown, and any discrepancies, conflicts, or omissions shall be reported to the Architect/Engineer for resolution before rough-in work is started.

C. Contractor shall provide a Site Assessment Report that provides information about the feasibility of the Customer's existing IT and Building Automation System infrastructure to support the enterprise-wide system capabilities.

3.3 PROTECTION

A. The FMS Contractor shall protect all work and material from damage by his/her work or workers, and shall be liable for all damage thus caused.

B. The Contractor shall be responsible for his/her work and equipment until finally inspected, tested, and accepted. The Contractor shall protect his/her work against theft or damage, and shall carefully store material and equipment received on site that is not immediately installed. The Contractor shall close all open ends of work with temporary covers or plugs during storage and construction to prevent entry of foreign objects.

3.4 GENERAL WORKMANSHIP

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

B. Provide sufficient slack and flexible connections to allow for vibration of piping and equipment.

C. Install all equipment in readily accessible location as defined by chapter 1 article 100 part A of the NEC. Control panels shall be attached to structural walls unless mounted in equipment enclosure specifically designed for that purpose. Panels shall be mounted to allow for unobstructed access for service.

D. Verify integrity of all wiring to ensure continuity and freedom from shorts and grounds.

E. All equipment, installation, and wiring shall comply with acceptable industry specifications and standards for performance, reliability, and compatibility and be executed in strict adherence to local codes and standard practices.

3.5 FIELD QUALITY CONTROL

A. All work, materials and equipment shall comply with the rules and regulations of applicable local, state, and federal codes and ordinances as identified in Part 1 of this Section.

B. Contractor shall continually monitor the field installation for code compliance and quality of workmanship. All visible piping and or wiring runs shall be installed parallel to building lines and properly supported.

C. Contractor shall arrange for field inspections by local and/or state authorities having jurisdiction over the work.

3.6 CENTRAL SERVER INSTALLATION

A. The system installer shall perform complete installation and configuration of the following:

1. Server hardware
2. Server operating system
3. Server database software
4. Server application software

3.7 WIRING

A. All control and interlock wiring shall comply with the national and local electrical codes and Division 16 of these specifications. Where the requirements of this section differ with those in Division 16, the requirements of this section shall take precedence.

B. Where Class 2 wires are in concealed and accessible locations including ceiling return air plenums, approved cables not in raceway may be used provided that circuits meet NEC Class 2 (current-limited) requirements. (Low-voltage power circuits shall be sub-fused when required to meet Class 2 current-limit.)

C. All cables shall be UL listed for application, i.e., cables used in ceiling plenums shall be UL listed specifically for that purpose.

D. Do not install Class 2 wiring in conduit containing Class 1 wiring. Boxes and panels containing high voltage may not be used for low voltage wiring except for the purpose of interfacing the two (e.g. relays and transformers).

E. Where class 2 wiring is run exposed, wiring shall be run parallel along a surface or perpendicular to it, and bundled, using approved wire ties at no greater than 3 m [10 ft] intervals. Such bundled cable shall be fastened to the structure, using specified fasteners, at 1.5 m [5 ft] intervals or more often to achieve a neat and workmanlike result.

F. All wire-to-device connections shall be made at a terminal blocks or terminal strip. All wire-to wire connections shall be at a terminal block, or with a crimped connector. All wiring within enclosures shall be neatly bundled and anchored to permit access and prevent restriction to devices and terminals.

G. Maximum allowable voltage for control wiring shall be 120V. If only higher voltages are available, the Control System Contractor shall provide step down transformers.

H. All wiring shall be installed as continuous lengths, where possible. Any required splices shall be made only within an approved junction box or other approved protective device.

I. Install plenum wiring in sleeves where it passes through walls and floors. Maintain fire rating at all penetrations in accordance with other sections of this specification and local codes.

J. Size of conduit and size and type of wire shall be the design responsibility of the Control System Contractor, in keeping with the manufacturer's recommendation and NEC.

K. Control and status relays are to be located in designated enclosures only. These relays may also be located within packaged equipment control panel enclosures. These relays shall not be located within Class 1 starter enclosures.

L. Follow manufacturer's installation recommendations for all communication and network cabling. Network or communication cabling shall be run separately from other wiring.

M. Adhere to Division 16 requirements for installation of raceway.

N. This Contractor shall terminate all control and/or interlock wiring and shall maintain updated (as-built) wiring diagrams with terminations identified at the job site.

O. Flexible metal conduits and liquid-tight, flexible metal conduits shall not exceed 3' in length and shall be supported at each end. Flexible metal conduit less than 1/2" electrical trade size shall not be used. In areas exposed to moisture, including chiller and boiler rooms, liquid-tight, flexible metal conduits shall be used.

3.8 FIBER OPTIC CABLE SYSTEM

A. All cabling shall be installed in a neat and workmanlike manner. Minimum cable and unjacketed fiber bend radii as specified by cable manufacturer shall be maintained.

B. Maximum pulling tensions as specified by the cable manufacturer shall not be exceeded during installation. Post installation residual cable tension shall be within cable manufacture's specifications.

C. Fiber optic cabinets, hardware, and cable entering the cabinet shall be installed in accordance with manufacturers' instructions. Minimum cable and unjacketed fiber bend radii as specified by cable manufacturer shall be maintained.

3.9 INSTALLATION OF SENSORS

A. Install sensors in accordance with the manufacturer's recommendations.

B. Mount sensors rigidly and adequate for the environment within which the sensor operates.

C. Room temperature sensors shall be installed on concealed junction boxes properly supported by the wall framing.

D. All wires attached to sensors shall be air sealed in their conduits or in the wall to stop air transmitted from other areas affecting sensor readings.

E. Install duct static pressure tap with tube end facing directly down-stream of air flow.

F. Sensors used in mixing plenums, and hot and cold decks shall be of the averaging type. Averaging sensors shall be installed in a serpentine manner horizontally across duct. Each bend shall be supported with a capillary clip.

G. All pipe mounted temperature sensors shall be installed in wells. Install all liquid temperature sensors with heat conducting fluid in thermal wells.

H. Wiring for space sensors shall be concealed in building walls. EMT conduit is acceptable within mechanical and service rooms.

I. Install outdoor air temperature sensors on north wall complete with sun shield at designated location.

3.10 FLOW SWITCH INSTALLATION

A. Use correct paddle for pipe diameter.

B. Install and adjust flow switch in accordance with manufacturers' instructions.

C. Assure correct flow direction and alignment.

D. Mount in horizontal piping - flow switch on top of the pipe.

3.11 ACTUATORS

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

B. To compress seals when spring return actuators are used on normally closed dampers, power actuator to approximately 5 degrees open position, manually close the damper, and then tighten the linkage.

C. Check operation of damper/actuator combination to confirm that actuator modulates damper smoothly throughout stroke to both open and closed positions.

D. Valves - Actuators shall be mounted on valves with adapters approved by the actuator manufacturer. Actuators and adapters shall be mounted following manufacturer's recommendations.

3.12 WARNING LABELS

A. Affix labels on each starter and equipment automatically controlled through the DDC System. Warning label shall indicate the following:

CAUTION

This equipment is operating under automatic control and may start or stop at any time without warning. Switch disconnect to “Off” position before servicing.

B. Affix labels to motor starters and control panels that are connected to multiple power sources utilizing separate disconnects. Labels shall indicate the following:

CAUTION

This equipment is fed from more than one power source with separate disconnects.

Disconnect all power sources before servicing.

3.13 IDENTIFICATION OF HARDWARE AND WIRING

A. All wiring and cabling, including that within factory-fabricated panels, shall be labeled at each end within 2" of termination with a cable identifier and other descriptive information.

B. Permanently label or code each point of field terminal strips to show the instrument or item served.

C. Identify control panels with minimum 1-cm (1/2”) letters on nameplates.

D. Identify all other control components with permanent labels. Identifiers shall match record documents. All plug-in components shall be labeled such that removal of the component does not remove the label.

3.14 CONTROLLERS

A. Provide a separate Controller for each major piece of HVAC equipment. A custom application controller may control more than one system provided that all points associated with that system are assigned to the same controller. Points used for control loop reset such as outside air or space temperature are exempt from this requirement.

B. Building Controllers and Custom Application Controllers shall be selected to provide a minimum of 15% spare I/O point capacity for each point type found at each location. If input points are not universal, 15% of each type is required. If outputs are not universal, 15% of each type is required. A minimum of one spare is required for each type of point used.

1. Future use of spare capacity shall require providing the field device, field wiring, points database definition, and custom software. No additional Controller boards or point modules shall be required to implement use of these spare points.

3.15 PROGRAMMING

A. Provide sufficient internal memory for the specified control sequences and trend logging. There shall be a minimum of 25% of available memory in building controllers free for future use.

B. Point Naming: System point names shall be modular in design, allowing easy operator interface without the use of a written point index.

C. Software Programming

1. Provide programming for the system as written in the specifications and adhere to the sequence strategies provided. All other system programming necessary for the operation of the system but not specified in this document shall also be provided by the Control System Contractor. Imbed into any custom-written control programs sufficient comment statements or inherent flow diagrams to clearly describe each section of the program. The comment statements shall reflect the language used in the sequence of operations.

D. Operators' Interface

1. Standard Graphics. Provide graphics for each major piece of equipment and floor plan in the building. This includes each VAV box, air handling unit, ERV, and central geothermal plant equipment. These standard graphics shall show all points dynamically as specified in the points list.

2. The controls contractor shall provide all the labor necessary to install, initialize, start-up, and trouble-shoot all operator interface software and their functions as described in this section. This includes any operating system software, the operator interface database, and any third party software installation and integration required for successful operation of the operator interface.

3. As part of this execution phase, the controls contractor will perform a complete test of the operator interface. Test duration shall be a minimum of 16 hours on-site. Tests shall be made in the presence of the Owner or Owner's representative.

E. Demonstration: A complete demonstration and readout of the capabilities of the monitoring and control system shall be performed. The contractor shall dedicate a minimum of 16 hours on-site with the Owner and his representatives for a complete functional demonstration of all the system requirements. This demonstration constitutes a joint acceptance inspection, and permits acceptance of the delivered system for on-line operation.

3.16 CLEANING

A. This contractor shall clean up all debris resulting from his or her activities daily. The contractor shall remove all cartons, containers, crates, etc. under his control as soon as their contents have been removed. Waste shall be collected and placed in a location designated by the Construction Manager or General Contractor.

B. At the completion of work in any area, the Contractor shall clean all of his/her work, equipment, etc., making it free from dust, dirt and debris, etc.

C. At the completion of work, all equipment furnished under this Section shall be checked for paint damage, and any factory finished paint that has been damaged shall be repaired to match the adjacent areas. Any metal cabinet or enclosure that has been deformed shall be replaced with new material and repainted to match the adjacent areas.

3.17 TRAINING

A. Provide a minimum of 4 classroom training sessions, 4 hours each, throughout the contract period for personnel designated by the Owner.

B. Train the designated staff of Owner's representative and Owner to enable them to proficiently operate the system; create, modify and delete programming; add, remove and modify physical points for the system, and perform routine diagnostic and troubleshooting procedures.

C. Additional training shall be available in courses designed to meet objectives as divided into three logical groupings; participants may attend one or more of these, depending on the level of knowledge required:

1. Day-to-day Operators

2. Advanced Operators

3. System Managers/Administrators

D. Provide course outline and materials as per Part 1 of this Section. The instructor(s) shall provide one copy of training material per student.

E. The instructor(s) shall be factory-trained instructors experienced in presenting this material.

F. Classroom training shall be done using a network of working controllers representative of the installed hardware or at the customer’s site.

3.18 ACCEPTANCE

A. The control systems will not be accepted as meeting the requirements of Completion until all tests described in this specification have been performed to the satisfaction of both the Engineer and Owner. Any tests that cannot be performed due to circumstances beyond the control of the Contractor may be exempt from the Completion requirements if stated as such in writing by the Owner's representative. Such tests shall then be performed as part of the warranty.

ANNEX 1: INSTRUCTIONS TO OTHER CONTRACTORS

3.19 CONTROL VALVE INSTALLATION

A. Valve submittals shall be coordinated for type, quantity, size, and piping configuration to ensure compatibility with pipe design.

B. All control valves shall be installed so that the stem position is not more than 60° from the vertical up position.

C. Valves shall be installed in accordance with the manufacturer's recommendations.

D. Control valves shall be installed so that they are accessible and serviceable, and such that actuators may be serviced and removed without interference from structure or other pipes and/or equipment.

E. Isolation valves shall be installed such that control valve body may be serviced without draining the supply/return side piping system. {Note to designer: this must also be shown.} Unions shall be installed at all connections to screwed type control valves.

F. Provide tags for all control valves indicating service and number. Tags shall be brass, 1-1/2" in diameter, with 1/4" high letters. Securely fasten with chain and hook. Match identification numbers as shown on approved controls shop drawings.

ANNEX 1: INSTRUCTIONS TO OTHER CONTRACTORS

3.20 CONTROL DAMPER INSTALLATION

A. Damper submittals shall be coordinated for type, quantity, and size to ensure compatibility with sheet metal design.

B. Duct openings shall be free of any obstruction or irregularities that might interfere with blade or linkage rotation or actuator mounting. Duct openings shall measure 1/4" larger than damper dimensions and shall be square, straight, and level.

C. Individual damper sections, as well as entire multiple section assemblies, must be completely square and free from racking, twisting, or bending. Measure diagonally from upper corners to opposite lower corners of each damper section. Both dimensions must be equal ±1/8".

D. Follow manufacturer's instructions for field installation of control dampers. Unless specifically designed for vertical blade application, dampers must be mounted with blade axis horizontal.

E. Install extended shaft or jackshaft per manufacturer's instructions. (Typically, a sticker on the damper face shows recommended extended shaft location. Attach shaft on labeled side of damper to that blade.)

F. Damper blades, axles, and linkage must operate without binding. Before system operation, cycle damper after installation to assure proper operation. On multiple section assemblies, all sections must open and close simultaneously.

G. Provide a visible and accessible indication of damper position on the drive shaft end.

H. Support duct-work in area of damper when required to prevent sagging due to damper weight.

I. After installation of low-leakage dampers with seals, caulk between frame and duct or opening to prevent leakage around perimeter of damper.

ANNEX 1: INSTRUCTIONS TO OTHER CONTRACTORS

3.21 DUCT SMOKE DETECTION

A. Provide complete submittal data to controls system contractor for coordination of duct smoke detector interface to HVAC systems. This contractor shall provide a dry-contact alarm output in the same room as the HVAC equipment to be controlled.

3.22 VARIABLE FREQUENCY DRIVES (FOR BASE MOUNTED PUMPS)

A. Description

1. This specification is to cover a complete Variable Frequency motor Drive (VFD) consisting of a pulse width modulated (PWM) inverter designed for use on a standard NEMA Design B induction motor. The drives and all controls shall be furnished by the Temperature Control Contractor.

2. The drive manufacturer shall supply the drive and all necessary controls as herein specified. The manufacturer shall have been engaged in the production of this type of equipment for a minimum of ten years.

3. Provide two (2) differential pressure transmitters and one (1) flow sensor transmitter. The transmitters shall be furnished and wired by Control Contractor and installed by Mechanical Contractor.

4. The Temperature Control Contractor shall provide and power and control wiring unless wiring is shown on electrical drawings.

5. The VFD's shall control pump P-1 and P-2. Coordinate all work with pump manufacturer.

B. Quality Assurance

1. Referenced Standards:

a. Institute of Electrical and Electronic Engineers (IEEE)

1) Standard 519-1992, IEEE Guide for Harmonic Content and Control.

b. Underwriters laboratories

1) UL508C

c. National Electrical Manufacturer's Association (NEMA)

1) ICS 7.0, AC Adjustable Speed Drives

d. IEC 16800 Parts 1 and 2

2. Qualifications:

a. VFDs and options shall be UL listed as a complete assembly. VFDs that require the customer to supply external fuses for the VFD to be UL listed are not acceptable. VFDs with requiring additional branch circuit protection are not acceptable. The base VFD shall be UL listed for 100 KAIC without the need for input fusing.

b. CE Mark – The VFD shall conform to the European Union ElectroMagnetic Compatibility directive, a requirement for CE marking. The VFD shall meet product standard EN 61800-3 for the First Environment restricted level.

c. Acceptable Manufactures:

d. ABB ACH Series; Grahm; Danfoss

e. Alternate manufacturer's requests must be submitted in writing at least 10 working days prior to bid. Approval does not relieve supplier of specification requirements.

f. VFDs that are manufactured by a third party and "brand labeled" shall not be acceptable.

g. The variable frequency drive system must be a complete and operating system.

C. Submittals

1. Submittals shall include the following information:

a. Outline dimensions, conduit entry locations and weight.

2. Customer connection and power wiring diagrams.

3. Complete technical product description include a complete list of options provided. Any portions of the specifications not complied with must be clearly indicated or the supplier and contractor shall be liable to provide all components required to meet the specification.

4. Compliance to IEEE 519 – harmonic analysis for particular jobsite including total harmonic voltage distortion and total harmonic current distortion (TDD).

a. The VFD manufacturer shall provide calculations; specific to the installation, showing total harmonic voltage distortion is less than 5%. Input filters shall be sized and provided as required by the VFD manufacturer to ensure compliance with the IEEE electrical system standard 519. All VFDs shall include a minimum of 5% equivalent impedance reactors, no exceptions.

D. Variable Frequency Drives

1. The VFD package as specified herein shall be enclosed in a UL Listed Type enclosure, (NEMA rated enclosures are not acceptable) completely assembled and tested by the manufacturer in an ISO9001 facility. The VFD tolerated voltage window shall allow the VFD to operate from a line of +30% nominal, and -35% nominal voltage as a minimum.

a. Environmental operating conditions: 0 – 400 C continuous. Altitude 0 to 3300 feet above sea level, up to 95% humidity, non-condensing. All circuit boards shall have conformal coating.

b. Enclosure shall be rated UL type 1 and shall be UL listed as a plenum rated VFD.

2. All VFDs shall have the following features:

a. All VFDs shall have the same customer interface, including digital display, and keypad, regardless of horsepower rating. The keypad shall be removable, capable of remote mounting and allow for uploading and downloading of parameter settings as an aid for start-up of multiple VFDs.

b. The keypad shall include Hand-Off-Auto selections and manual speed control. There shall be fault reset and "Help" buttons on the keypad.

The Help button shall include “on-line” assistance for programming and troubleshooting.

c. There shall be a built-in time clock in the VFD keypad. The clock shall have a battery back up with 10 years minimum life span. The clock shall be used to date and time stamp faults and record operating parameters at the time of fault. If the battery fails, the VFD shall automatically revert to hours of operation since initial power up. The clock shall also be programmable to control start/stop functions, constant speeds, PID parameter sets and output relays. The VFD shall have a digital input that allows an override to the time clock (when in the off mode) for a programmable time frame. There shall be four (4) separate, independent timer functions that have both weekday and weekend settings. Capacitor backup is not acceptable.

d. The VFD shall be capable of starting into a coasting load (forward or reverse) up to full speed and accelerate or decelerate to setpoint without safety tripping or component damage (flying start).

e. The overload rating of the drive shall be 110% of its normal duty current rating for 1 minute every 10 minutes, 130% overload for 2 seconds. The minimum FLA rating shall meet or exceed the values in the NEC/UL table 430-150 for 4-pole motors.

f. The VFD shall have 5% equivalent impedance internal reactors to reduce the harmonics to the power line and to add protection from AC line transients. The 5% equivalent impedance may be from dual (positive and negative DC bus) reactors, or 5% AC line reactors. VFDs with only one DC reactor shall add an AC line reactor.

g. The VFD shall include a coordinated AC transient protection system consisting of 4-120 joule rated MOV’s (phase to phase and phase to ground), a capacitor clamp, and 5% equivalent impedance internal reactors.

h. The VFD shall provide a programmable proof of flow Form-C relay output (broken belt / broken coupling). The drive shall be programmable to signal this condition via a keypad warning, relay output and/or over the serial communications bus. Relay outputs shall include programmable time delays that will allow for drive acceleration from zero speed without signaling a false underload condition.

3. All VFDs to have the following adjustments:

a. Two (2) programmable critical frequency lockout ranges to prevent the VFD from operating the load continuously at an unstable speed.

b. Two (2) PID Setpoint controllers shall be standard in the drive, allowing pressure or flow signals to be connected to the VFD, using the microprocessor in the VFD for the closed loop control. The VFD shall have 250 ma of 24 VDC auxiliary power and be capable of loop powering a transmitter supplied by others. There shall be two parameter sets for the first PID that allow the sets to be switched via a digital input, serial communications or from the keypad for night setback, summer/winter setpoints, etc. There shall be an independent, second PID

loop that can utilize the second analog input and modulate one of the analog outputs to maintain setpoint of an independent process (ie. valves, dampers, etc.). All setpoints, process variables, etc. to be accessible from the serial communication network.

c. Two (2) programmable analog inputs shall accept current or voltage signals.

d. Two (2) programmable analog outputs (0-20ma or 4-20 ma). The outputs may be programmed to output proportional to Frequency, Motor Speed, Output Voltage, Output Current, Motor Torque, Motor Power (kW), DC Bus voltage, Active Reference, and other data.

e. Six (6) programmable digital inputs.

f. Three (3) programmable digital Form-C relay outputs. The relays shall include programmable on and off delay times and adjustable hysteresis. The relays shall be rated for maximum switching current 8 amps at 24 VDC and 0.4 A at 250 VAC; Maximum voltage 300 VDC and 250 VAC; continuous current rating 2 amps RMS. Outputs shall be true Form-C type contacts; open collector outputs are not acceptable.

g. Run permissive circuit - There shall be a run permissive circuit for damper or valve control. Regardless of the source of a run command (keypad, time-clock control, or serial communications) the VFD shall provide a dry contact closure that will signal the damper to open (VFD motor does not operate). When the damper is fully open, a normally open dry contact (end-switch) shall close. The closed end-switch is wired to a VFD digital input and allows motor operation. Two separate safety interlock inputs shall be provided. When either safety is opened, the motor shall be commanded to coast to stop, and the damper shall be commanded to close.

h. Two independently adjustable accel and decel ramps with 1 – 1800 seconds adjustable time ramps.

i. The VFD shall include a motor flux optimization circuit that will automatically reduce applied motor voltage to the motor to optimize energy consumption and audible motor noise.

j. The VFD shall include a carrier frequency control circuit that reduces the carrier frequency based on actual VFD temperature that allows higher carrier frequency without derating the VFD or operating at high carrier frequency only at low speeds.

k. The VFD shall include password protection against parameter changes.

4. The Keypad shall include a backlit LCD display. The display shall be in complete English words for programming and fault diagnostics (LED and alpha-numeric codes are not acceptable). All VFD faults shall be displayed in English words.

5. All applicable operating values shall be capable of being displayed in engineering (user) units. A minimum of three operating values from the list below shall be capable of being displayed at all times. The display shall be in complete English words (alpha-numeric codes are not acceptable):

a. Output Frequency

b. Motor Speed (RPM, %, or Engineering units)

c. Motor Current

d. Drive Temperature

e. DC Bus Voltage

f. Output Voltage

6. The VFD shall include a fireman's override input. Upon receipt of a contact closure from the fireman's control station, the VFD shall operate in one of two modes: 1) Operate at a programmed predetermined fixed speed or operate in a specific fireman's override PID algorithm that automatically adjusts motor speed based on override set point and feedback. The mode shall override all other inputs (analog/digital, serial communication, and all keypad commands), except customer defined safety run interlock, and force the motor to run in one of the two modes above. "Override Mode" shall be displayed on the keypad. Upon removal of the override signal, the VFD shall resume normal operation.

7. EMI / RFI filters. All VFDs shall include EMI/RFI filters. The VFD shall comply with standard EN 61800-3 for the First Environment, restricted level with up to 100' of motor cables. No Exceptions. Certified test lab test reports shall be provided with the submittals.

8. All VFDs through 60HP shall be protected from input and output power mis-wiring. The VFD shall sense this condition and display an alarm on the keypad. The VFD shall not be damaged by this condition.

9. OPTIONAL FEATURES – Optional features to be furnished and mounted by the drive manufacturer. All optional features shall be UL Listed by the drive manufacturer as a complete assembly and carry a UL508 label. The bypass enclosure door and VFD enclosure must be interlocked such that input power is turned off before either enclosure can be opened. The VFD and Bypass as a package shall have a UL listed short circuit rating of 100,000 amps and shall be indicated on the data label.

   a. A complete factory wired and tested bypass system consisting of an output contactor and bypass contactor, service (isolation) switch and VFD input fuses are required. Bypass designs, which have no VFD only fuses, or that incorporate fuses common to both the VFD and the bypass will not be accepted

   b. Door interlocked padlockable circuit breaker that will disconnect all input power from the drive and all internally mounted options.

10. The following operators shall be provided:

    a. Bypass Hand-Off-Auto

       1) Drive mode selector and light

       2) Bypass mode selector and light

       3) Bypass fault reset

       4) Bypass LDC display, 2 lines, for programming and status / fault / warning indications

5) Differential pressure transmitters

6) Flow sensor transmitter

b. Motor protection from single phase power conditions - The Bypass system must be able to detect a single phase input power condition while running in bypass, disengage the motor in a controlled fashion, and give a single phase input power indication. Bypass systems not incorporating single phase protection in Bypass mode are not acceptable.

c. The system (VFD and Bypass) tolerated voltage window shall allow the system to operate from a line of +30%, -35% nominal voltage as a minimum. The system shall incorporate circuitry that will allow the drive or bypass contactor to remain "sealed in" over this voltage tolerance at a minimum.

d. The Bypass system shall NOT depend on the VFD for bypass operation. The bypass shall be completely functional in both Hand and Automatic modes even if the VFD has been removed from the enclosure for repair / replacement.

e. Serial communications – the bypass and VFD shall be capable of being monitored and or controlled via serial communications. Provide communications protocols for LON in the bypass controller.

f. LON communication bypass capabilities shall include, but not be limited to; bypass run-stop control; the ability to force the unit to bypass; and the ability to lock and unlock the keypad. The bypass shall have the capability of allowing the DDC to monitor feedback such as, bypass current (in amps), bypass kilowatt hours (resettable), bypass operating hours (resettable), and bypass logic board temperature. The DDC shall also be capable of monitoring the bypass relays output status, and all digital input status. All bypass diagnostic warning and fault information shall be transmitted over the serial communications bus. Remote bypass fault reset shall be possible. The following additional bypass status indications and settings shall be transmitted over the serial communications bus – keypad "Hand" or "Auto" selected, and bypass selected. The DDC system shall also be able to monitor if the motor is running under load in both VFD and bypass (proof of flow) in the VFD mode over serial communications or Form-C relay output. A minimum of 40 field parameters shall be capable of being monitored in the bypass mode.

g. Run permissive circuit - there shall be a run permissive circuit for damper or valve control. Regardless of the source of a run command (keypad, time-clock control, or serial communications) the VFD and bypass shall provide a dry contact closure that will signal the damper to open (VFD motor does not operate). When the damper is fully open, a normally open dry contact (end-switch) shall close. The closed end-switch is wired to a VFD system input and allows motor operation. Two separate safety interlock inputs shall be provided. When either safety is opened, the motor shall be commanded to coast to stop, and the damper shall be commanded to close.

h. The bypass control shall monitor the status of the VFD and bypass contactors and indicate when there is a welded contactor contact or open contactor coil. This failed contactor operation shall be indicated on the Bypass LCD display as well as over the serial communications protocol.

i. The bypass control shall include a programmable time delay for bypass start and keypad indication that this time delay is in process. This will allow VAV boxes to be driven open before the motor operates at full speed in the bypass mode. The time delay shall be field programmable from 0 – 120 seconds.

j. The bypass control shall be programmable for manual or automatic transfer to bypass. The user shall be able to select via keypad programming which drive faults will generate an automatic transfer to bypass and which faults require a manual transfer to bypass.

k. There shall be an adjustable motor current sensing circuit for the bypass and VFD mode to provide proof of flow indication. The condition shall be indicated on the keypad display, transmitted over the building automation protocol and on a relay output contact closure.

l. The bypass controller shall have six programmable digital inputs, and five programmable Form-C relay outputs.

m. The relay outputs from the bypass shall programmable for any of the following indications.

1) System started
2) System running
3) Bypass override enabled
4) Drive fault
5) Bypass fault
6) Bypass H-O-A position
7) Motor proof of flow (broken belt)
8) Overload
9) Bypass selected
10) Bypass run
11) System started (damper opening)
12) Bypass alarm
13) Over temperature

n. The digital inputs for the system shall accept 24VAC or 24VDC. The bypass shall incorporate internally sourced power supply and not require an external control power source. The bypass power board shall supply 250 ma of 24 VDC for use by others to power external devices.

o. Customer Interlock Terminal Strip – provide a separate terminal strip for connection of freeze, fire, smoke contacts, and external start command. All external safety interlocks shall remain fully functional whether the

system is in VFD or Bypass mode. The remote start/stop contact shall operate in VFD and bypass modes. The terminal strip shall allow for independent connection of up to four (4) unique safety inputs.

p. The user shall be able to select the text to be displayed on the keypad when the safety opens. Example text display indications include "Firestat", "Freezestat", "Over pressure" and "Low pressure". The user shall also be able to determine which of the four (4) safety contacts is open over the serial communications connection.

q. Class 10, 20, or 30 (selectable) electronic motor overload protection shall be included.

E. Installation

1. Installation shall be the responsibility of the Mechanical Contractor; and wired by the Electrical Contractor as shown on the electrical drawings. The contractor shall install the drive in accordance with the requirements of the VFD manufacturer's installation manual.

2. Installation of the DP transmitters and flow transmitter shall be the responsibility of the Mechanical Contractor. The wiring shall be furnished by the Control Contractor.

F. Start-Up

1. Certified factory start-up shall be provided for each drive by a factory certified service center. A certified start-up form shall be filled out for each drive with a copy provided to the owner, and a copy kept on file at the manufacturer.

G. Product Support

1. Factory trained application engineering and service personnel that are thoroughly familiar with the VFD products offered shall be locally available at both the specifying and installation locations. A toll free 24/365 technical support line shall be available.

2. A computer based training CD or 8-hour professionally generated video (VCR format) shall be provided to the owner at the time of project closeout. The training shall include installation, programming and operation of the VFD, bypass and serial communication.

H. Warranty

1. Warranty shall be 24 months from the date of certified start-up. The warranty shall include all parts, labor, travel time and expenses.

1.1 SEQUENCE OF OPERATION - ENERGY RECOVERY UNITS (ERU-01, 02):

1.1 DEDICATED OUTSIDE AIR UNITS

1. OCCUPANCY

1.1. Occupied

1. Unit shall enter occupied mode if one of the following conditions is met:

1.1. Internal time clock in microprocessor controller determines occupied mode.

1.2. Dry contact for occupied mode is closed.

2. The controller shall perform the following operations in occupied mode:
    2.1. Supply fan shall enable.
    2.2. 30 seconds (adj.) after confirmation of supply fan pressure switch, outside air damper shall be energized to the minimum position (adj., default set at 100%).
    2.3. 30 seconds (adj.) after confirmation of supply fan pressure switch, return air damper shall be energized and controlled inversely to the outside air damper.
    2.4. 30 seconds (adj.) after confirmation of the supply fan pressure switch, exhaust fan shall enable
    if the outside air damper is greater than 15% open (adj).

1.2. Unoccupied
1. Unit shall enter unoccupied mode if one of the following conditions is met:
    1.1. Internal time clock in microprocessor controller determines unoccupied mode.
    1.2. Dry contact for occupied mode is opened.
2. The controller shall perform the following operations in unoccupied mode:
    2.1. Cooling, dehumidification, heating, or economizer shall be disabled.
    2.2. After 30 seconds (adj.) the supply fan shall be disabled.
    2.3. Outside air damper shall be de-energized and fail closed.
    2.4. Return air damper shall be de-energized and fail open.

2. DISCHARGE AIR CONTROL SEQUENCE:
2.1. Discharge Air Control with Space Temperature and Humidity Reset
1. The discharge air temperature set point shall be automatically determined based on the difference between the measured space temperature and active space temperature set point (discharge air temperature reset).

2.2. Discharge Air Control
1. The discharge air set point is determined based on the discharge air heating and cooling set points (adj.) stored in the controller.

2.3. Energy Recovery
1. Upon entering the occupied mode of operation, the controller shall enable the energy recovery sequence if one of the following conditions are met:
    1.1. The outdoor air temperature is below the energy recovery outdoor air temperature lock on set point of 45°F (adj.).
    1.2. The outdoor air temperature is above the energy recovery outdoor air temperature lock on set point of 85°F (adj.).
    1.3. The outdoor air relative humidity is above 65% RH (adj.).
    1.4. The unit is in heating mode and the energy recovery outside air enable set point is below 70°F (adj.).

1.5. The unit is in cooling mode and the energy recovery cooling outside air enable is above 75°F (adj.).

2. Upon enabling the energy recovery sequence, the controller shall perform the following functions:
   2.1. The face and bypass dampers will modulate to maintain the discharge air set point.
3. If the exhaust air temperature drops below 35°F (adj.), the controller shall perform the following operations:
   3.1. The face and bypass dampers will modulate to maintain the frost protect setpoint35°F (adj.).

3. COOLING & DEHUMIDIFICATION: WATER-SOURCE HEAT PUMP WITH DIGITAL SCROLL™ COMPRESSORS

3.1. Cooling

1. Cooling sequence shall be enabled when all of the following conditions are met:
   1.1. Unit is in occupied mode.
   1.2. Outside air temperature is greater than 55°F (adj.).
   1.3. Outside air dew point is less than 55°F by 2 to 5°F (adj.).
2. Upon entering cooling mode the controller shall perform the following functions:
   2.1. Hot gas reheat valve shall remain disabled in the closed position.
   2.2. Digital Scroll compressor shall modulate to meet the discharge air temperature set point.
   2.3. If the unit is unable to meet the discharge air set point, additional fixed stages of cooling shall enable in addition to the Digital Scroll compressor to meet the discharge air set point.
   2.4. If the discharge air set has been met and the Digital Scroll compressor is at its minimum modulation, a fixed compressor stage shall be disabled.
   2.5. Water valve on coaxial heat exchanger shall modulate water flow to maintain refrigerant head pressure set point.
3. Cooling mode shall be disabled when the following conditions are met:
   3.1. Outside air temperature falls below 55°F by 2 to 5°F maximum (adj.).

3.2. Dehumidification

1. Dehumidification mode shall be enabled if one of the following two conditions are met:
   1.1. Outside air dew point is greater than 55°F (adj.).
   1.2. Space relative humidity is greater than 55% RH (adj.).
2. The controller shall provide the following operations in dehumidification mode:
   2.1. Digital Scroll compressor shall modulate to meet the evaporator coil set point.

2.2. If the unit is unable to meet the evaporator coil set point, additional fixed stages of cooling shall enable in addition to the Digital Scroll compressor to meet the discharge air set point.

2.3. If the evaporator coil set point has been met and the Digital Scroll compressor is at its minimum modulation, a fixed compressor stage shall be disabled.

2.4. Hot gas reheat valve shall modulate capacity to maintain discharge air set point.

2.5. Water valve on coaxial heat exchanger shall modulate water flow to maintain refrigerant head pressure set point.

3. If hot gas reheat is in the open position for 5 minutes, one of two modes shall enable:

3.1. Dehumidification priority (default): The hot-gas reheat gets locked to 100%, and the Digital Scroll will modulate to maintain the coil leaving air temperature. Getting the most dehumidification possible, but allowing the discharge air temperature to get cooler than the discharge air temperature set point.

3.2. Temperature priority: The hot-gas reheat gets locked to 100%, and the Digital Scroll will modulate to maintain the discharge air temperature set point. Getting as much dehumidification as possible, while maintaining the discharge air temperature.

4. Once every 45 minutes (adj.) the hot gas reheat valve shall be controlled full open for 45 seconds (adj.) to allow oil return to the compressors.

5. Dehumidification mode shall be disabled if both of the following conditions are true:

5.1. Outside air dew point falls below 55°F by 2 to 5°F maximum (adj.)

5.2. Space relative humidity falls below 55% RH by 2 to 5% maximum (adj.).

4. HEATING SEQUENCE

4.1. Water Source Heat Pump

1. Heating shall be enabled when unit is not in cooling, dehumidification, or economizer mode.

2. The controller shall perform the following operations in heating mode:

2.1. Digital Scroll compressor shall modulate to meet the discharge air temperature set point.

2.2. If the unit is unable to meet the discharge air set point, additional fixed stages of heating shall enable in addition to the Digital Scroll compressor to meet the discharge air set point.

2.3. If the discharge air set has been met and the Digital Scroll compressor is at its minimum modulation, a fixed compressor stage shall be disabled.

2.4. Water valve on coaxial heat exchanger shall modulate water flow to maintain refrigerant head pressure set point.

3. Heating mode shall disable if any of the conditions below are met:

3.1. Cooling mode enabled.

3.2. Dehumidification mode enabled.

3.3. Occupied mode disabled.

3.4. Economizer mode enabled.

5. ECONOMIZER

5.1. Economizer mode shall be enabled if both of the following two conditions are met:

1. Outside air enthalpy is less than space / return air enthalpy.
2. Space / discharge air requires cooling.
3. Economizer enable is set to true on LCD or UMT.

5.2. Upon entering economizer mode the controller shall provide the following operations:

1. Outside air damper and return air damper shall modulate inversely in order to maintain the cooling discharge air temperature set point.

6. SECONDARY SEQUENCE OF CONTROL

6.1. Pressurization Control: Exhaust Fan Modulation

1. Constant air volume sequence shall be enabled when the following conditions are met:

1.1. Controller is in occupied mode.

2. Under the constant air volume sequence the controller shall perform the following operations:

2.1. Exhaust fan speed shall be modulated through a variable frequency drive in order to maintain space static pressure set point.

3. Space static pressure sensor shall be provided by factory and installed in the field.

1.2 GYMNASIUM WATER SOURCE HEAT PUMPS:

A. Run Conditions - Scheduled:

1. The unit will run according to a user definable time schedule in the following modes:

a. Occupied Mode: The unit will maintain

i. A 74°F (adj.) cooling setpoint

ii. A 70°F (adj.) heating setpoint

b. Unoccupied Mode (night setback): The unit will maintain

i. An 85°F (adj.) cooling setpoint.

ii. A 55°F (adj.) heating setpoint.

2. Alarms will be provided as follows:

a. High Zone Temp: If the zone temperature is greater than the cooling setpoint by a user definable amount (adj.).

b. Low Zone Temp: If the zone temperature is less than the heating setpoint by a user definable amount (adj.).

B. Zone Setpoint Adjust:

1. Where applicable, the occupant will be able to adjust the zone temperature heating and cooling setpoints at the zone sensor (limits of adjustment shall be adjust-

able at the operator workstation). Common areas will have setpoint adjusted by BAS operator. See plans for locations of sensors with setpoint adjustment.

C. Zone Unoccupied Override:

1. Where applicable, A timed local override control will allow an occupant to override the schedule and place the unit into an occupied mode as a zone for an adjustable period of time. At the expiration of this time, control of the unit will automatically return to the schedule (limits of override time shall be adjustable at the operator workstation). See plans for locations of sensors with occupancy override.

D. Emergency Shutdown:

1. The unit will shut down and generate an alarm upon receiving an emergency shutdown signal from heat pump loop system.

E. Fan:

1. The fan will run anytime the unit is commanded to run, unless shutdown on safeties.

F. Heating and Cooling - 1 or 2 Compressor Stage(s):

1. The controller will receive a signal from the loop water source monitor indicating that there is water flow and that the water temperature is within acceptable limits.

2. The controller will measure the zone temperature and cycle the compressor to maintain its setpoint. To prevent short cycling, the stage will have a user definable (adj.) minimum runtime. The compressor will run subject to its own internal safeties and controls.

3. The heating will be enabled whenever:

a. Flow is established in the heat pump loop system

i. AND the fan is on.

ii. AND the reversing valve is in heat mode.

iii. And the unit is not economizing.

4. The cooling will be enabled whenever:

a. Flow is established in the heat pump loop system

b. AND the fan is on.

c. AND the reversing valve is in cool mode

d. And the economizer damper is at its minimum

5. On mode change, the compressor will be disabled and remain off until after the reversing valve has changed position.

6. Alarms will be provided as follows:

a. Compressor Runtime Exceeded: The compressor runtime exceeds a user definable limit (adj.).

G. Condensate Overflow Shutdown:

a. The unit will shut down and generate an alarm upon receiving a condensate overflow signal.

H. Return Air Smoke Detection:

1. The unit will shut down when the detector goes into alarm.

I. Outside Air Ventilation - Carbon Dioxide (CO2) Control:

1. When in the occupied mode, the motorized damper shall be closed and motorized damper in return air duct shall open fully 7800 CFM (adj).

2. The controller will measure the zone CO2 level and open the outside air dampers on rising CO2 concentrations, once the CO2 levels rises to 1100 ppm(adj.) the motorized damper will go to 100% open. Once 100% open the motorized damper in the R/A duct shall partially close to allow 6400 CFM. Once the CO2 levels drop to 800 ppm(adj.) the damper shall close and the R/A damper shall open fully.

J. Zone Carbon Dioxide (CO2) Concentration Monitoring:

1. The controller will measure the return air CO2 levels.

2. Alarms will be provided as follows:

a. High Return Air Carbon Dioxide Concentration: If the return air CO2 concentration is greater than 1000ppm (adj.) when in the unit is running.

K. Supply Air Temperature:

1. The controller will monitor the supply air temperature.

2. Alarms will be provided as follows:

a. High Supply Air Temp: If the supply air temperature is greater than 120°F (adj.).

b. Low Supply Air Temp: If the supply air temperature is less than 45°F (adj.).

L. Unit Fault Status:

1. The controller will monitor the fault status of the unit. When normal, the contact to the controller is closed. Should one of the safeties activate or the disconnect on the unit is pulled, the fault status will open – indicating an alarm.

M. Unit Remote Reset:

1. Should the unit be tripped on any software safeties (low temperature, high/low suction pressure, condensate), the controller can be used to restart the unit from the ALC system. This restart is accomplished by cycling the Y1 input for 10 secs.

N. Return Air Filter Differential Pressure Monitor:

1. The controller shall monitor the differential pressure across the return air filter.

2. Alarms shall be provided as follows:

a. Return Air Filter Change Required: Filter differential pressure exceeds a user definable limit (adj.).

1.3 KITCHEN WATER SOURCE HEAT PUMPS:

A. Run Conditions - Scheduled:

1. The unit will run according to a user definable time schedule in the following modes:

a. Occupied Mode: The unit will maintain

i. A 74°F (adj.) cooling setpoint

ii. A 70°F (adj.) heating setpoint

b. Unoccupied Mode (night setback): The unit will maintain

i. An 85°F (adj.) cooling setpoint.

ii. A 55°F (adj.) heating setpoint.

2. Alarms will be provided as follows:

a. High Zone Temp: If the zone temperature is greater than the cooling setpoint by a user definable amount (adj.).

b. Low Zone Temp: If the zone temperature is less than the heating setpoint by a user definable amount (adj.).

B. Zone Setpoint Adjust:

1. Where applicable, the occupant will be able to adjust the zone temperature heating and cooling setpoints at the zone sensor (limits of adjustment shall be adjustable at the operator workstation). Common areas will have setpoint adjusted by BAS operator. See plans for locations of sensors with setpoint adjustment.

C. Zone Unoccupied Override:

1. Where applicable, A timed local override control will allow an occupant to override the schedule and place the unit into an occupied mode as a zone for an adjustable period of time. At the expiration of this time, control of the unit will automatically return to the schedule (limits of override time shall be adjustable at the operator workstation). See plans for locations of sensors with occupancy override.

D. Emergency Shutdown:

1. The unit will shut down and generate an alarm upon receiving an emergency shutdown signal from heat pump loop system.

E. Fan:

1. The fan will run anytime the unit is commanded to run, unless shutdown on safeties.

F. Cooling - 2 Compressor Stages:

1. The controller will measure the zone temperature and cycle the compressor to maintain its setpoint. To prevent short cycling, each stage will have a user definable (adj.) minimum runtime. The compressor will run subject to its own internal safeties and controls. The controller shall stage the digital scroll compressors to modulate from 0% to 100% as the total capacity increases from 0% to 50%. As the cooling demand increases from 50% to 100% of total capacity the second stage compressor shall be energized and the digital scroll compressors shall modulate between 0% and 100%.

2. The cooling will be enabled whenever:

    a. Flow is established in the heat pump loop system

    b. AND the space temperature is above setpoint

    c. AND the fan is on.

    d. AND the reversing valve is in cool mode

    e. And the economizer damper is at its minimum

G. Hot Gas Reheat Control:

1. The controller shall measure the zone space temperature and modulate the hot gas reheat to maintain the space humididty setpoint of 55% (adj.) RH)

2. The hot gas reheat shall be enabled whenever:

    a. The space temp is below setpoint

    b. AND the space humidity is above setpoint

    c. AND the compressors are operating

    d. AND the supply fan status is on.

H. Heating - 2 Compressor Stage(s):

1. The controller will receive a signal from the loop water source monitor indicating that there is water flow and that the water temperature is within acceptable limits.

2. The controller will measure the zone temperature and cycle the compressor to maintain its setpoint. To prevent short cycling, the stage will have a user definable (adj.) minimum runtime. The compressor will run subject to its own internal safeties and controls. The controller shall stage the digital scroll compressors to modulate from 0% to 100% as the total capacity increases from 0% to 50%. As the heating demand increases from 50% to 100% of total capacity the second stage compressor shall be energized and the digital scroll compressors shall modulate between 0% and 100%..

3. The heating will be enabled whenever:

    a. Flow is established in the heat pump loop system

    b. AND the space temperature is below setpoint

    c. AND the fan is on.

    d. AND the reversing valve is in heat mode.

    e. AND the unit is not economizing.

I. Supply Air Temperature:

1. The controller will monitor the supply air temperature.

2. Alarms will be provided as follows:

    a. High Supply Air Temp: If the supply air temperature is greater than 120°F (adj.).

    b. Low Supply Air Temp: If the supply air temperature is less than 45°F (adj.).

J. Condensate Overflow Shutdown:

1. The unit will shut down and generate an alarm upon receiving a condensate overflow signal.

K. Return Air Smoke Detection:

1. The unit will shut down when the detector goes into alarm.

L. Unit Fault Status:

1. The controller will monitor the fault status of the unit. When normal, the contact to the controller is closed. Should one of the safeties activate or the disconnect on the unit is pulled, the fault status will open – indicating an alarm.

M. Unit Remote Reset:

1. Should the unit be tripped on any software safeties (low temperature, high/low suction pressure, condensate), the controller can be used to restart the unit from the ALC system. This restart is accomplished by cycling the Y1 input for 10 secs.

N. Return Air Filter Differential Pressure Monitor:

1. The controller shall monitor the differential pressure across the return air filter.

2. Alarms shall be provided as follows:

a. Return Air Filter Change Required: Filter differential pressure exceeds a user definable limit (adj.).

1.4 STANDARD WATER SOURCE HEAT PUMPS:

A. Run Conditions - Scheduled:

1. The unit will run according to a user definable time schedule in the following modes:

a. Occupied Mode: The unit will maintain

i. 74°F (adj.) cooling setpoint

ii. A 70°F (adj.) heating setpoint

b. Unoccupied Mode (night setback): The unit will maintain

i. A 85°F (adj.) cooling setpoint.

ii. A 55°F (adj.) heating setpoint.

Building Automation System Interface:
The Building Automation System (BAS) shall send the controller Occupied Bypass, Morning Warm-up / Pre-Cool, Occupied / Unoccupied and Heat / Cool modes. If a BAS is not present, or communication is lost with the BAS the controller shall operate using default modes and setpoints.

Occupied Mode:
During occupied periods, the supply fan shall run continuously and the outside air damper shall open to maintain minimum ventilation requirements. The DX heating and cooling shall stage to maintain the occupied space temperature setpoint.

Unoccupied Mode:
The outside air dampers shall remain closed in the unoccupied mode

The fans shall not run in the unoccupied mode unless there is a call for unoccupied heating or cooling

When the space temperature is above the Unoccupied cooling setpoint of 85.0 deg. F (adj.) the supply fan shall start, the outside air damper shall remain closed and the DX cooling shall be enabled. When the space temperature falls below the unoccupied cooling setpoint of 85.0 deg. F minus the unoccupied differential of 4.0 deg. F (adj.) the supply fan shall stop and the DX cooling shall be disabled.

When the space temperature is below the unoccupied heating setpoint of 60.0 deg. F (adj.) the supply fan shall start, the outside air damper shall remain closed and the DX heating shall be enabled. When the space temperature rises above the unoccupied heating setpoint of 60.0 deg. F (adj.) plus the unoccupied differential of 4.0 deg. F (adj.) the supply fan shall stop and the DX heating shall be disabled.

Optimal Start:
The BAS shall monitor the scheduled occupied time, occupied space setpoints and space temperature to calculate when the optimal start occurs.

Morning Warm-Up Mode:
During optimal start, if the space temperature is below the occupied heating setpoint a morning warm-up mode shall be activated. When morning warm-up is initiated the unit shall enable the heating and supply fan. The outside air damper shall remain closed. When the space temperature reaches the occupied heating setpoint (adj.), the unit shall transition to the occupied mode.

Pre-Cool Mode:
During optimal start, if the space temperature is above the occupied cooling setpoint, pre-cool mode shall be activated. When pre-cool is initiated the unit shall enable the fan and cooling. The outside air damper shall remain closed. When the space temperature reaches occupied cooling setpoint (adj.), the unit shall transition to the occupied mode.

Optimal Stop:
The BAS shall monitor the scheduled unoccupied time, occupied setpoints and space temperature to calculate when the optimal stop occurs. When the optimal stop mode is active the unit controller shall maintain the space temperature to the space temperature offset setpoint.

Occupied Bypass:
The BAS shall monitor the status of the “on” and “cancel” buttons of the space temperature sensor. When an occupied bypass request is received from a space sensor, the unit shall transition from its current occupancy mode to occupied bypass mode and the unit shall maintain the space temperature to the occupied setpoints (adj.).

Cooling Mode:
The unit controller shall use space temperature and space temperature setpoint to determine when to stage the cooling. When the space temperature rises above the setpoint, the unit controller shall stage the DX cooling as required to maintain the space temperature setpoint. When the space temperature falls below the setpoint the controller shall disable DX cooling.

Heating Mode:
The unit controller shall use the space temperature and space temperature setpoint to determine when to initiate requests for heat. When the space temperature drops below the setpoint, the unit controller shall enable DX heating to maintain the space temperature setpoint. Once the space temperature rises above the setpoint the DX heating shall be disabled.

Dehumidification:
Where indicated on the plans, factory installed hot gas reheat shall allow application of dehumidification. Dehumidification shall be allowed only when the unit mode is cooling and the zone relative humidity is greater than the dehumidification enable setpoint.

Single compressor units:
On a call for dehumidification, the reheat valve shall energize and the compressor shall enable. When the humidity control setpoint is satisfied, the valve shall be de-energized and the compressor shall be disabled. If there is a call for cooling from the space temperature controller, while in reheat, the reheat valve shall be de-energized and the compressor continues to run.

Dual compressor units:
When in dehumidification only the first stage compressor will be allowed to run in conjunction with the reheat valve.

Ventilation Optimization:
Where indicated on the plans, the WSHP ASC shall monitor space CO2 levels and adjust the outside air dampers as follows:

When the space CO2 is 1400ppm or higher the outside air damper shall be at its maximum position

When the space CO2 is 250ppm or lower the outside air damper shall be at its minimum position

Supply Fan:
The supply fan shall be enabled while in the occupied mode and cycled on during the unoccupied mode. A differential pressure switch shall monitor the differential pressure across the fan. If the switch does not open within 40 seconds after a request for fan operation a fan failure alarm shall be annunciated at the BAS, the unit shall stop, requiring a manual reset.

Filter Timer:
The fan-run time (hrs) shall be compared to the filter maintenance timer setpoint. Once the setpoint is reached a filter timer alarm diagnostic shall be annunciated at the BAS. When the diagnostic is cleared, the filter-maintenance timer is reset to zero, and the timer begins accumulating fan-run time again.

1.5 CONDENSER WATER CONTROL SYSTEM:

A. Summary of Controls

1. The geothermal heat pump condenser water loop consists of a variable-primary pumping arrangement. The system is served by (2) variable speed pumps. During part load conditions the systems flow requirements will be met by a single “part load pump” with a fully redundant backup. During full load conditions the systems flow requirements will be met by a single “full load pump” with a fully redundant backup. The pumps will operate in a Lead/Standby arrangement within each pump motor size. The operational mode (part load or full load pump operation) will be determined based on pump speed and the efficiency curve of the actual equipment as determined during T&B.

B. Water Source Heat Pump Condenser Pumps - Run Conditions:

1. The loop pumps shall run whenever:

a. Any zone is occupied and requires heating or cooling.

b. OR a definable number of unoccupied zones need heating or cooling.

2. The following loop water conditions shall be monitored:

a. Flow status.

b. Supply temperature.

c. Return temperature.

d. Flow Rate

e. BTU Meter

3. Alarms and a heat pump shutdown signal shall be generated upon any of the following loop water conditions:

a. No Loop Flow.

b. High Loop Water Supply Temp Shutdown: If the loop water supply temperature is greater than 100°F (adj.).

c. Low Loop Water Supply Temp Shutdown: If the loop water supply temperature is less than 30°F (adj.).

4. Alarms shall be provided as follows:

a. High Loop Water Supply Temp: If the loop water supply temperature is greater than 95°F (adj.).

b. Low Loop Water Supply Temp: If the loop water supply temperature is less than 35°F (adj.).

C. Loop Water Pump Lead/Lag Operation:

1. The two chilled water pumps shall operate in a lead/lag/standby fashion. The lead pump shall be enabled whenever any zone is occupied and requires heating or cooling or a defineable number of unoccupied zones need heating or cooling. On decreasing chilled water differential pressure, the lag pump shall stage on and run in unison with the lead pump to maintain chilled water differential pressure setpoint.

2. The two loop water pumps shall operate in a lead/lag/standby fashion.

a. The lead pump shall run first.

b. On decreasing loop water differential pressure below 80% (adj.) of the loop DP setpoint, or increasing motor speed above 50 Hz (adj.) lag pump shall stage on and run in unison with the lead pump.

c. On increasing loop water differential pressure above 120% (adj.) of the loop DP setpoint, or decreasing motor speed below 35 Hz (adj.) the lag pump shall stage off while the lead pump remains on.

d. There shall be a minimum delay of 10 mins. (adj.) between the enabling and disabling of the lag pump.

e. On failure of the lead pump during single pump operation, the lag pump shall be enabled and the lead pump shall be disabled. Should the lag pump already be in operation at the time of the lead pump failure the standby pump shall be enabled.

f. On failure of the lead or lag pump during two pump operation the working pump shall be enabled and the failed pump shall be disabled.

3. The designated lead pump for each motor size shall rotate upon one of the following conditions (user selectable):

   a. manually through a software switch

   b. if pump runtime (adj.) is exceeded

   c. daily

   d. weekly

   e. monthly

D. Loop Water Differential Pressure Control:

1. The controller shall measure loop water differential pressure and modulate the loop water pump VFDs in sequence to maintain its loop water differential pressure setpoint. The following setpoints are recommended values. All setpoints shall be field adjusted during the commissioning period to meet the requirements of actual field conditions.

2. The controller shall modulate loop water pump speeds to maintain a loop water differential pressure of 12lbf/in2 (adj.) as measured at the lowest sensor. The VFD minimum speed shall not drop below 20% (adj.).

3. Alarms shall be provided as follows:

   a. High Loop Water Differential Pressure: If the loop water differential pressure is 25% (adj.) greater than setpoint.

   b. Low Loop Water Differential Pressure: If the loop water differential pressure is 25% (adj.) less than setpoint.

4. Alarms shall be provided as follows:

   a. Loop Water Pump 1

      i. Failure: Commanded on, but the status is off.

      ii. Running in Hand: Commanded off, but the status is on.

      iii. Runtime Exceeded: Status runtime exceeds a user definable limit.

      iv. VFD Fault.

   b. Loop Water Pump 2

      i. Failure: Commanded on, but the status is off.

      ii. Running in Hand: Commanded off, but the status is on.

      iii. Runtime Exceeded: Status runtime exceeds a user definable limit.

      iv. VFD Fault.

1.6 OUTSIDE AIR CONDITIONS:

A. The controller will monitor the outside air temperature and humidity and calculate the outside air enthalpy on a continual basis. These values will be made available to the system at all times.

B. Alarm will be generated as follows:

1. Sensor Failure: Sensor reading indicates shorted or disconnected sensor.

C. Outside Air Temperature History:

1. The controller will monitor and record the high and low temperature readings for the outside air. These readings will be recorded on a daily, month-to-date, and year-to-date basis.

D. Cooling Degree Day:

1. The controller will provide a Degree Day history index that reflects the energy consumption for the facilities cooling demand. Computations will use a mean daily temperature of 65°F (adj.). The Degree Day peak value readings will be recorded on a daily, month-to-date, and year-to-date basis.

E. Heating Degree Day:

1. The controller will provide a Degree Day history index that reflects the energy consumption for the facilities heating demand. Computations will use a mean daily temperature of 65°F (adj.). The Degree Day peak value readings will be recorded on a daily, month-to-date, and year-to-date basis.

1.7 VARIABLE FREQUENCY DRIVES (FOR BASE MOUNTED PUMPS)

A. Description

1. This specification is to cover a complete Variable Frequency motor Drive (VFD) consisting of a pulse width modulated (PWM) inverter designed for use on a standard NEMA Design B induction motor. The drives and all controls shall be furnished by the Temperature Control Contractor.

2. The drive manufacturer shall supply the drive and all necessary controls as herein specified. The manufacturer shall have been engaged in the production of this type of equipment for a minimum of ten years.

3. Provide two (2) differential pressure transmitters and one (1) flow sensor transmitter. The transmitters shall be furnished and wired by Control Contractor and installed by Mechanical Contractor.

4. The Temperature Control Contractor shall provide and power and control wiring unless wiring is shown on electrical drawings.

5. The VFD's shall control pump P-1 and P-1A. Coordinate all work with pump manufacturer.

B. Quality Assurance

1. Referenced Standards:

a. Institute of Electrical and Electronic Engineers (IEEE)

i. Standard 519-1992, IEEE Guide for Harmonic Content and Control.

b. Underwriters laboratories

i. UL508C

c. National Electrical Manufacturer's Association (NEMA)

i. ICS 7.0, AC Adjustable Speed Drives

d. IEC 16800 Parts 1 and 2

2. Qualifications:

a. VFDs and options shall be UL listed as a complete assembly. VFDs that require the customer to supply external fuses for the VFD to be UL listed are not acceptable. VFDs with requiring additional branch circuit protection are not acceptable. The base VFD shall be UL listed for 100 KAIC without the need for input fusing.

b. CE Mark – The VFD shall conform to the European Union ElectroMagnetic Compatibility directive, a requirement for CE marking. The VFD shall meet product standard EN 61800-3 for the First Environment restricted level.

c. Acceptable Manufactures:

i. ABB ACH Series; Grahm; Danfoss

d. Alternate manufacturer's requests must be submitted in writing at least 10 working days prior to bid. Approval does not relieve supplier of specification requirements.

e. VFDs that are manufactured by a third party and "brand labeled" shall not be acceptable.

f. The variable frequency drive system must be a complete and operating system.

C. Submittals

1. Submittals shall include the following information:

a. Outline dimensions, conduit entry locations and weight.

2. Customer connection and power wiring diagrams.

3. Complete technical product description include a complete list of options provided. Any portions of the specifications not complied with must be clearly indicated or the supplier and contractor shall be liable to provide all components required to meet the specification.

4. Compliance to IEEE 519 – harmonic analysis for particular jobsite including total harmonic voltage distortion and total harmonic current distortion (TDD).

a. The VFD manufacturer shall provide calculations; specific to the installation, showing total harmonic voltage distortion is less than 5%. Input filters shall be sized and provided as required by the VFD manufacturer to ensure compliance with the IEEE electrical system standard 519. All VFDs shall include a minimum of 5% equivalent impedance reactors, no exceptions.

D. Variable Frequency Drives

1. The VFD package as specified herein shall be enclosed in a UL Listed Type enclosure, (NEMA rated enclosures are not acceptable) completely assembled and tested by the manufacturer in an ISO9001 facility. The VFD tolerated voltage window shall allow the VFD to operate from a line of +30% nominal, and -35% nominal voltage as a minimum.

a. Environmental operating conditions: 0 – 400 C continuous. Altitude 0 to 3300 feet above sea level, up to 95% humidity, non-condensing. All circuit boards shall have conformal coating.

b. Enclosure shall be rated UL type 1 and shall be UL listed as a plenum rated VFD.

2. All VFDs shall have the following features:

a. All VFDs shall have the same customer interface, including digital display, and keypad, regardless of horsepower rating. The keypad shall be removable, capable of remote mounting and allow for uploading and downloading of parameter settings as an aid for start-up of multiple VFDs.

b. The keypad shall include Hand-Off-Auto selections and manual speed control. There shall be fault reset and "Help" buttons on the keypad. The Help button shall include "on-line" assistance for programming and troubleshooting.

c. There shall be a built-in time clock in the VFD keypad. The clock shall have a battery back up with 10 years minimum life span. The clock shall be used to date and time stamp faults and record operating parameters at the time of fault. If the battery fails, the VFD shall automatically revert to hours of operation since initial power up. The clock shall also be programmable to control start/stop functions, constant speeds, PID parameter sets and output relays. The VFD shall have a digital input that allows an override to the time clock (when in the off mode) for a programmable time frame. There shall be four (4) separate, independent timer functions that have both weekday and weekend settings. Capacitor backup is not acceptable.

d. The VFD shall be capable of starting into a coasting load (forward or reverse) up to full speed and accelerate or decelerate to setpoint without safety tripping or component damage (flying start).

e. The overload rating of the drive shall be 110% of its normal duty current rating for 1 minute every 10 minutes, 130% overload for 2 seconds. The minimum FLA rating shall meet or exceed the values in the NEC/UL table 430-150 for 4-pole motors.

f. The VFD shall have 5% equivalent impedance internal reactors to reduce the harmonics to the power line and to add protection from AC line transients. The 5% equivalent impedance may be from dual (positive and negative DC bus) reactors, or 5% AC line reactors. VFDs with only one DC reactor shall add an AC line reactor.

g. The VFD shall include a coordinated AC transient protection system consisting of 4-120 joule rated MOV's (phase to phase and phase to ground), a capacitor clamp, and 5% equivalent impedance internal reactors.

h. The VFD shall provide a programmable proof of flow Form-C relay output (broken belt / broken coupling). The drive shall be programmable to signal this condition via a keypad warning, relay output and/or over the serial communications bus. Relay outputs shall include programmable

time delays that will allow for drive acceleration from zero speed without signaling a false underload condition.

3. All VFDs to have the following adjustments:

   a. Two(2) programmable critical frequency lockout ranges to prevent the VFD from operating the load continuously at an unstable speed.

   b. Two (2) PID Setpoint controllers shall be standard in the drive, allowing pressure or flow signals to be connected to the VFD, using the microprocessor in the VFD for the closed loop control. The VFD shall have 250 ma of 24 VDC auxiliary power and be capable of loop powering a transmitter supplied by others. There shall be two parameter sets for the first PID that allow the sets to be switched via a digital input, serial communications or from the keypad for night setback, summer/winter setpoints, etc. There shall be an independent, second PID loop that can utilize the second analog input and modulate one of the analog outputs to maintain setpoint of an independent process (ie. valves, dampers, etc.). All setpoints, process variables, etc. to be accessible from the serial communication network.

   c. Two (2) programmable analog inputs shall accept current or voltage signals.

   d. Two (2) programmable analog outputs (0-20ma or 4-20 ma). The outputs may be programmed to output proportional to Frequency, Motor Speed, Output Voltage, Output Current, Motor Torque, Motor Power (kW), DC Bus voltage, Active Reference, and other data.

   e. Six (6) programmable digital inputs.

   f. Three (3) programmable digital Form-C relay outputs. The relays shall include programmable on and off delay times and adjustable hysteresis. The relays shall be rated for maximum switching current 8 amps at 24 VDC and 0.4 A at 250 VAC; Maximum voltage 300 VDC and 250 VAC; continuous current rating 2 amps RMS. Outputs shall be true Form-C type contacts; open collector outputs are not acceptable.

   g. Run permissive circuit - There shall be a run permissive circuit for damper or valve control. Regardless of the source of a run command (keypad, time-clock control, or serial communications) the VFD shall provide a dry contact closure that will signal the damper to open (VFD motor does not operate). When the damper is fully open, a normally open dry contact (end-switch) shall close. The closed end-switch is wired to a VFD digital input and allows motor operation. Two separate safety interlock inputs shall be provided. When either safety is opened, the motor shall be commanded to coast to stop, and the damper shall be commanded to close.

   h. Two independently adjustable accel and decel ramps with 1 – 1800 seconds adjustable time ramps.

   i. The VFD shall include a motor flux optimization circuit that will automatically reduce applied motor voltage to the motor to optimize energy consumption and audible motor noise.

j. The VFD shall include a carrier frequency control circuit that reduces the carrier frequency based on actual VFD temperature that allows higher carrier frequency without derating the VFD or operating at high carrier frequency only at low speeds.

k. The VFD shall include password protection against parameter changes.

4. The Keypad shall include a backlit LCD display. The display shall be in complete English words for programming and fault diagnostics (LED and alpha-numeric codes are not acceptable). All VFD faults shall be displayed in English words.

5. All applicable operating values shall be capable of being displayed in engineering (user) units. A minimum of three operating values from the list below shall be capable of being displayed at all times. The display shall be in complete English words (alpha-numeric codes are not acceptable):

   Output Frequency

   Motor Speed (RPM, %, or Engineering units)

   Motor Current

   Drive Temperature

   DC Bus Voltage

   Output Voltage

6. The VFD shall include a fireman's override input. Upon receipt of a contact closure from the fireman's control station, the VFD shall operate in one of two modes: 1) Operate at a programmed predetermined fixed speed or operate in a specific fireman's override PID algorithm that automatically adjusts motor speed based on override set point and feedback . The mode shall override all other inputs (analog/digital, serial communication, and all keypad commands), except customer defined safety run interlock, and force the motor to run in one of the two modes above. "Override Mode" shall be displayed on the keypad. Upon removal of the override signal, the VFD shall resume normal operation.

7. EMI / RFI filters. All VFDs shall include EMI/RFI filters. The VFD shall comply with standard EN 61800-3 for the First Environment, restricted level with up to 100' of motor cables. No Exceptions. Certified test lab test reports shall be provided with the submittals.

8. All VFDs through 60HP shall be protected from input and output power miswiring. The VFD shall sense this condition and display an alarm on the keypad. The VFD shall not be damaged by this condition.

9. OPTIONAL FEATURES – Optional features to be furnished and mounted by the drive manufacturer. All optional features shall be UL Listed by the drive manufacturer as a complete assembly and carry a UL508 label. The bypass enclosure door and VFD enclosure must be interlocked such that input power is turned off before either enclosure can be opened. The VFD and Bypass as a package shall have a UL listed short circuit rating of 100,000 amps and shall be indicated on the data label.

   a. A complete factory wired and tested bypass system consisting of an output contactor and bypass contactor, service (isolation) switch and VFD

input fuses are required. Bypass designs, which have no VFD only fuses, or that incorporate fuses common to both the VFD and the bypass will not be accepted

b. Door interlocked padlockable circuit breaker that will disconnect all input power from the drive and all internally mounted options.

10. The following operators shall be provided:

a. Bypass Hand-Off-Auto

i. Drive mode selector and light

ii. Bypass mode selector and light

iii. Bypass fault reset

iv. Bypass LDC display, 2 lines, for programming and status / fault / warning indications

v. Differential pressure transmitters

vi. Flow sensor transmitter

b. Motor protection from single phase power conditions - The Bypass system must be able to detect a single phase input power condition while running in bypass, disengage the motor in a controlled fashion, and give a single phase input power indication. Bypass systems not incorporating single phase protection in Bypass mode are not acceptable.

c. The system (VFD and Bypass) tolerated voltage window shall allow the system to operate from a line of +30%, -35% nominal voltage as a minimum. The system shall incorporate circuitry that will allow the drive or bypass contactor to remain "sealed in" over this voltage tolerance at a minimum.

d. The Bypass system shall NOT depend on the VFD for bypass operation. The bypass shall be completely functional in both Hand and Automatic modes even if the VFD has been removed from the enclosure for repair / replacement.

e. Serial communications – the bypass and VFD shall be capable of being monitored and or controlled via serial communications. Provide communications protocols for LON in the bypass controller.

f. LON communication bypass capabilities shall include, but not be limited to; bypass run-stop control; the ability to force the unit to bypass; and the ability to lock and unlock the keypad. The bypass shall have the capability of allowing the DDC to monitor feedback such as, bypass current (in amps), bypass kilowatt hours (resettable), bypass operating hours (resettable), and bypass logic board temperature. The DDC shall also be capable of monitoring the bypass relays output status, and all digital input status. All bypass diagnostic warning and fault information shall be transmitted over the serial communications bus. Remote bypass fault reset shall be possible. The following additional bypass status indications and settings shall be transmitted over the serial communications bus – keypad "Hand" or "Auto" selected, and bypass selected. The DDC system shall also be able to monitor if the motor is running under load in both VFD

and bypass (proof of flow) in the VFD mode over serial communications or Form-C relay output. A minimum of 40 field parameters shall be capable of being monitored in the bypass mode.

g. Run permissive circuit - there shall be a run permissive circuit for damper or valve control. Regardless of the source of a run command (keypad, time-clock control, or serial communications) the VFD and bypass shall provide a dry contact closure that will signal the damper to open (VFD motor does not operate). When the damper is fully open, a normally open dry contact (end-switch) shall close. The closed end-switch is wired to a VFD system input and allows motor operation. Two separate safety interlock inputs shall be provided. When either safety is opened, the motor shall be commanded to coast to stop, and the damper shall be commanded to close.

h. The bypass control shall monitor the status of the VFD and bypass contactors and indicate when there is a welded contactor contact or open contactor coil. This failed contactor operation shall be indicated on the Bypass LCD display as well as over the serial communications protocol.

i. The bypass control shall include a programmable time delay for bypass start and keypad indication that this time delay is in process. This will allow VAV boxes to be driven open before the motor operates at full speed in the bypass mode. The time delay shall be field programmable from 0 – 120 seconds.

j. The bypass control shall be programmable for manual or automatic transfer to bypass. The user shall be able to select via keypad programming which drive faults will generate an automatic transfer to bypass and which faults require a manual transfer to bypass.

k. There shall be an adjustable motor current sensing circuit for the bypass and VFD mode to provide proof of flow indication. The condition shall be indicated on the keypad display, transmitted over the building automation protocol and on a relay output contact closure.

l. The bypass controller shall have six programmable digital inputs, and five programmable Form-C relay outputs.

m. The relay outputs from the bypass shall programmable for any of the following indications.

   i. System started

   ii. System running

   iii. Bypass override enabled

   iv. Drive fault

   v. Bypass fault

   vi. Bypass H-O-A position

   vii. Motor proof of flow (broken belt)

   viii. Overload

   ix. Bypass selected

x. Bypass run

xi. System started (damper opening)

xii. Bypass alarm

xiii. Over temperature

n. The digital inputs for the system shall accept 24VAC or 24VDC. The bypass shall incorporate internally sourced power supply and not require an external control power source. The bypass power board shall supply 250 ma of 24 VDC for use by others to power external devices.

o. Customer Interlock Terminal Strip – provide a separate terminal strip for connection of freeze, fire, smoke contacts, and external start command. All external safety interlocks shall remain fully functional whether the system is in VFD or Bypass mode. The remote start/stop contact shall operate in VFD and bypass modes. The terminal strip shall allow for independent connection of up to four (4) unique safety inputs.

p. The user shall be able to select the text to be displayed on the keypad when the safety opens. Example text display indications include "Firestat", "Freezestat", "Over pressure" and "Low pressure". The user shall also be able to determine which of the four (4) safety contacts is open over the serial communications connection.

q. Class 10, 20, or 30 (selectable) electronic motor overload protection shall be included.

E. Installation

1. Installation shall be the responsibility of the Mechanical Contractor; and wired by the Electrical Contractor as shown on the electrical drawings. The contractor shall install the drive in accordance with the requirements of the VFD manufacturer's installation manual.

2. Installation of the DP transmitters and flow transmitter shall be the responsibility of the Mechanical Contractor. The wiring shall be furnished by the Control Contractor.

F. Start-Up

a. Certified factory start-up shall be provided for each drive by a factory certified service center. A certified start-up form shall be filled out for each drive with a copy provided to the owner, and a copy kept on file at the manufacturer.

G. Product Support

1. Factory trained application engineering and service personnel that are thoroughly familiar with the VFD products offered shall be locally available at both the specifying and installation locations. A toll free 24/365 technical support line shall be available.

2. A computer based training CD or 8-hour professionally generated video (VCR format) shall be provided to the owner at the time of project closeout. The training shall include installation, programming and operation of the VFD, bypass and serial communication.

H. Warranty

1. Warranty shall be 24 months from the date of certified start-up. The warranty shall include all parts, labor, travel time and expenses.

1.58 POINTS LIST

EQUIPMENT	POINT TYPE					ALARMS							
	GRAPHIC	HARDWARE INPUT	HARDWARE OUTPUT	SOFTWARE POINT	DEFAULT VALUE	HIGH ANALOG LIMIT	LOW ANALOG LIMIT	BINARY	LATCH DIAGNOSTIC	SENSOR FAIL	COMMUNICATION FAIL	DIAGNOSTICS	NOTES:
100% OA ERU AHUs													
SUPPLY FAN START/STOP			BO										
SUPPLY FAN STATUS	X	BI						X	X			FAN FAILURE	
SUPPLY FAN SPEED			AO										
EXHAUST FAN START/STOP			BO										
EXHAUST FAN STATUS	X	BI						X	X			FAN FAILURE	
EXHAUST FAN SPEED			AO										
LEAVING COOLING COIL AIR TEMP		AI				X	X			X		SENSOR FAILURE	
DISCHARGE AIR TEMP		AI				X	X			X		SENSOR FAILURE	
HGRH			AO										
HEAT			AO										
LOW LIMIT THERMOSTAT		BI						X	X			LOW LIMIT TEMPERATURE	DEVICE IS HARDWIRE INTERLOCKED TO VFD, MANUAL RESET REQUIRED
FILTER STATUS		BI						X				DIRTY FILTER GUAGE	
OUTSIDE AIR DAMPER			AO										
OUTSIDE AIR FLOW		AI											
ENERGY WHEEL START/STOP	X		BO										
ENERGY WHEEL SPEED			AO										
ENTERING ENERGY WHEEL TEMP - RETURN AIR		AI											
ENTERING ENERGY WHEEL HUMD - RETURN AIR		AI											
LEAVING ENERGY WHEEL TEMP - RETURN AIR		AI											
ENTERING ENERGY WHEEL TEMP - OUTSIDE AIR		AI											
ENTERING ENERGY WHEEL HUMD - OUTSIDE AIR		AI											
RECIRC ENERGY WHEEL BYPASS DAMPER		AO											
WSHP WITH DX COOLING													
ZONE SENSOR — ZONE TEMPERATURE		AI				X	X			X		SENSOR FAILURE	
ZONE SENSOR — ZONE TEMPERATURE SETPOINT		AI								X		SENSOR FAILURE	NOTE 1
ZONE SENSOR — ON/CANCEL													NOTE 1
ZONE SENSOR — FAN SWITCH													
FAN START/STOP	X		BO										
REVERSING VALVE			BO										
DX COOLING STAGE 1	X		BO										
LEAVING WATER TEMPERATURE		AI				X	X			X		SENSOR FAILURE	
DISCHARGE AIR TEMPERATURE		AI				X	X			X		SENSOR FAILURE	NOTE 2
CONDENSATE OVERFLOW		BI						X				CONDENSATE OVERFLOW	
OCCUPIED COOLING SETPOINT				X	74°F								
OCCUPIED HEATING SETPOINT				X	70°F								
OCCUPIED STANDBY COOLING SETPOINT				X	80°F								
OCCUPIED STANDBY HEATING SETPOINT				X	65°F								
UNOCCUPIED COOLING SETPOINT				X	85°F								
UNOCCUPIED HEATING SETPOINT				X	60°F								
OCCUPIED BYPASS TIMER				X	2.0 HRS								
DISCHARGE AIR TEMPERING SETPOINT				X	55°F								
DISCHARGE AIR TEMPERATURE CONTROL POINTS				X									
BAS COMMUNICATION STATE				X							X		
MAINTENANCE REQUIRED				X	600 HRS							MAINTENANCE REQUIRED	

MECHANICAL ROOM													
PUMP (P-1) ENABLE/DISABLE			BO										
PUMP (P-1) PUMP STATUS	X	BI						X	X			PUMP FAILURE	
PUMP (P-1) SPEED			AO										
PUMP (P-2) ENABLE/DISABLE			BO										
PUMP (P-2) PUMP STATUS	X	BI						X	X			PUMP FAILURE	
PUMP (P-2) SPEED			AO										
LOOP PRESSURE		AI				X				X			See plans for location
OUTSIDE AIR TEMP		AI											
OUTSIDE AIR HUMIDITY		AI											
FLUID COOLER FAN ENABLE/DISABLE			BO										Alternate #7
FLUID COOLER FAN STATUS	X	BI											Alternate #7
FLUID COOLER FAN SPEED			AO										Alternate #7
FLUID COOLER HEATER STAGE 1			BO										Alternate #7
FLUID COOLER HEATER STAGE 2			BO										Alternate #7
FLUID COOLER PUMP	X		BO										Alternate #7
VIBRATION SWITCH		BI						X	X			vibration switch	Hardwire to fan shutdown (by EC)
ENTERING FLUID COOLER		AI				X	X			X			
LEAVING FLUID COOLER		AI				X	X			X			

NOTES:

ALL points listed above shall be displayed on a user friendly graphic page.

ALL floor plans are to be color coded by zone and include 3-D renderings of walls, chairs, and HVAC equipment including ductwork

Points listed above that include an 'X' indicating a required graphic shall be represented by a 3-D color graphic with animation to indicate status where applicable

MISCELLANEOUS POINTS

	HARDWARE POINTS				SOFTWARE POINTS					SHOW ON	
POINT NAME	AI	AO	BI	BO	AV	BV	SCHED	TREND	ALARM	GRAPHIC	NOTES
CAFETERIA MOTORIZED DAMPER											
SPACE CARBON DIOXIDE (ppm)	X							X	X	X	
SPACE CARBON DIOXIDE SETPOINT					X			X		X	
CONTROL DAMPER % OPEN		X						X		X	
KITCHEN EQUIPMENT											
MAU SF STATUS			X					X		X	
MAU SUPPLY AIR TEMP	X							X		X	
HOOD EF STATUS					X			X		X	
DISHWASHER EF STATUS			X					X		X	
DISHWASHER EF COMMAND				X				X		X	
DISHWASHER STATUS			X					X		X	
KITCHEN FREEZER/COOLER											
FREEZER TEMP	X							X	X	X	
COOLER TEMP	X							X	X	X	
DOMESTIC HOT WATER HEATERS											
BLDG (140°F) HOT WATER TEMP	X							X	X	X	TYPICAL OF EACH HEATER
BLDG (120°F) HOT WATER TEMP	X							X	X	X	
DOMESTIC HW CIRC PUMP STATUS			X					X		X	
DOMESTIC HW CIRC PUMP ENABLE				X				X		X	

END OF SECTION 15014

SECTION 15015 – FIRE PROTECTION

1.1 SUMMARY

A. The General Conditions, Special Conditions and the applicable portions of Division 1 of the Specifications are a part of this Section.

B. The Contractor for this work shall be governed by any Alternate Bids requested insofar as they affect this work.

C. The building sprinkler system shall be a wet type system. Heads to be pendent, upright and sidewall as required. Provide drains as required.

1.2 SCOPE OF WORK

A. Furnish all materials, labor, tools, equipment and supervision required for installation of a complete wet pipe sprinkler system for the entire building, including all necessary piping, sprinkler heads, test connections, valves, and drains. Areas to be sprinkled are indicated on Drawings and described hereinafter.

B. Install guards over sprinkler heads where heads are 7' 0" or less above floor and on other heads where subject to mechanical injury.

C. Exterior work to include connecting new fire protection line into existing fire protection line, new backflow preventer, new fire department connection, and new post indicator valve. Comply with all local water company and fire department requirements. The Contractor shall coordinate the exact location and size of the fire vault and location of all valves and equipment with the local water company, Fire Marshall, and Ky Building Code. See detail on drawing. All hydrant piping shall be flushed per the requirements of the local fire department. Coordinate flushing of lines with local fire department and local water company.

D. Provide all piping including all valves, sprinkler heads, alarm valves, test valves, control valves, tap on and etc.

E. Any apparatus, machinery, material, spares, small items or incidentals not mentioned herein, which may be found necessary to complete or perfect any portion of the installation in a substantial manner, and in compliance with the requirements stated, implied or intended in these Specifications, shall be furnished without extra cost to the Owner.

F. The building areas in general are based on light hazard occupancy with storage rooms and mechanical rooms on ordinary hazard; head spacing as required. A system based on hydraulic calculation, as approved by NFPA 13, is acceptable, and as required by the insuring company. Occupancy hazard shall be confirmed by the Insurance Service Office of Kentucky and the Fire Marshal before calculations are performed.

G. The Fire Protection Contractor shall provide all electrical power and control wiring and interlock which is not shown on the Electrical Drawings to provide a complete system and approved fire protection system.

1.3 SPECIAL REQUIREMENTS

A. No Contractor other than those regularly engaged in the installation of approved and franchised automatic sprinkler systems will be considered or approved for the work under this Section of the specifications. Bidders must have had not less than five years experience in the fabrication and erection of such systems, and shall have completed

installations similar and equal in scope to this system under approval by one or more of the recognized underwriting associations in the insurance field.

B. Before submitting bid, examine all mechanical, electrical, architectural and structural drawings, visit the site and become acquainted with all conditions that may, in any way whatsoever, affect the execution of this work. This bidder shall check with the rating bureau and insuring agency to verify adequacy of water supply for the proposed sprinkler system.

C. The Contractor shall take his own measurements and be responsible for exact size and location of all openings required for installation of this work. Figured dimensions where indicated are reasonably accurate and should govern in setting out work. Detailed method of installation is not indicated. Sprinkler Contractor shall coordinate exact ceiling grid location and install sprinkler heads centered in the 2' x 2' and 2' x 4' ceiling panels. Location of sprinkler head must be carefully coordinated with the Architect.

D. It shall be this Contractor's responsibility to verify all existing water line sizes and to conduct flow test at the new fire hydrant and report to the Architect results of flow test.

E. It is not the intent of these Plans and Specifications to provide a complete detailed description of the apparatus, materials, equipment, etc., which is required to make a complete installation of a specified fire protection system. Include all required sprinkler heads, tamper switches, material and equipment and perform all work required to install a complete and approved installation.

F. All road crossings or excavation and backfill required for the completion of this work shall be a part of this Contract.

G. The installing Contractor shall provide the Owner with three (3) copies of the following (submit IAW shop drawing review standards):

1. Instruction charts describing operation and proper maintenance of sprinkler devices.

2. Published pamphlet on care and maintenance of fire protection systems.

3. All materials and methods shall be in accordance with applicable codes, regulations and/or ordinances and meet approval of local inspection authority and insuring agency having jurisdiction. The latest edition of the National Board of Fire Underwriters Bulletins shall be the minimum requirement for all work. All materials under this Contract shall be listed by the Underwriter's Laboratories, Inc., as approved for fire protection installation. The installation shall comply with the NFPA, and the Kentucky Building Code and Local Fire Marshal in every respect.

H. Perform work under this section in close harmony with other sections so completed work shall present a neat and workmanlike installation.

I. Any paving, floors, or other improvements disturbed or destroyed as a result of installation of sprinkler system, shall be restored or replace to Owner's satisfaction.

1.4 SUBMITTALS

A. The Contractor's attention is directed to the General Conditions and all other Contract Documents of these specifications.

B. Each shop drawing and/or manufacturer's descriptive literature shall have the project name indicated thereon and shall be clearly referenced to the Specifications, Section

Number, schedule, material, etc., so the Engineer/Architect may readily determine the particular item the Contractor or Subcontractor proposes to furnish. Each submission shall also contain date submitted. If Shop Drawings and/or other items are transmitted by correspondence, each item of correspondence shall bear the A/E project number.

C. Contractor shall submit shop drawings and data sheets of all major items to be furnished to the Architect/Engineer for approval.

D. Shop drawings and descriptive literature shall be submitted as a minimum, but not limited to the following:

1. Sprinkler Heads
2. O. S. & Y Valve
3. Alarm Control
4. Back Flow Preventer Detector Check
5. Pipe Hanger and Support
6. Post Indicator Valve
7. Fire Department Connection

1.5 PERMITS, CODES AND INSTALLATIONS

A. Obtain and pay for all necessary state, municipal, county, and city permits and taxes which are applicable.

B. Contact the serving Water Company to determine their cost for any tap on fees, vault, values, piping, equipment required to complete the fire protection tie in. These costs shall be included in this Contract.

C. Pay for all fees and costs arising from this installation and for any and all destruction to property, both public and private, which may arise from this service tap on.

D. No work is to be started by the Contractor until Contractor's drawings are approved by the Division of Housing, Building and Construction and the local Fire Marshal's offices, and one copy delivered to the Architect. Entire installation is to be approved by the Insurance Service Office of Kentucky, Division of Housing, Building and Construction, and the local Fire Marshal. Final payment will not be made until these approvals are received.

1.6 EXCAVATING AND BACKFILLING

A. This Contractor shall perform all excavation, including necessary shoring, and all backfilling required for the completion of work under this Contract that is to be installed underground, outside, or within building walls.

1.7 RECORD DRAWINGS

A. After all work has been completed, provide for the Architect's records one (1) complete set of as built "Record Drawings" showing final installation of the work.

1.8 PIPE, FITTINGS AND HANGERS

A. Pipe and Pipe Fittings

1. Exterior Water Mains

a. INSTALLATION: All water mains will be installed in compliance with the American Water Works Association specifications and also the water lines will comply with the specifications of the Insurance Services Office of Kentucky and the local water company.

b. TESTS: All water lines shall pass the test of the AWWA specifications and all leaks discovered by this test will be repaired by the contractors. All visible leaks shall be stopped.

c. COVER: All water lines will have a minimum of thirty six inches of cover.

d. PIPES: All water mains below roads, driveways and all other paved areas shall be ductile iron class 350 pipe, adequate for 150 psi working pressure. Interior of the pipes shall be cement mortar lined with bituminous seal coat. Exterior of the pipe shall receive either coal tar or asphalt base coating. Each piece of pipe shall bear the manufacturer's name or trade mark, the year in which it was produced and the letters, DI or ductile shall appear on the exterior of the pipe. Contractor can use PVC piping (when approved by the local water company) as listed below:

   i. Exterior fire protection water piping 4" and larger not below paved surfaces shall be PVC meeting the minimum requirements of AWWA C900, Class 200 (DR 14), 200 PSI. Joints and fittings shall be slip joint, rubber ring type; 45 degree and 90 degree turns shall be Ductile Iron with bolted flange fittings. Provide thrust blocks at all turns in strict accordance with manufacturer's requirements. Piping shall be CAPCO Class 200, Johns Manville, Blue Brute Class 200 or equivalent. Piping shall be UL and F.M. approved.

   ii. The pipe shall be homogeneous throughout and free from cracks, holes, foreign inclusions or other defects. The pipe shall be as uniform as commercially practical in color.

   iii. Plastic couplings and fittings shall meet the minimum requirements of ASTM D266S. Fittings, couplings, adapters, and welding solvent shall be furnished by the manufacturer furnishing the pipe and shall accommodate the pipe for which they are used. They shall have a minimum pressure rating of 200 psi.

   iv. Insertion depth of the pipe in the coupling shall be controlled by an internal PVC mechanical stop in the coupling which will allow for a thermal expansion and contraction. The dry fit of fittings and coupling sockets shall be snug.

      a) Service tees shall be molded type fittings.

e. GATE VALVES: All gate valves shall be installed with valve boxes and gate valves shall be provided with a two inch square operating nut and shall be opened by turning to the left, counter clockwise. They shall be Mueller or M & H. All valves and connection must comply with local water company requirements. See details on drawings.

f. FIRE HYDRANTS: Hydrants shall be of the type in conformity with the requirements of the local fire department.

i. Pipe used overhead shall be wrought steel and must comply with the specifications of the ASTM as listed in NFPA 13, 3 1.1 Piping.

ii. Dimensions for all overhead pipe must be in accordance with the American Standard for Wrought Steel and Wrought Iron Pipe, ASA No. B 36, 10 70 for pressures up to 300 psi is permitted.

iii. Bell holes shall be excavated accurately to size and barrel of pipe shall bear firmly on bottom of trench throughout its length. All foreign matter and dirt shall be removed from the inside of the pipe before it is lowered into its position in the trench, and it shall be kept clean by approved means during and after laying. At times when pipe laying is not in progress, the open ends of pipe shall be closed by approved means, and no trench water shall be permitted to enter the pipe. Cutting of pipe, where necessary, shall be done in a neat and workmanlike manner, without damage to pipe. After being laid and joined, the pipe shall have a firm bedding for its entire length except that the joints must be left exposed for inspection during the pressure tests.

B. Hangers

1. Furnish and install all hangers of approved pattern and size per NFPA to support all pipes in a substantial manner.

2. Hangers for overhead piping shall comply with NBFU requirements as to size and spacing. Special and improvised supports and hangers shall meet with the approval of the Underwriters' Laboratories and the Architect.

1.9 IDENTIFICATION

A. This Contractor shall furnish and install metal signs identifying valves, drains, etc., as required. Signs shall be secured with approved ball chain.

1.10 DRAINS

A. Where drains, flushing connections, etc., are necessary to comply with local code or NBFU requirements, they shall be considered a part of this Contract and furnished and installed accordingly, whether shown specifically on the Drawings or covered in these Specifications.

B. All sprinkler branch piping shall be installed to drain at main riser wherever possible.

C. Where sprinkler piping is trapped, an approved auxiliary drawoff shall be provided and installed. Provide all test drains as required. All exposed piping on the exterior of the building shall be rust proofed and painted, color as selected by Architect. Provide splash blocks at all exterior drains.

1.11 VALVES

A. Control Valves

1. All valves 2 inches and smaller shall be bronze, solid bronze solid wedge disc, screwed pattern, rising stem, designed for 150 psi working pressure and approved by Underwriters' Laboratories and Factory Mutual.

2. All valves 2 1/2 inches and larger shall be iron body, bronze mounted, double disc, parallel seats, outside screw and yoke, and screwed of flanged pattern designed for 175 psi working pressure and approved by Underwriters' Laboratories.

B. Check Valves

1. Check valves shall be iron body, bronze mounted, flanged and Underwriters' and Factory Mutual approved for 175 lbs. working pressure. Detector check valves, with bypass meter, must meet the requirement of local water company and Fire Marshal.

C. Alarm Valves and Flow Indicators

1. Alarm valve shall be of variable pressure type, designed to prevent false alarms due to water hammer or other pressure surges, and shall be of Underwriters' approved type.

2. Provide all valves, gauges and other accessories needed to make a complete installation.

3. Wiring and connection shall be done under Division 16.

1.12 SPRINKLER HEADS AND CABINET

A. All sprinklers shall be Underwriters' Laboratories approved automatic spray sprinklers of correct temperature and type.

B. The Contractor shall furnish and install in an approved metal cabinet with four (4) replacement heads of each type as required by the National Board of Fire Underwriters.

C. Sprinklers shall be Reliable, Viking, Star, Grinnell, or equivalent. Side wall sprinkler heads and pendent sprinkler heads for finished ceilings (unless otherwise noted) shall be semi recessed type, with chrome plated finish with escutcheon. (Color as selected by Architect). Upright sprinkler heads in unfinished areas shall be plain brass or bronze finish. Orifice size to be selected by Contractor according to available water pressure and head spacing.

D. Heads shall not be painted; cover and protect during any painting operations in area.

1.13 PAINTING AND SIGNS

A. Painting

1. All painting of sprinkler piping and equipment, except sprinkler heads, shall be performed under Division 9, Finishes; unless otherwise noted. Painting colors shall be according to the color coding chart hereinafter specified. All stenciled markers and arrows shall be provided under this Division of the Specifications after piping has been painted.

2. The following shall be painted: all equipment and metal surfaces which are not factory finished in high grade machinery enamel on all damaged or rusted surfaces; all exposed piping in all areas.

3. All piping shall be painted and stenciled according to the following chart:

PIPE	PIPE COLOR CODE	ABBREVIATION
Fire Protection Piping	Bright Red	F.

4. Markers and arrows shall be painted on the piping using machine cut stencils. All letters shall be sprayed using fast drying black lacquer paint. On pipe sizes 3" and over, letters and arrows shall be 2" in height. On pipe sizes smaller than 3" letters shall be 1" in height. All markers and arrows shall be properly oriented so that descriptive name may be easily read from the floor.

5. Piping, whether exposed or concealed, shall be marked not less than every 20 linear feet or in every room; whichever is greater, and at the point where the piping passes through walls or floors.

1.14 WALL AND CEILING PLATES

A. This Contractor shall furnish and install on all lines passing through the floor, ceiling or wall in finished areas, as approved type chrome plate similar to Beaton and Caldwell, No. 10. Plates must be submitted for approval before installation.

1.15 INSPECTOR'S TESTS

A. Install a 1" inspection test connection. Discharge from test connections shall run to open air. All locations must comply with Fire Marshal requirements.

B. Inspection test connection to control valve shall be located not over 7' above floor.

C. Inspection test connection shall have an attached metal tag bearing the words "Test Connection".

1.16 TESTING FLUSHING AND CLEANING

A. Furnish all labor, equipment, and conduct all required tests in the presence of the Owner and Architect/Engineer or designated representative.

B. All piping and devices comprising the fire protection system shall be tested under hydrostatic pressure of not less than 200 psi and maintained for not less than 2 hours in accordance with the NFPA Pamphlet #13, and leakage shall not exceed quantities indicated.

C. Any leaks or cracks developing as a result of these tests shall be repaired to the satisfaction of the Owner.

D. The Owner and Architect/Engineer or designated representative shall be notified three days in advance of any tests.

E. Upon satisfactory completion of the the test, a written approval, signed by the Architect/Engineer shall be given to the Contractor. This written approval, however, does not relieve the Contractor of responsibility for any failure during the period of the guarantee.

F. All underground piping shall be thoroughly flushed in accordance with the requirements of NFPA Standards Pamphlet #13, and flush test must be witnessed by proper authority.

G. Upon completion of this work, all debris, materials, and equipment shall be removed from the building and premises; all piping shall be cleaned ready for painting when installed.

1.17 CUTTING, PATCHING AND WELDING

A. Be responsible for cutting, patching and welding all openings required in walls, floors, ceilings or roof for all materials and equipment furnished under this Section of the Specifications.

B. Sleeves or openings shall be left in all new construction for passage of pipes and/or ducts. Where openings or sleeves have been omitted, they shall be drilled or sawed as required by the Architect. All cutting and patching shall be done by the trades whose work is affected. All expenses incurred shall be a responsibility of this Section of the Specifications.

C. Welding is at option to the Contractor; unless otherwise specified.

1.18 CHANGES

A. The Contractor shall make no changes in installation from layout as shown on approved working drawings which may be requested by any Inspection Bureau or Insurance Association unless such change is specifically approved by the Architect. Any changes made other than as above stated are at the Contractor's own expense and responsibility.

1.19 LEAK DAMAGE AND GUARANTEE

A. This Contractor shall be responsible during the installation and testing periods of the sprinkler systems for any damage to the buildings, their contents, etc., due to leaks, or by overflow; and shall pay for necessary replacements or repairs to the building, equipment, or stored materials damaged by such leakage.

B. At the completion of the work under this Sprinkler Contract the Contractor shall furnish, in writing, to the Architect a guarantee stating that all equipment, materials, and work performed are in full accordance with the Plans and Specifications and all authorities having jurisdiction.

C. The Contractor shall also furnish to the Architect a written guarantee (in triplicate) that all equipment, materials, and work performed under this Contract, and any subsequent Change Orders thereto, are fully guaranteed for one (1) year from date of substantial completion and that any equipment, material, or workmanship which may prove defective within that time will be replaced at no cost to the Owner.

1.20 OPERATION AND MAINTENANCE INSTRUCTIONS

A. At the completion of the work specified above, the Sprinkler Contractor shall provide a small scale plan of the building indicating the locations of all control valves, low point drains, and Inspector's test. The plans shall be neatly adjacent to the sprinkler riser or header, or as directed by the Engineer.

B. The Contractor shall furnish three (3) sets of printed operating and maintenance instructions to the Owner, and adequately instruct the Owner's maintenance personnel in the proper operation of all sprinkler devices installed. See Section 15001 for a complete description of manual requirements.

END OF SECTION 15015