

DIVISION 23: HEATING, VENTILATING, AND AIR-CONDITIONING

23 0000 HEATING, VENTILATING, AND AIR-CONDITIONING

- 23 0501 COMMON HVAC REQUIREMENTS
- 23 0502 DEMOLITION AND REPAIR
- 23 0514 VARIABLE FREQUENCY DRIVE SYSTEM
- 23 0553 IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT
- 23 0593 TESTING, ADJUSTING, AND BALANCING
- 23 0712 MECHANICAL INSULATION AND FIRE STOPPING
- 23 0714 PREMOLDED ONE PIECE PVC FITTINGS INSULATION
- 23 0716 DUCTWORK INSULATION
- 23 0717 ROUND SUPPLY DUCT INSULATION
- 23 0718 DUCT LINING
- 23 0800 FIRE STOPPING
- 23 0953 TEMERPATURE CONTROLS (DDC)

23 2000 HVAC PIPING AND PUMPS

- 23 2113 HYDRONIC PIPING
- 23 2115 HOT WATER HEATING SYSTEM
- 23 2116 HOT WATER HEATING SYSTEM SPECIALTIES
- 23 2118 BACKFLOW PREVENTER VALVE
- 23 2123 CIRCULATING PUMPS AND ACCESSORIES
- 23 2166 SPLIT SYSTEM HEAT PUMPS
- 23 2200 WATER SOURCE HEAT PUMP SYSTEM
- 23 2500 CHEMICAL WATER TREATMENT
- 23 2510 GLYCOL SYSTEM

23 3000 HVAC AIR DISTRIBUTION

- 23 3114 LOW-PRESSURE STEEL DUCTWORK
- 23 3123 UNDERGROUND DUCTWORK
- 23 3346 FLEX DUCT
- 23 3400 EXHAUST FANS
- 23 3713 AIR OUTLETS & INLETS
- 23 4100 DISPOSABLE FILTERS

23 5000 CENTRAL HEATING EQUIPMENT

- 23 5315 HEATING BOILERS
- 23 5415 DUCT HEATER (SEPARATED COMBUSTION)
- 23 5719 PLATE AND FRAME HEAT EXCHANGERS

23 6000 CENTRAL COOLING EQUIPMENT

- 23 6210 AIR COOLED WATER CHILLERS
- 23 6514 COOLING TOWER

END TABLE OF CONTENTS

## SECTION 230501 – COMMON HVAC REQUIREMENTS

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

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

#### 1.2 SUMMARY

- A. Furnish labor, materials, and equipment necessary for completion of work as described in Contract Documents.
- B. It is the intent of these specifications that the systems specified herein are to be complete and operational before being turned over to the owner. During the bidding process, the contractor is to ask questions or call to the engineer's attention any items that are not shown or may be required to make the system complete and operational. Once the project is bid and the contractor has accepted the contract, it is his responsibility to furnish and install all equipment and parts necessary to provide a complete and operational system without additional cost to the owner.
- C. Furnish and install fire stopping materials to seal penetrations through fire rated structures and draft stops.
- D. Includes But Not Limited To:
  - 1. General procedures and requirements for HVAC.
- E. Related Sections:
  - 1. Section 23 0593: Testing, Adjusting, and Balancing for HVAC.

#### 1.3 SUBMITTALS

- A. Substitutions: By specific designation and description, standards are established for specialties and equipment. Other makes of specialties and equipment of equal quality will be considered provided such proposed substitutions are submitted to the Architect for his approval, complete with specification data showing how it meets the specifications, at least 5 working days prior to bid opening. A list of approved substitutions will be published as an addendum.
  - 1. Submit a single copy of Manufacturer's catalog data including Manufacturer's complete specification for each proposed substitution.
  - 2. The Architect or Engineer is to be the sole judge as to the quality of any material offered as an equal.
- B. Product Data, Shop Drawings: Within 30 days after award of contract, submit 10 sets of Manufacturer's catalog data for each manufactured item.
  - 1. Literature shall include enough information to show complete compliance with Contract Document requirements.
  - 2. Mark literature to indicate specific item with applicable data underlined.
  - 3. Information shall include but not be limited to capacities, ratings, type of material used, guarantee, and such dimensions as are necessary to check space requirements.
  - 4. When accepted, submittal shall be an addition to Contract Documents and shall be in equal force. No variation shall be permitted.

5. Even though the submittals have been accepted by the Engineer, it does not relieve the contractor from meeting all of the requirements of the plans and specifications and providing a complete and operational system.
- C. Drawings of Record: One complete sets of blue line mechanical drawings shall be provided for the purpose of showing a complete picture of the work as actually installed.
1. These drawings shall serve as work progress report sheets. Contractor shall make notations neat and legible therein daily as the work proceeds.
  2. The drawings shall be kept at the job at a location designated by the Mechanical Engineer.
  3. At completion of the project these "as-built" drawings shall be signed by the Contractor, dated, and returned to the Architect.
- D. Operating Instructions and Service Manual: The Mechanical Contractor shall prepare 2 copies of an Operation and Maintenance Manual for all mechanical systems and equipment used in this project. Manuals shall be bound in hard-backed binders and the front cover and spine of each binder shall indicate the name and location of the project. Use plastic tab indexes for all sections. Provide a section for each different type of equipment item. The following items shall be included in the manual, together with any other pertinent data. This list is not complete and is to be used as a guide.
1. Provide a master index at the beginning of the manual showing all items included.
  2. The first section of the manual shall contain:
    - a. Names, addresses, and telephone numbers of Architect, Mechanical Engineer, Electrical Engineer, General Contractor, Plumbing Contractor, Sheet Metal Contractor, and Temperature Control Contractor.
    - b. List of Suppliers which shall include a complete list of each piece of equipment used with the name, address, and telephone number of vendor.
    - c. General Description of Systems including –
      - 1) Location of all major equipment
      - 2) Description of the various mechanical systems
      - 3) Description of operation and control of the mechanical systems
      - 4) Suggested maintenance schedule
    - d. Copy of contractor's written warranty
  3. Provide a copy of approved submittal literature for each piece of equipment.
  4. Provide maintenance and operation literature published by the manufacturer for each piece of equipment which includes: oiling, lubrication and greasing data; belt sizes, types and lengths; wiring diagrams; step-by-step procedure to follow in putting each piece of mechanical equipment in operation.
  5. Include parts numbers of all replaceable items.
  6. Provide control diagram and operation sequence, along with labeling of control piping and instruments to match diagram.
  7. Include a valve chart indicating valve locations.
- E. Include air balance and/or water balance reports.

#### 1.4 SUBMITTALS FOR COMMON HVAC REQUIREMENTS

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

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

#### 1.5 QUALITY ASSURANCE

- A. Requirements of Regulatory Agencies:
1. Perform work in accordance with applicable provisions of local and state Plumbing Code, Gas Ordinances, and adoptions thereof. Provide materials and labor necessary to comply with rules, regulations, and ordinances.
  2. In case of differences between building codes, state laws, local ordinances, utility company regulations, and Contract Documents, the most stringent shall govern. Promptly notify Architect in writing of such differences.
- B. Applicable Specifications: Referenced specifications, standards, and publications shall be of the issues in effect on date of Advertisement for Bid.
1. "Heating, Ventilating and Air Conditioning Guide" published by the American Society of Heating and Air Conditioning Engineers.
  2. "Engineering Standards" published by the Heating, Piping, and Air Conditioning Contractors National Association.
  3. "2015 International Building Code", "2015 International Mechanical Code", "2015 International Plumbing Code" and "2015 International Fire Code" as published by the International Conference of Building Officials.
  4. "National Electrical Code" as published by the National Fire Protection Association.
  5. "2015 International Energy Conservation Code".
- C. Identification: Motor and equipment name plates as well as applicable UL and AGA labels shall be in place when Project is turned over to Owner.

#### 1.6 INSPECTIONS AND PERMITS

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

#### 1.7 ADDITIONAL WORK:

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

#### PART 2 - PRODUCTS FOR COMMON HVAC REQUIREMENTS

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

### PART 3 - EXECUTION

#### 3.1 EXAMINATION

- A. Site Inspection:
  - 1. Examine premises and understand the conditions which may affect performance of work of this Division before submitting proposals for this work.
  - 2. No subsequent allowance for time or money will be considered for any consequence related to failure to examine site conditions.
  
- B. Drawings:
  - 1. Mechanical drawings show general arrangement of piping, ductwork, equipment, etc, and do not attempt to show complete details of building construction which affect installation. This Contractor shall refer to architectural, structural, and electrical drawings for additional building detail which affect installation of his work.
    - a. Follow mechanical drawings as closely as actual building construction and work of other trades will permit.
    - b. No extra payments will be allowed where piping and/or ductwork must be offset to avoid other work or where minor changes are necessary to facilitate installation.
    - c. Everything shown on the mechanical drawings shall be the responsibility of Mechanical Contractor unless specifically noted otherwise.
  - 2. Consider architectural and structural drawings part of this work insofar as these drawings furnish information relating to design and construction of building. These drawings take precedence over mechanical drawings.
  - 3. Because of small scale of mechanical drawings, it is not possible to indicate all offsets, fittings, and accessories which may be required. Investigate structural and finish conditions affecting this work and arrange work accordingly, providing such fittings, valves, and accessories required to meet conditions. Do not scale drawings for locations of equipment or piping. Refer to large scale dimensioned drawings for exact locations.
  
- C. Insure that items to be furnished fit space available. Make necessary field measurements to ascertain space requirements including those for connections and furnish and install equipment of size and shape so final installation shall suit true intent and meaning of Contract Documents.
  - 1. If approval is received to use other than specified items, responsibility for specified capacities and insuring that items to be furnished will fit space available lies with this Division.
  - 2. If non-specified equipment is used and it will not fit job site conditions, this Contractor assumes responsibility for replacement with items named in Contract Documents.

#### 3.2 PREPARATION

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

#### 3.3 INSTALLATION

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

### 3.4 STORAGE AND PROTECTION OF MATERIALS:

- A. Provide storage space for storage of materials and assume complete responsibility for losses due to any cause whatsoever. Storage shall not interfere with traffic conditions in any public thoroughfare.
- B. Protect completed work, work underway, and materials against loss or damage.
- C. Close pipe openings with caps or plugs during installation. Cover fixtures and equipment and protect against dirt, or injury caused by water, chemical, or mechanical accident.

### 3.5 EXCAVATION AND BACKFILL

- A. Perform necessary excavation of whatever substance encountered for proper laying of all pipes and underground ducts.
  - 1. Excavated materials not required for fill shall be removed from site as directed by Engineer.
  - 2. Excavation shall be carried low enough to allow a minimum coverage over underground piping of 5'-0" or to be below local frost level.
  - 3. Excess excavation below required level shall be backfilled at Contractor's expense with earth, sand, or gravel as directed by Engineer. Tamp ground thoroughly.
  - 4. Ground adjacent to all excavations shall be graded to prevent water running into excavated areas.
- B. Backfill pipe trenches and allow for settlement.
  - 1. Backfill shall be mechanically compacted to same density as surrounding undisturbed earth.
  - 2. Cinders shall not be used in backfilling where steel or iron pipe is used.
  - 3. No backfilling shall be done until installation has been approved by the Engineer.

### 3.6 COOPERATION

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

### 3.7 SUPERVISION

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

### 3.8 INSTALLATION CHECK:

- A. An experienced, competent, and authorized representative of the manufacturer or supplier of each item of equipment indicated in the equipment schedule shall visit the project to inspect, check, adjust if necessary, and approve the equipment installation. In each case, the equipment supplier's representative shall be present when the equipment is placed in operation. The equipment supplier's representative shall revisit the project as often as necessary until all trouble is corrected and the equipment installation and operation is satisfactory to the Engineer.
- B. Each equipment supplier's representative shall furnish to the Owner, through the Engineer, a written report certifying the following:
  - 1. Equipment has been properly installed and lubricated.

2. Equipment is in accurate alignment.
3. Equipment is free from any undue stress imposed by connecting piping or anchor bolts.
4. Equipment has been operated under full load conditions.
5. Equipment operated satisfactorily.

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

### 3.9 CLEANING EQUIPMENT AND PREMISES

- A. Properly lubricate equipment before Owner's acceptance.
- B. Clean exposed piping, ductwork, equipment, and fixtures. Repair damaged finishes and leave everything in working order.
- C. Remove stickers from fixtures and adjust flush valves.
- D. At date of Substantial Completion, air filters shall be new, clean, and approved by Owner's representative.
- E. Trap elements shall be removed during cleaning and flushing period. Replace trap elements and adjust after cleaning and flushing period.

### 3.10 TESTS

- A. No piping work, fixtures, or equipment shall be concealed or covered until they have been inspected and approved by the inspector. Notify inspector when the work is ready for inspection.
- B. All work shall be completely installed, tested as required by Contract Documents and the city and county ordinances and shall be leak-tight before the inspection is requested.
- C. Tests shall be repeated to the satisfaction of those making the inspections.
- D. Water piping shall be flushed out, tested at 100 psi and left under pressure of supply main or a minimum of 40 psi for the balance of the construction period.

### 3.11 WARRANTY

- A. Contractor shall guarantee work under Division 23 to be free from inherent defects for a period of one year from acceptance.
  1. Contractor shall repair, revise or replace any and all such leaks, failure or inoperativeness due to defective work, materials, or parts free of charge for a period of one year from final acceptance, provided such defect is not due to carelessness in operation or maintenance.
  2. In addition, the Contractor shall furnish all refrigeration emergency repairs, emergency service and all refrigerant required due to defective workmanship, materials, or parts for a period of one year from final acceptance at no cost to the Owner, provided such repairs, service and refrigerant are not caused by lack of proper operation and maintenance.
- B. In addition to warranty specified in General Conditions, heating, cooling, and plumbing systems are to be free from noise in operation that may develop from failure to construct system in accordance with Contract Documents.

### 3.12 SYSTEM START-UP, OWNER'S INSTRUCTIONS

- A. Off-Season Start-up
  - 1. If Substantial Completion inspection occurs during heating season, schedule spring start-up of cooling systems. If inspection occurs during cooling season, schedule autumn start-up for heating systems.
  - 2. Notify Owner 7 days minimum before scheduled start-up.
  - 3. Time will be allowed to completely service, test, check, and off-season start systems. During allowed time, train Owner's representatives in operation and maintenance of system.
  - 4. At end of off-season start-up, furnish Owner with letter confirming that above work has been satisfactorily completed.
  
- B. Owner's Instructions
  - 1. Instruct building maintenance personnel and Owner Representative in operation and maintenance of mechanical systems utilizing Operation & Maintenance Manual when so doing.
  - 2. Minimum instruction periods shall be as follows –
    - a. Mechanical - Four hours.
    - b. Temperature Control - Four hours.
    - c. Refrigeration - Two hours.
  - 3. Instruction periods shall occur after Substantial Completion inspection when systems are properly working and before final payment is made.
  - 4. None of these instructional periods shall overlap another.

### 3.13 PROTECTION

- A. Do not run heat pump, air handling units, fan coil units, or other pieces of equipment used for moving supply air without proper air filters installed properly in system.
  
- B. The mechanical systems are not designed to be used for temporary construction heat. If any equipment is to be started prior to testing and substantial completion, such equipment will be returned to new condition with full one year warranties, from date of substantial completion after any construction use. This includes, but is not necessarily limited to: Equipment, filters, ductwork, fixtures, etc.

### 3.14 COMMON HVAC REQUIREMENTS:

- A. INSTALLATION
  - 1. During installation, protect open ends of ducts by covering with plastic sheet tied in place to prevent entrance of debris and dirt.
  - 2. Make necessary allowances and provisions in installation of sheet metal ducts for structural conditions of building. Revisions in layout and configuration may be allowed, with prior written approval of Architect. Maintain required airflows in suggesting revisions.
  - 3. Hangers And Supports:
    - a. Install pair of hangers close to each transverse joint and elsewhere as required by spacing indicated in table on Drawings.
    - b. Install upper ends of hanger securely to floor or roof construction above by method shown on Drawings.
    - c. Attach strap hangers to ducts with cadmium-plated screws. Use of pop rivets or other means will not be accepted.
    - d. Where hangers are secured to forms before concrete slabs are poured, cut off flush all nails, strap ends, and other projections after forms are removed.
    - e. Secure vertical ducts passing through floors by extending bracing angles to rest firmly on floors without loose blocking or shimming. Support vertical ducts, which do not pass through floors, by using bands bolted to walls, columns, etc. Size, spacing,



and method of attachment to vertical ducts shall be same as specified for hanger bands on horizontal ducts.

B. CLEANING

1. Clean interior of duct systems before final completion.

END OF SECTION 230501

## SECTION 230502 - DEMOLITION AND REPAIR

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

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

#### 1.2 SUMMARY

- A. Under this section remove obsolete piping and mechanical equipment and relocate, reconnect or replace existing piping affected by demolition or new construction. Remove concealed piping abandoned due to demolition or new construction, or cap piping flush with existing surfaces.

#### 1.3 DRAWINGS AND EXISTING CONDITIONS

- A. All relocations, reconnections and removals are not necessarily indicated on the drawings. As such, the Contractor shall make adequate allowance in his proposal for this work as no extra charges will be allowed for these items.

### PART 2 - NOT USED

### PART 3 - EXECUTION

#### 3.1 TEMPORARY CONNECTIONS

- A. Where existing piping must remain in service to supply occupied areas during construction, provide temporary piping, connections, and equipment to maintain service to such areas. All shall be performed in a neat and safe manner to prevent injury to the building or its occupants.

#### 3.2 EXISTING TO BE ABANDONED

- A. All required drilling, cutting, block-outs and demolition work required for the removal and/or installation of the mechanical system is the responsibility of this Contractor.
- B. No joists, beams, girders, trusses or columns shall be cut by any Contractor without written permission from the Architect.
- C. The patching, repair, and finishing to existing or new surfaces is the responsibility of this Contractor, unless specifically called for under sections of specifications covering these materials.
- D. Disconnect all equipment that is to be removed or relocated. Relocate any existing equipment that obstructs new construction.

#### 3.3 EXISTING TO REMAIN IN USE

- A. Where affected by demolition or new construction, relocate, replace, extend, or repair piping and equipment to allow continued use of same. Use methods and materials as specified for new construction.

3.4 MATERIALS AND EQUIPMENT REMOVED

- A. All obsolete materials, piping, and equipment shall become the property of the Contractor and be removed from the site promptly.

END OF SECTION 230502

## SECTION 230514 – VARIABLE FREQUENCY DRIVE SYSTEM

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

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

#### 1.2 SUMMARY

- A. Furnish and install variable frequency drive system (VFD) as described in Contract Documents.

#### 1.3 QUALITY ASSURANCE

- A. The complete VFD package being supplied shall be listed and carry the label of at least one of the following: UL - Underwriters Laboratory; ETL - ETL Testing Laboratories, Inc.; CSA - Canadian Standards Association.

#### 1.4 SUPPLIER & VENDOR REQUIREMENTS

- A. Suppliers of VFD systems must be in the primary business of supplying variable frequency drives and have a minimum of five (5) years of service in that business.
- B. Vendor must have local service center with factory spare parts inventory and factory authorized service technician on call 24 hr/day. The vendor must be able to show that the recommended spare parts are available locally and any repair could take place within 24 hours for equipment supplied on this project.

#### 1.5 TESTING

- A. Prior to shipping, each unit shall be tested and a certified test report shall be supplied with each unit. Standard tests to include:
  - 1. Visual inspection - consisting of checking unit enclosure, wiring, connections, fasteners, covers and locking mechanism.
  - 2. High pot test: Two (2) X rated voltage plus 1000 volts AC for 60 seconds shall be applied per UL 508 on all peripheral drive system power components (circuit breakers, contactors, motor overloads, line reactors, disconnect switches, etc.) as a complete package. A copy of test results shall be included in operation manuals.
  - 3. Motor run test.
  - 4. Control panel devices; test all devices and lights.
  - 5. Optional equipment; test optional equipment specified with VFD system.
  - 6. Special tests; as required and specified.

#### 1.6 DRAWINGS/MANUALS

- A. Vendor shall supply approval drawings of system being supplied, in strict compliance with the specifications, within two (2) weeks ARO. Drawings shall include, as a minimum:
  - 1. General arrangement of each unit showing size and incoming and outgoing conduit locations.
  - 2. Schematic.
  - 3. Connection diagram, sufficient to install drive system.
- B. Each unit shall be supplied with two owner/maintenance manuals which shall include:

1. Vendor information of equipment being supplied.
2. Connection Information.
3. Startup Procedure.
4. Fault Reset Instruction.
5. Wiring Diagrams (power and control).
6. Parts List.
7. Test Results:
  - Harmonic voltage distortion on line with unit off
  - Harmonic voltage distortion with unit on line
  - Telephone Influence Factor (TIF) Report
  - Transformer Derate Report
  - Displacement Power Factor Report

## 1.7 WARRANTY

- A. The vendor shall supply a warranty consisting of the following:
  1. Unit shall carry a warranty of parts and labor for 1 year after start-up.
  2. The unit is to be stored in a vendor approved area, said area to be free of dirt, vibration and moisture. Unit shall not be exposed to excessive heat or cold.
  3. The unit is not to be started by owner or his contractor, but by a vendor-furnished field start-up service technician.

## PART 2 - PRODUCTS

### 2.1 MANUFACTURED UNITS

- A. The vendor shall verify compatibility of the VFD System being supplied with the specified motor. The motor shall be high efficiency with a 1.15 service factor, and shall be subject to VFD vendor approval.
- B. Each system shall be supplied in a NEMA 1 force ventilated filtered enclosure, either wall mounted or free standing.
- C. Each system shall have screened or engraved labels on all door operator and pilot devices.
- D. Each system shall bear an electrical shock warning label to warn personnel that a potential of electric shock exists.
- E. Each system shall be supplied complete, wired with all components assembled in a single enclosure including, but not limited to the VFD units, contactors, door interlocked circuit breaker, differential pressure controller, and/or other items listed in this specification or shown on the plans. Units requiring mounting and interwiring of separate bypass enclosure shall not be acceptable under this specification.
- F. The vendor shall supply a complete set of engineering drawings consisting of, as a minimum, general arrangements, power wiring diagram, control wiring diagram and schematic of VFD System components and options.
- G. The vendor shall supply an owner's manual consisting of catalog sheets listing actual component and part numbers. Manual shall also show test certificates, warranty and service personnel responsible for warranty.
- H. Vendor shall supply VFD System and start-up service. Mounting unit and connecting to power supply and mounting and wiring of remote devices shall be by mechanical contractor.

- I. The VFD inverter shall be altitude compensated and sized for the elevation at which the unit will be installed. The inverter shall operate in an ambient temperature of -10 degrees C to 50 degrees C and humidity of 0% to 90% noncondensing.
- J. The VFD inverter unit shall be mounted on a removable panel along with all other components such that, if required, panel could be removed from enclosure for maintenance or part replacement.
- K. The door shall be mounted with a minimum of two hinges with removable pins. Door shall be rigid and large doors shall have additional hinges and stiffening steel.
- L. Enclosure shall be painted with high grade enamel, with a minimum of 50-70 microns thick.
- M. The enclosure shall be force ventilated and the exhaust ports covered with louvers. All components of the system shall be contained in this single enclosure as an integrated package.
- N. Door mounted operator devices shall be industrial oil tight similar to those found on motor control centers.
- O. All control power for operator devices and customer connections shall be 120 volts. The control power transformer shall be a "Machine Tool" type and have both primary and secondary fusing.

## 2.2 STANDARD FEATURES

- A. The VFD unit shall be a solid state AC to DC converter sinusoidal pulse-width modulation (PWM) type.
- B. The unit shall operate on:
  - Input Voltage 480 VAC +/- 10%
  - Input Frequency 60 Hz +/- 5%
- C. Motor braking torque shall be available by means of regenerative braking.
- D. The drive shall contain an output frequency clamp such that minimum of maximum output frequency can be set at desired limits.
- E. Rated overload current shall be 110% for 1 minute.
- F. The VFD unit shall have an adjustable acceleration/deceleration time setting from 1 second to 120 seconds.
- G. The VFD unit shall maintain a 95% or better displacement power factor over the entire speed range.
- H. The inverter shall be supplied with a door interlocked input disconnect motor circuit protector. The MCP shall allow trip adjustment sufficient to start the motor across the line in the bypass mode and normally be set at a minimum setting for maximum protection in the VFD mode. The door mounted handle shall be able to lock in the Off position.
- I. The following door mounted operator controls shall be provided as a minimum:
  - Hand/Off/Auto Switch
  - Local/Remote Selector
  - Frequency Setting Speed Selector

Frequency Indication Meter Calibrated in % Speed  
Power on Light  
VFD/Bypass Switch  
VFD Enable Light Bypass on Light  
VFD Fault Light  
External Fault Light (safeties interlock)

- J. The inverter shall have a minimum of the following protective features with an alarm display indication:

Overcurrent shut-off  
Regenerative Overvoltage  
Electronic Thermal Protector  
Heatsink Overheat  
Instantaneous Power Failure  
Ground Fault

- K. The following termination points shall be provided on a terminal strip for field connections:

Safeties Interlock (N.C. Contacts by owner)  
Remote Start/Stop Contact (N.O. Contacts by owner)  
Remote VFD Fault Contact (N.C.)  
Remote VFD/Bypass Enable Contact (N.O.)  
Remote Electronic Signal Input (4-20Ma)

- L. Auto restart shall be initiated by means of an automatic time delayed restart after recovering from undervoltage or loss of power. The inverter shall not automatically restart after overcurrent, overvoltage, overtemperature, or any other damaging conditions, but shall require a manual restart.

- M. Bypass: The inverter shall be supplied with a bypass contactor arrangement for transfer to the feeder line to operate at constant speed. The Contactors shall be electrically and mechanically interlocked and supplied with an adjustable motor overload relay.

- N. A VFD isolation switch shall be provided to allow maintenance on the VFD while operating in the bypass mode. It will be prewired in the same enclosure, including contactors, input disconnect MCP, motor overload, VFD/Bypass selector switch and Bypass ON light.

- O. Digital or Analog Ammeter.

- P. Elapsed Time meter.

- Q. NEMA 12 Enclosure with filters on forced-ventilation system.

- R. Frequency Jump: The drive shall be supplied with the capability of being field retrofitted with a frequency jump control to avoid operating at a point of resonance with the natural frequency of the machine.

- S. VFD unit shall have computer signal control option through the addition of a RS 232 data card which can be added at any time by plugging said card in existing unit.

- T. Fault Diagnostics: The drive system shall have non-volatile fault retention so that the VFDs fault history is available from memory even after power loss.

### 2.3 APPROVED MANUFACTURERS

- A. Energy Management Corporation EMC M Series
- B. Mitsubishi VTP Series
- C. Toshiba G2 Series
- D. ABB

### 2.4 APPROVED SUPPLIERS

- A. The following suppliers have been approved for assembling and local support of the VFDS:
  - 1. Energy Management Corporation
  - 2. Toshiba
  - 3. Midgley-Huber
  - 4. Other manufacturers and suppliers may submit for prior approval by submitting a point-by-point compliance to these specifications to the engineer at least 10 days before the published bid date. Sample test reports shall be included.

## PART 3 - EXECUTION

### 3.1 INSTALLATION

- A. Painting: Manufacturer's standard paint shall be supplied. Touch-up paint shall be supplied if required.
- B. Mounting and power connection shall be provided by mechanical contractor.
- C. Vendor to supply field start-up service by an authorized factory service representative consisting of system check-out, start-up and system run. The vendor shall provide warranty and authorized factory service including operator training (if required). A written certificate of same shall be provided at start-up. VFD service technicians shall be full time employees of the vendor or manufacturer, primarily engaged in VFD service work during normal business hours and also on call 24 hours a day. Start-up by sales representative is not acceptable.

END OF SECTION 230514



## SECTION 230553 - IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

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

#### 1.2 SUMMARY

- A. Furnish and install identification of equipment and piping as described in Contract Documents.
- B. Mechanical Contractor shall touch-up equipment where factory paint has been damaged. Repaint entire item where more than 20 percent of the surface is involved.
- C. Primary painting of walls, ceilings, ductwork, piping and plenums is covered in the general painting section of these Contract Documents.

### PART 2 - PRODUCTS

#### 2.1 PAINT

- A. Benjamin Moore Impervo or equivalent by Paint Manufacturer approved in Section 09 900.
- B. Use appropriate primer.

#### 2.2 LABELS

- A. Black Formica with white reveal on engraving.

#### 2.3 CODED BANDS

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

#### 2.4 PIPE IDENTIFICATION

- A. In addition to the colored bands, stencil with black paint in 1/2 inch high letters a symbol and directional arrow for all fluids handled or use Seaton coded and colored pipe markers and arrows to meet ANSI Standards.

#### 2.5 EQUIPMENT IDENTIFICATION

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

## 2.6 VALVE IDENTIFICATION

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

## PART 3 - EXECUTION

### 3.1 APPLICATION

- A. Engraved Plates:
  - 1. Identify thermostats and control panels in mechanical rooms, furnaces, boilers and hot water heating specialties, duct furnaces, air handling units, electric duct heaters, and condensing units with following data engraved and fastened to equipment with screws –
    - a. Equipment mark noted on Drawings (i.e., SF-1)
    - b. Area served (i.e., North Classrooms)
    - c. Capacity (10,000 CFM @ 2.5)
- B. Stenciling:
  - 1. Locate identifying legends and directional arrows at following points on each piping system –
    - a. Adjacent to each item of equipment and special fitting.
    - b. At point of entry and exit where piping goes through wall.
    - c. On each riser and junction.
    - d. Every 50 feet on long continuous lines.
  - 2. Heat Pump Heating, Chilled Water, Gas, & Valve Identification –
    - a. Identify specific pipe contents by stenciling pipe with written legend and placing of arrows to indicate direction of flow.

- C. Painting:

- 1. Background Color - Provide by continuous painting of piping.

Symbol	Name	Color
HP	Hot Pump Heating	Green
CHW	Chilled Water	Blue
NG	Natural Gas	Yellow
FS	Fire Sprinkler	Red

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

<u>Arrows &amp; ID Stenciling</u>	<u>Color Shade of Pipe</u>
White	Red, Grays, & black
Black	Yellows, Oranges, Greens, & White

END OF SECTION 230553

## SECTION 230593 - TESTING, ADJUSTING, AND BALANCING

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

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

#### 1.2 SUMMARY SCOPE

- A. This Section includes TAB to produce design objectives for the following:
  - 1. Air Systems.
    - a. Heat Pumps.
    - b. Exhaust Fans.
    - c. Laboratory Fume Hoods
  - 2. Hydronic Piping Systems.
    - a. Primary - Secondary Systems
    - b. Chiller
    - c. Cooling Tower
    - d. Pumps

#### 1.3 SUBMITTALS

- A. Agency Data:
  - 1. Submit proof that the proposed testing, adjusting, and balancing agency meets the qualifications specified below. The firm or individuals performing the work herein specified may not be the installing firm.
- B. Engineer and Technicians Data:
  - 1. Submit proof that the Test and Balance Engineer assigned to supervise the procedures, and the technicians proposed to perform the procedures meet the qualifications specified below.
- C. Procedures and Agenda: Submit a synopsis of the testing, adjusting, and balancing procedures and agenda proposed to be used for this project.
- D. Sample Forms: Submit sample forms, if other than those standard forms prepared by the AABC or NEBB are proposed.
- E. Certified Reports: Submit testing, adjusting, and balancing reports bearing the seal and signature of the Test and Balance Engineer. The reports shall be certified proof that the systems have been tested, adjusted, and balanced in accordance with the referenced standards; are an accurate representation of how the systems have been installed; are a true representation of how the systems are operating at the completion of the testing, adjusting, and balancing procedures; and are an accurate record of all final quantities measured, to establish normal operating values of the systems. Follow the procedures and format specified below.
  - 1. Draft Reports: Upon completion of testing, adjusting, and balancing procedures, prepare draft reports on the approved forms. Draft reports may be hand written, but must be complete, factual, accurate, and legible. Organize and format draft reports in the same manner specified for the final reports. Submit 2 complete sets of draft reports. Only 1 complete set of draft reports will be returned.

2. Final Report: Upon verification and approval of draft reports, prepare final reports, type written, and organized and formatted as specified below. Submit 4 complete sets of final reports.
  3. Report Format: Report forms shall be those standard forms prepared by the referenced standard for each respective item and system to be tested, adjusted, and balanced. Bind report forms complete with schematic systems diagrams and other data. Divide the contents of the binder into the below listed divisions, separated by divider tabs:
    - a. General Information and Summary
    - b. Air Systems
    - c. Temperature Control System Verification.
- F. Report Contents: Provide the following minimum information, forms, and data:
1. General information and Summary: Inside cover sheet to identify testing, adjusting, balancing agency, Contractor, Owner, Engineer, and Project. Include addresses and contact names and telephone numbers. Also include a certification sheet containing the seal and name, address, telephone number, and signature of the Certified Test and Balance Engineer. Include in this division a listing of the instrumentation used for the procedures along with the instrument calibration sheet.
  2. The remainder of the report shall contain the appropriate forms containing as a minimum, the information indicated on the standard report forms prepared by the AABC or NEBB, for each respective item and system. Prepare a schematic diagram for each item of equipment and system to accompany each respective report form. The report shall contain the following information, and all other data resulting from the testing, adjusting, and balancing work:
    - a. All nameplate and specification data for all air handling equipment and motors.
    - b. Actual metered running amperage for each phase of each motor on all pumps and air handling equipment.
    - c. Actual metered voltage at air handling equipment (phase-to-phase for all phases).
    - d. Fan RPM for each piece of air handling equipment.
    - e. Total actual CFM being handled by each piece of air handling equipment.
    - f. Actual CFM of systems by rooms.
  3. Certify that all smoke and fire dampers operate properly and can be reset under actual system operating conditions.
- G. Calibration Reports:
1. Submit proof that all required instrumentation has been calibrated to tolerances specified in the referenced standards, within a period of six months prior to starting the project.

#### 1.4 CERTIFICATION

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

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

#### 1.5 PROJECT CONDITIONS

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

#### 1.6 SEQUENCING AND SCHEDULING

- A. Test, adjust, and balance the air systems before hydronic, steam, and refrigerant systems within +10% to -5% of contract requirements.
- B. The report shall be approved by the Engineer. Test and balance shall be performed prior to substantial completion.

#### PART 2 - NOT USED

#### PART 3 - EXECUTION

##### 3.1 PRELIMINARY PROCEDURES FOR AIR SYSTEM BALANCING

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

##### 3.2 FUME HOOD BALANCE

###### A. GENERAL REQUIREMENTS

1. The fume hood, when properly installed in a laboratory and connected to an exhaust fan of the proper capacity, shall contain and remove fumes generated within the hood. The face velocity range shall be between 100-125 fpm as selected. The hood shall operate efficiently at any setting within this range. Hood design shall be such that it will exhaust

light or heavy gases efficiently when the hood is used for ordinary laboratory work in a room free from cross drafts and without high thermal loads or other special conditions of this nature. No reverse flows of air will be allowed along the sides, top, bottom, or front of the hood. The owner and/or a designated representative shall view the tests and successful compliance results are contingent upon concurrence by the owner and/or the representative.

2. The performance test requirements listed in this section are also applicable for the establishment of baseline performance characteristics for comparison with periodic evaluations of existing laboratory chemical fume hoods.
3. The following instrumentation, equipment, and supplies shall be on hand for use in the performance tests:
  - a. Alnor "Velometer" or approved equal, direct reading, with graduations from 0-350 feet/minute.
  - b. Pitot tube and inclined manometer with graduations no greater than 0.02".
  - c. One-half minute smoke bombs (3 dozen).
  - d. Titanium tetrachloride (4 ounces). Titanium Tetrachloride and its hydrolysis products are highly toxic and irritating. Skin exposure may cause irritation and burns, and even brief contact with the eyes may cause irreversible damage (suppurating conjunctivitis and keratitis, followed by clouding of the cornea). For this reason, certain precautions should be taken when handling this material. These precautions include the wearing of eye protection and rubber gloves. Care should also be taken to avoid inhalation of aerosolized material.
  - e. Supply of cotton throat swabs.

B. PERFORMANCE TEST PROCEDURES:

1. "Properly installed" means that the hood shall be installed in an area where there is at least 5 feet clear space in front for observation of the airflow pattern entering the hood. This area shall be without cross drafts or other air currents exceeding 20 fpm that would affect the hood performance in the area in front and around the hood.
2. Fume hood face velocities shall be verified as follows: with exhaust fan on, the quantity of air being exhausted shall be determined by measuring the velocity of air entering the hood face and multiplying this velocity by the square feet of hood opening. The hood sash shall be in the fully raised position. The air velocity shall be determined by averaging at least nine velocity readings taken at the hood face. Readings shall be taken in the center of a grid made up of 3 sections across the middle of the hood face and 3 sections each across the bottom and top of the hood face. Reading shall not vary more than  $\pm 10$  fpm from the average face velocity.
3. When the selected face velocity has been established, the following tests shall be made:
  - a. Make a complete traverse of the hood face with a cotton swab dipped in titanium tetrachloride to demonstrate a positive flow of air is maintained into the hood over the entire hood face. No reverse air flows or dead air space shall be permitted.
  - b. Paint a strip of titanium tetrachloride along each end and across the working surface of the hood, in a line parallel with the hood face and 6" back into the hood to demonstrate that no back flows of air exist at these points. The flow of smoke shall be directly to the rear of the hood without swirling turbulence or reverse flows.
  - c. A smoke bomb (one-half minute size, as available from E. Vernon Hill Company, San Francisco, California) shall be discharged within the hood area to show the exhaust capability of the hood and its design efficiency. No reverse air flows will be permitted. Place lighted bomb in the hood area and move it to various places, meanwhile checking end panels and working surface to verify that no reverse air flows exist at any point. Lower the sash to closed position to verify that a sufficient air volume is flowing through the hood working area to carry away fumes from a massive fume source. Immediately after the

smoke bomb stops discharging smoke, the hood area shall be purged of smoke.

4. Lower sash to a point 6 inches above work surface. Velocity, as measured at three points across the reduced face opening, shall be at least two times but less than three times the design face velocity when the sash was fully raised.
5. With the sash still at the lowered position, the exhaust air volume (indicated as a function of the average velocity determined in the duct with the pitot tube) shall be essentially the same as when the sash was fully raised. Now lower sash to fully closed position and measure exhaust flow. Total exhaust flow shall be essentially as measured previously with the different sash opening positions.
6. Check sash operation by raising and lowering sash. Sash shall glide smoothly and freely, and hold at any height without creeping, assuring proper counterbalance. No metal-to-metal contact shall be allowed between the sash and the sash tract.

### 3.4 PROCEDURES FOR HYDRONIC SYSTEMS

- A. Measure water flow at pumps. Use the following procedures, except for positive-displacement pumps:
  1. Verify impeller size by operating the pump with the discharge valve closed. Read pressure differential across the pump. Convert pressure to head and correct for differences in gage heights. Note the point on manufacturer's pump curve at zero flow and verify that the pump has the intended impeller size.
  2. Check system resistance. With all valves open, read pressure differential across the pump and mark pump manufacturer's head-capacity curve. Adjust pump discharge valve until indicated water flow is achieved.
  3. Verify pump-motor brake horsepower. Calculate the intended brake horsepower for the system based on pump manufacturer's performance data. Compare calculated brake horsepower with nameplate data on the pump motor. Report conditions where actual amperage exceeds motor nameplate amperage.
  4. Report flow rates that are not within plus or minus 5 percent of design.
- B. Set calibrated balancing valves, if installed, at calculated presettings.
- C. Measure flow at all stations and adjust, where necessary, to obtain first balance.
  1. System components that have Cv rating or an accurately cataloged flow-pressure-drop relationship may be used as a flow-indicating device.
- D. Measure flow at main balancing station and set main balancing device to achieve flow that is 5 percent greater than indicated flow.
- E. Adjust balancing stations to within specified tolerances of indicated flow rate as follows:
  1. Determine the balancing station with the highest percentage over indicated flow.
  2. Adjust each station in turn, beginning with the station with the highest percentage over indicated flow and proceeding to the station with the lowest percentage over indicated flow.
  3. Record settings and mark balancing devices.
- F. Measure pump flow rate and make final measurements of pump amperage, voltage, rpm, pump heads, and systems' pressures and temperatures including outdoor-air temperature.
- G. Measure the differential-pressure control valve settings existing at the conclusions of balancing.

### 3.5 MEASUREMENTS

- A. Provide all required instrumentation to obtain proper measurements, calibrated to the tolerances specified in the referenced standards. Instruments shall be properly maintained and protected against damage.
- B. Provide instruments meeting the specifications of the referenced standards.
- C. Use only those instruments which have the maximum field measuring accuracy and are best suited to the function being measured.
- D. Apply instrument as recommended by the manufacturer.
- E. Use instruments with minimum scale and maximum subdivisions and with scale ranges proper for the value being measured.
- F. When averaging values, take a sufficient quantity of readings which will result in a repeatability error of less than 5%. When measuring a single point, repeat readings until 2 consecutive identical values are obtained.
- G. Take all readings with the eye at the level of the indicated value to prevent parallax.
- H. Use pulsation dampeners where necessary to eliminate error involved in estimating average of rapidly fluctuation readings.
- I. Take measurements in the system where best suited to the task.

### 3.6 PERFORMING TESTING, ADJUSTING, AND BALANCING

- A. Perform testing and balancing procedures on each system identified, in accordance with the detailed procedures outlined in the referenced standards. Balancing of the air systems and hydronic systems shall be achieved by adjusting the automatic controls, balancing valves, dampers, air terminal devices, and the fan/motor drives within each system.
- B. Cut insulation, ductwork, and piping for installation of test probes to the minimum extent necessary to allow adequate performance of procedures.
- C. Patch insulation, ductwork, and housings, using materials identical to those removed.
- D. Seal ducts and piping, and test for and repair leaks.
- E. Seal insulation to re-establish integrity of the vapor barrier.
- F. Adjust timing relays of environmental equipment motor reduced voltage starters to the optimum time period for the motor to come up to the maximum reduced voltage speed and then transition to the full voltage speed to prevent damage to motor, and to limit starting current spike to the lowest possible and practical.
- G. Mark equipment settings, including damper control positions, valve indicators, fan speed control levers, and similar controls and devices, to show final settings. Mark with paint or other suitable, permanent identification materials.
- H. Retest, adjust, and balance systems subsequent to significant system modifications, and resubmit test results.



3.7 RECORD AND REPORT DATA

- A. Record all data obtained during testing, adjusting, and balancing in accordance with, and on the forms recommended by the referenced standards, and as approved on the sample report forms.
- B. Prepare report of recommendations for correcting unsatisfactory mechanical performances when system cannot be successfully balanced.
- C. Report shall be certified and stamped by a registered professional mechanical engineer employed by the agency and licensed in the state where the work will be performed.
- D. Engineer is to provide a floor plan and test and balance contractor to include the plan in test and balance report and identify actual cfm on drawing or number the diffusers to match report.

3.8 DEMONSTRATION

- A. If requested, testing, adjusting, and balancing agency shall conduct any or all of the field tests in the presence of the engineer.
- B. Agency shall include a maximum of one (1) call back to the project within the one year warranty period to make additional adjustments if requested by the engineer.

END OF SECTION 230593

SECTION 230712 - MECHANICAL INSULATION AND FIRE STOPPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Furnish and install mechanical insulation and fire stopping as described in Contract Documents including but not limited to the following:
  1. Chilled Water Cooling
  2. Ductwork Insulation
  3. Boilers, Tanks, Headers, and Breechings
  4. Refrigerant Piping
  5. Fire Stopping

1.3 QUALITY ASSURANCE

- A. Insulation shall have composite (insulation, jacket or facing and adhesive used to adhere facing or jacket to insulation) fire and smoke hazard ratings as tested by Procedure ASTM E-84, NFPA 255 and UL 723 not exceeding: Flame Spread of 25 and Smoke Developed of 50.
- B. Insulation Contractor shall certify in writing, prior to installation, that all products to be used will meet the above criteria.
- C. Accessories, such as adhesives, mastics, cements, and tapes, for fittings shall have the same component ratings as listed above.
- D. Products, or their shipping cartons, shall bear a label indicating that flame and smoke ratings do not exceed above requirements.
- E. Any treatment of jacket or facings to impart flame and smoke safety shall be permanent.
- F. The use of water-soluble treatments is prohibited.

END OF SECTION 230712

## SECTION 230714 – PREMOLDED ONE PIECE PVC FITTINGS INSULATION

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

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

#### 1.2 SUMMARY

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

#### 1.3 QUALITY ASSURANCE

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

### PART 2 - PRODUCTS

#### 2.1 MANUFACTURED UNITS

- A. Approved Manufacturers:
  1. Zeston

### PART 3 - EXECUTION

#### 3.1 INSTALLATION

- A. Where factory premolded one piece PVC insulating fitting covers are to be used, proper factory precut Hi-Lo Temp insulation shall be applied to the fitting. Ends of Hi-Lo Temp insulation shall be tucked snugly into throat of fitting and edges adjacent to pipe covering tufted and tucked in. Fully insulate pipe fittings. One piece PVC fitting cover is then secured by stapling, tack fastening, banding or taping ends to adjacent pipe covering.
- B. Cold:
  1. Chilled water systems shall be insulated as "A" above and have all seam edges of cover sealed with Zeston's vapor barrier adhesive or equal.
  2. Circumferential edges of cover shall be wrapped with Zeston's vapor barrier pressure sensitive color matched Z tape.
  3. Tape shall extend over adjacent pipe insulation and have an overlap on itself at least 2" on downward side.
- C. Hot:
  1. On fittings where temperature exceeds 250 degrees F., two layers of factory precut Hi-Lo Temp insulation inserts shall be applied with a few wrappings of twine on first layer, to be sure there are no voids or hot spots. Fitting cover shall then be applied over Hi-Lo Temp insulation as described above in "A."

END OF SECTION 230714

SECTION 230716 - DUCTWORK INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Furnish and install insulation on air ducts outside building insulation envelope as described in Contract Documents.
- B. Furnish and install insulation on fresh air ducts and combustion air ducts within building insulation envelope as described in Contract Documents.
- C. Furnish and install insulation on other air ducts where indicated on Drawings.

PART 2 - PRODUCTS

2.1 INSULATION

- A. 1-1/2 inch thick fiberglass with aluminum foil scrim kraft facing and have a density of one lb/cu ft.
- B. Approved Manufacturers:
  - 1. Manville Microlite FSK
  - 2. CSG Type IV standard duct insulation
  - 3. Owens-Corning FRK
  - 4. Knauf (Duct Wrap FSK)

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install duct wrap in accordance with Manufacturer's recommendations.
- B. Do not compress insulation except in areas of structural interference.
- C. Completely seal joints.

END OF SECTION 230716

## SECTION 230717 – ROUND SUPPLY DUCT INSULATION

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

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

#### 1.2 SUMMARY

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

#### 1.3 QUALITY ASSURANCE

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

### PART 2 - PRODUCTS

#### 2.1 MANUFACTURED UNITS

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

### PART 3 - EXECUTION

#### 3.1 INSTALLATION

- A. Insulate round air supply ducts.
- B. Facing shall overlap 2" at joints and shall be secured with outward clinch staples on 4" centers.
- C. Ducts over 30" in width shall have spot application of adhesive, weld pins or metal screws and caps on not more than 18" centers applied to underside.
- D. 3" wide vapor barrier paper shall be applied over seams and sealed with vapor barrier adhesive.
- E. Insulate attenuators.
- F. Insulate high and low pressure flex ducts.

END OF SECTION 230717

## SECTION 230718 - DUCT LINING

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

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

#### 1.2 SUMMARY

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

#### 1.3 SYSTEM DESCRIPTION

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

#### 1.4 RATINGS:

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

### PART 2 - PRODUCTS

#### 2.1 DUCT LINER

- A. One inch thick, 1-1/2 lb density fiberglass, factory edge coated.
- B. Duct lining materials are to meet the requirements of UL 181 for mold, humidity, and erosion resistance.
- C. Approved Manufacturers:
  1. Certaineed Ultralite 150 Certa Edge Coat
  2. Knauf - Type M
  3. Manville - Lina-Coustic
  4. Owen Corning Fiberglas - Aeroflex

#### 2.2 ADHESIVE

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

6. Techno Adhesive - 133

B. Solvent Base (non-flammable) Type:

1. Cain - Safetak
2. Duro Dyne - FPG
3. Kingco - 15-137
4. Miracle - PF-91
5. Mon-Eco - 22-24
6. Techno Adhesive - 'Non-Flam' 106

C. Solvent Base (flammable) Type:

1. Cain - HV200
2. Duro Dyne - MPG
3. Kingco - 15-146
4. Miracle - PF-96
5. Mon-Eco - 22-22
6. Techno Adhesive - 'Flammable' 106

### 2.3 FASTENERS

A. Adhesively secured fasteners not allowed.

B. Approved Manufacturers:

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

## PART 3 - EXECUTION

### 3.1 INSTALLATION

- A. Install mat finish surface on air stream side. Secure insulation to cleaned sheet metal duct with continuous 100% coat of adhesive and with 3/4 inch long mechanical fasteners 12 inches on center maximum unless detailed otherwise on Drawings. Pin all duct liner.
- B. Accurately cut liner and thoroughly coat ends with adhesive. Butt joints tightly. Top and bottom sections of insulation shall overlap sides. If liner is all one piece, folded corners shall be tight against metal. Ends shall butt tightly together.
- C. In casings and plenums further contain insulation with wire mesh.

### 3.2 FIELD QUALITY CONTROL

- A. If insulation is installed without longitudinal and end joints butted together, installation will be rejected and work removed and replaced with work that conforms to this Specification.
- B. Insulation shall be installed in accordance with Duct Liner Application Standard SMACNA Manual 15.

### 3.3 ADJUSTING, CLEANING

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

POCATELLO HIGH SCHOOL - ADDITION  
POCATELLO / CHUBBUCK SD25  
325 N. ARTHUR AVE, POCATELLO, ID 83204

JANUARY 24, 2020  
BID SET

or dusty.

END OF SECTION 230717



## SECTION 230800 – FIRE STOPPING

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

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

#### 1.2 SUMMARY

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

#### 1.3 QUALITY ASSURANCE

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

### PART 2 - PRODUCTS

#### 2.1 MANUFACTURED UNITS

- A. Material shall be flexible, long lasting, intumescent acrylic seal to accommodate vibration and building movement.
- B. Caulk simple penetrations with gaps of 1/4" or less with:
  - 1. Dow Corning Fire Stop Sealant
  - 2. Pensil 300
- C. Caulk multiple penetrations and/or penetrations with gaps in excess of 1/4" with:
  - 1. Dow Corning Fire Stop Foam
  - 2. Pensil 200
  - 3. IPC flame safe FS-1900
  - 4. Tremco "Tremstop 1A"

### PART 3 - EXECUTION

#### 3.1 INSTALLATION

- A. Follow manufacturer's installation instructions explicitly.
- B. Seal penetrations of ductwork, piping, and other mechanical equipment through one-hour and two-hour rated partitions as shown on Architectural and Mechanical Drawings.
- C. Install fire stopping material on clean surfaces to assure adherence.

END OF SECTION 230800

SECTION 230953 – TEMPERATURE CONTROLS (DDC)

PART 1 - SYSTEM OVERVIEW

1.1 DDC CONTROL SYSTEM

- A. Statement of Intent: The intent of this specification is to provide a high-quality Direct Digital Control system at Pocatello High School for integration into the current Pocatello School District WebCTRL™ front end. In order to maintain seamless interface and consistency of user screens all new control hardware must be programmed using the Eikon™ control programming utility. System must continue to have realtime presentation of these programs showing current operating parameters and conditions. Graphical User Interface screens must be developed using ViewBuilder™ graphics development software.
- B. Specification Compliance: These specifications are intended to provide a minimum capability for the DDC system. Manufacturer's data sheets included in the submittals will be reviewed to verify significant hardware and software system features. Key system features must be documented by manufacturer's data sheets in the submittals or by demonstration of an existing installation. Anyone wishing approval to bid must coordinate with the Mechanical Engineer and School District personnel not later than 10 days prior to bid date for a system demonstration of integration capabilities to existing front end software as noted above.
- C. Approved DDC Contractor and System
  - 1. DDC Control System shall be:
  - 2. Automated Logic WebCTRL by Clima-Tech Corporation

1.2 SCOPE OF WORK

- A. Control Hardware and Software: Automatic Temperature Control Contractor shall be responsible to furnish and install all control hardware and software necessary for complete DDC control system as specified. ATC contractor shall furnish all modules, temperature sensors, flow sensors, humidity sensors, IAQ sensors, control valves, control valve actuators, dampers, damper actuators and any other items necessary for a complete system and sequence of control.
- B. Specifically the ATC Contractor shall furnish the following:
  - 1. Individual unitary control modules for each unitary system:
    - a. Water Source Heat Pumps
    - b. Air Handling Units
- C. Individual control modules for all non unitary air handlers or package units:
  - 1. Make-Up Air Units
- D. General purpose modules for control of central fan, pump, chiller, boiler or tower operation:
  - 1. Hot Water Systems
  - 2. Chilled Water Systems
  - 3. Heat Pump Loop Circulation System
  - 4. Cooling Tower Control
  - 5. Domestic Hot Water System
- E. Control Wiring and Interface to Line Voltage Control
  - 1. ATC Contractor shall be responsible for all wiring required for this project regardless of VA requirements.
- F. Commissioning: ATC Contractor shall be responsible for self-commissioning of all hardware and

software furnished with the project. Completed field commissioning sheets shall be included with the final "as-built" O&M manuals. These sheets shall include validation check fields for all physical and LAN inputs and outputs and graphics for each operating unit or system within the facility. Each system and point shall be listed, using logical names for future reference by the owner. Commissioning shall include calibration and verification of operation of each I/O and graphic field. Functional commissioning of software programming to meet sequences of operation as submitted and approved shall be verified on the field commissioning sheets.

- G. Training and Technical Support: Contractor shall provide 8 hours of training to owner representatives on operation and servicing of automatic temperature control system. Training shall be oriented to making the owner self sufficient in the day to day use and operation of the DDC system. Additionally the training shall include information specifically focused on showing the owners representative methods of troubleshooting the mechanical systems using the DDC system. For this purpose, the trainer must be well grounded in both DDC system operation and in mechanical systems service.
- H. The contractor shall provide unlimited phone technical support to the owners representative during the one year warranty period. If the technical support location of the contractor is outside of the toll free calling area for the customer, the contractor shall have a toll free number or accept collect calls for the purpose of providing technical support.

### 1.3 SUBMITTALS AND O&M MANUALS

#### A. Submittals

- 1. Submittals shall include the following sections:
- 2. Shop Drawings with:
  - a. Title Page
  - b. Table of Contents
  - c. Typical Device Wiring Drawings
  - d. Summary Bill of Materials
  - e. Local Area Network Drawings
  - f. Drawings for all operating systems showing both equipment and module connections (Note: drawings for individual operating systems shall include individual Bills of Materials)

#### B. Sequences of Operation

- 1. Manufacturers specification data sheets for all control modules, sensors, dampers, valves, actuators, flow switches, current sensors and transducers required in the project.
- 2. If the contractor wishes to substitute any item after approval of submittal they shall submit appropriate data sheets for approval before including substituted product on the project.

#### B. O&M Manuals

- 1. O&M Manuals shall be furnished upon project completion and include technical instructions for all items originally included in the submittal with "as built" modifications and completed Commissioning Worksheets. O&M Manuals shall be in a separate three ring binder. Contractor's toll free technical support number or the words "Call Collect" with the contractor's regular phone number shall be on the front of the manual.

### 1.4 SYSTEM SOFTWARE

#### A. System Software

- 1. All operating program and site specific software shall be furnished to the owner on 3½" diskettes or CD ROM disks.

## PART 2 - CONTRACTOR CAPABILITY

- 2.1 Contractor shall maintain toll-free technical support phone line or accept collect phone calls during warranty period. Contractor shall provide service within 24 hours. Contractor service and installation technicians shall be technically proficient in both control systems and mechanical service.

### PART 3 - PRODUCT CAPABILITY - HARDWARE

#### 3.1 SYSTEM SERVER

- A. Software shall be installed on owner's existing WebCTRL server.

#### 3.2 FIELD HARDWARE

##### A. BACnet Compatibility

1. The system shall be fully native BACnet at the time of installation. The system shall use BACnet as the native communication protocol between distributed controllers communicating on the controller network (i.e. Field Bus) and must, as a minimum, support the following Objects and Application Services (Conformance Class 3):

B. Objects	Binary Input	Services >	Readproperty
	Binary Output		Writeproperty
	Binary Value		I-Am
	Analog Input		I-Have
	Analog Output		ReadMultiple Property
	Analog Value		WriteMultiple Property
	Calendar		Who-Has
	Schedules		Who-Is

- C. Distributed Control: System shall observe the concept of distributed control. All modules shall have "stand alone" capability and shall maintain operator setpoints without connection to primary controllers or central station equipment. Modules shall be located at each operating equipment location such that individual systems or zones shall remain functional without communication to other systems on the network. Equipment operating logic, schedules and current trends shall reside in control modules serving each system. Use of global modules required to maintain programming, schedules or current trend data are not acceptable.
- D. Ethernet Gateway Routers: System shall include an Ethernet Router/Gateway between the control module network and owners Ethernet. This gateway shall route BACnet communications between the control module network and the owners IP network. If the system is not to be connected to customer Ethernet the gateway shall be capable of connection via a web browser on the local host server.
- E. Control Modules: Control modules shall include required inputs and outputs to meet sequence of operation and points list. Digital outputs shall be dry contact relays and analog outputs shall be industry standard 0-10 vdc, 2-10 vdc or 4-20 milli-amp. **Triac digital outputs are not acceptable.** Modules shall be fully programmable for maximum system flexibility. **Application specific controllers are not acceptable.**
- F. All modules shall have battery backup capable of maintaining all programs, setpoints, schedules and trend information for a minimum of 7 days.
- F. All schedules and current trends shall be maintained in the individual control modules. The modules shall be capable of maintaining sufficient trend samples to report 24 hours of trend

history in 5 minute increments for each input or output.

- G. Temperature Sensors: Wall mounted zone temperature sensors shall be 10 k ohm thermistor. Zone sensors in primary occupied areas other than restrooms, hallways or storage rooms shall have setpoint adjustment to allow the occupants to raise or lower setpoint within operator defined parameters. Additionally sensors in these primary areas shall have a push button to return the system to normal occupancy setpoints for an operator defined period. Exception will be common areas. Zone sensors for restrooms, hallways, storage rooms, gymnasiums, auditoriums and locker rooms shall be mounted on the back of an aluminum electrical box cover plate designed for zone sensing application. Gymnasium sensors shall also include a key access override feature.
- H. All other temperature sensors shall be industry standard thermistor or 4-20 milli-amp. Immersion sensors shall be mounted in a blind well for future serviceability.
- I. Valve and Damper Actuators: Actuators shall be manufactured by Belimo. Torque shall be rated for required load. Modulated actuator input shall be industry standard 0-10 vdc, 2-10 vdc, 4-20 milli-amp, floating motor (tri-state), or pulse width modulation. Two or three position operation is not acceptable for economizers, VAV dampers, multizone dampers, valves or any other application specifying modulated operation.
- J. Dampers: Outside air control dampers shall have neoprene or vinyl-grip blade seals, stainless spring steel edge seals and a specified leakage rate of not more than 65 CFM/damper face area at 2" W.G. static pressure drop.
- K. Wire: All wiring in open areas at heights below 12 feet must be run in conduit, otherwise control wiring may be run open in accessible ceiling or underfloor areas. Control wiring in non-accessible ceilings, walls or floors shall be in conduit. All wiring not in conduit or control cabinets shall be rated for plenum installation. Communication wiring shall be run in data cable tray whenever possible.

#### PART 4 - PRODUCT CAPABILITY - SOFTWARE

##### A.. BACnet COMPATIBILITY

1. The system shall be fully native BACnet at the time of installation. This means that the system must use BACnet as the native communication protocol between distributed controllers communicating on the controller network (i.e. Field Bus) and must, as a minimum, support the following Objects and Application Services (Conformance Class 3):

2. Objects	>Binary Input	Services	>Readproperty
	Binary Output		Writeproperty
	Binary Value		I-Am
	Analog Input		I-Have
	Analog Output		ReadMultiple Property
	Analog Value		WriteMultiple Property
	Calendar		Who-Has
	Schedules		Who-Is

- B. Programming for the system shall use BACnet objects and services. All BACnet objects and services shall be opened for read and/or read/write access during programming for future exposure to other BACnet systems. The front end software for the system shall be able to query other third party BACnet points for read/write access.
- C. MULTIPLE OPERATING PLATFORMS

1. The front end server software furnished as a part of the DDC system shall be capable of operating on multiple operating systems such as Microsoft Windows, Linux or Sun Solaris.

#### D. GRAPHICAL PROGRAMMING

1. The system shall be programmed using Eikon™ graphical programming language for ease of operator understanding. Operating sequences and logic flow shall be assembled in a schematic format using MicroBlocks representing inputs, outputs and logical functions such as setpoints, switches, limits, relays, PIDs etc. The programming software shall be furnished within this scope of work.
2. Full simulation capability shall also be provided with the graphic programming. User shall be able to fully simulate the constructed sequence on screen before the sequences are downloaded into the controllers. The system shall also include the ability to simulate multiple graphic programs communicating with each other on a simulated network.

#### E. GRAPHICAL INTERFACE SOFTWARE

1. System and Equipment Graphic User Interface: The operators interface software shall be developed using ViewBuilder™ graphical development software. Graphics display screens shall include a system level graphic of either a map of facilities or an elevation of the building, a graphic of each building floor plan and graphics for each operating system or unit within each building. Entry to the zone and equipment level interface graphics shall be through area maps and/or floor plans to facilitate user orientation. Additionally the system hierarchy shall be displayed in a fashion similar to Windows Explorer to enable the user to navigate to any graphical screen in the system by expanding building levels or floor levels and selecting a particular zone or system. Graphics shall be accessed by using a mouse or other pointer device. The system shall provide a visual indication of which building, floor and zone the user is accessing at any time. System shall be capable of changing all parameters and schedules, as well as downloading operating software from the same Graphical User Interface software program as that used for viewing system operation.
2. Thermal graphic floor plans shall display each temperature zone in a color appropriate to current space temperature conditions. The system shall display in 8 separate colors the following conditions: High or low temperature alarm, temperature at setpoint, cooling call, heating call, more than 2° above setpoint, more than 2° below setpoint, unoccupied between setpoints and no communication. Floor plans shall also include color graphic indicators for non-zone specific mechanical equipment operation showing On/Off and Alarm Conditions. Status indication colors shall be updated dynamically as conditions change.
3. Mechanical equipment pictorial graphics shall be displayed by the use of point-and-shoot selection using a mouse or other pointer device. Graphics shall be provided for all mechanical equipment and devices controlled by the DDC system. These graphics shall provide a current status of all I/O points being controlled and applicable to each piece of equipment including analog readouts in appropriate engineering units at appropriate locations on the graphic representation.
4. Software Graphic Programming Live User Interface: The system shall be able to display the graphic displays of system programming, operating logic and logic flow with real time conditions displayed at each input, output and logical function. This display will allow the operator to observe each step of a control logic process and facilitate system software

troubleshooting. Operator shall have the ability to select any MircoBlock in the graphical program to change parameters including the ability to lock values.

#### F. FACILITY MANAGEMENT AND ENERGY MANAGEMENT FUNCTIONS

1. Scheduling: The DDC system shall have the ability to schedule each individual zone, each building or floor or the entire network of buildings for any user with a single entry. Additionally the operator shall have the capability of assembling groups of zones, buildings or floors for single entry programming, e.g. several offices may be grouped for scheduling of Saturday operations. Available schedule types shall include normal operation, unoccupied operation, setback override and holidays. For maximum flexibility, schedules shall reside in the local control modules. Dated schedules shall be self managing and automatically delete after execution.
2. Interactive Operations: The system shall have the ability to send run requests, heating requests and cooling requests from one module to another for the purpose of optimizing run operations of central plant equipment. Additionally the system shall be capable of limiting operation of various equipment if another mechanical point elsewhere in the system allows that operation. e.g. a boiler loop circulating pump shall run only when requested by a zone requiring heating operation and will shut down during hours that zone demand is satisfied.

#### G. ALARMS, TRENDS AND REPORTS

1. System and Temperature Alarms: The system shall have the capability of monitoring conditions throughout the system and sending alarms or messages to an e-mail address, local PC or printer or to remote PC's, printers or to dial-up pagers. Alarms and messages shall be able to be prioritized for various levels of reporting and action. The operator shall have the ability to customize alarm text and messages.
2. Trends: The system shall be capable of trending any input or output, or any logical point within the graphic program. There shall be no limitation to the number of points that can be trended at any particular time. Modules shall store in live memory 288 trend samples points for each trended item. The interval between trend samples shall be adjustable from 1 second to 24 hours. Trends from one or more modules shall be able to be simultaneously displayed on a single trend graph. Operator shall be able to "window" any segment of a trend to enlarge the view by dragging a mouse to form the "window". The system shall also have the ability of automatically downloading trend information from any module to the server or other computer connected to the network for historical trend storage. This trend information shall be able to be displayed on the trend graph along with live current trends in seamless fashion. Trend data collection requiring the use of a locally connected PC for data storage is unacceptable.
3. Reports: The system shall be capable of generating reports of equipment run times, all trended points, temperature conditions, electric demand and usage and alarms or messages. The system shall also have the ability of automatically downloading report information from any module to the server or other computer connected to the network. The operator shall have the ability to create custom report and logging formats.

### PART 5 - SEQUENCES OF OPERATION

#### A. GENERAL

1. The following sequences of operation shall be strictly observed. All temperature setpoints, static pressure setpoints, percentage of PID output trip points and reset ratios within this

specification shall be changeable by operator using the operator software furnished with the system.

**B. DISTRIBUTED CONTROL**

1. System shall observe the concept of distributed control. Modules shall be located at each operating equipment location such that individual systems or zones shall remain functional without communication to other systems on the network.

**C. Central Plant, Pump and Fan Operation:** Control of all central fan systems, chillers, boilers and pumping stations shall be based on run requests, heating requests or cooling requests from zone controls. Reset of supply air static pressure, supply air temperature, chilled water temperature and hot water temperature shall be based on zone temperature conditions and heating or cooling requests from zones.

**D. Scheduling:** For maximum flexibility all occupancy schedules shall be stored in zone control modules. Central fans or pumps shall start when commanded from any associated zones that call for occupancy or for operation to meet setback heating or cooling requirements and shall not require separate scheduling unless required for the sequence of operation. Fans or pumps shall run for minimum of 30 minutes.

**5.1 EQUIPMENT POINTLIST & OPERATING SEQUENCES**

Water Source Heat Pump		AI	DI	DO	AO
Qty>	17 ZN551				
	Zone Temperature	1			
	No SP Adj/TLO Available	1			
	Supply Air Temperature	1			
	Fan Status		1		
	Fan S/S			1	
	Cooling S/S			1	
	Heating S/S			1	
	Loop Valve Open/Close			1	
	Relief Damper Open/Close			1	
<b>Sum of Points</b>		<b>3</b>	<b>1</b>	<b>5</b>	<b>0</b>
<b>702</b>					

Water Source Heat Pump w/EF		AI	DI	DO	AO
Qty>	2 ZN551				
	Zone Temperature	1			
	No SP Adj/TLO Available	1			
	Supply Air Temperature	1			
	Fan Status		1		
	EF 18/32 Status		1		
	EF 19/33 Status		1		
	Fan S/S			1	
	Cooling S/S			1	
	Heating S/S			1	
	Loop Valve Open/Close			1	
	Exhaust Fan S/S			1	
<b>Sum of Points</b>		<b>3</b>	<b>3</b>	<b>5</b>	<b>0</b>
<b>22</b>					



**Make-Up Air Units**

Qty> 2 SE6104

SA Temperature	1			
Fan Status		1		
Damper Status		1		
Fan S/S			1	
Damper Open/Close			1	
Heating S/S			1	

Sum of Points 1 2 3 0 72

**Mechanical Room**

Qty> 1 LGR-25 w/MX8102, MX880, MX440

HP Loop Supply Temperature	1			
HP Loop Return Temperature	1			
HP Loop Tower SWT	1			
HP Loop Boiler SWT	1			
HP Loop Pressure	1			
CHW Supply Temperature	1			
CHW Return Temperature	1			
OA Temperature	1			
Pump 1 Status		1		
Pump 2 Status		1		
Pump 3 Status		1		
Pump 4 Status		1		
Pump 5 Status		1		
Tower Fan 1 Status		1		
Chiller Alarm		1		
Boiler 1 Alarm		1		
Boiler 2 Alarm		1		
Pump 3 S/S (HP Loop)			1	
Pump 4 S/S (HP Loop)			1	
Pump 1 S/S (Tower)			1	
Pump 2 S/S (Tower)			1	
Boiler 1 S/S			1	
Boiler 2 S/S			1	
Chiller S/S			1	
Tower Fan 1 S/S			1	
Loop Pump 3 VFD				1
Loop Pump 4 VFD				1
Sum of Points	8	9	8	2
				27

END OF SECTION 230953

## SECTION 232113 - HYDRONIC PIPING

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

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

#### 1.2 SUMMARY

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

#### 1.3 DEFINITIONS

- A. CPVC: Chlorinated polyvinyl chloride.
- B. PVC: Polyvinyl chloride.

#### 1.4 SUBMITTALS

- A. Product Data: For each type of special-duty valve indicated. Include flow and pressure drop curves based on manufacturer's testing for diverting fittings, calibrated balancing valves, and automatic flow-control valves.
- B. Shop Drawings: Detail fabrication of pipe anchors, hangers, special pipe support assemblies, alignment guides, expansion joints and loops, and their attachment to the building structure. Detail location of anchors, alignment guides, and expansion joints and loops.
- C. Welding Certificates: Copies of certificates for welding procedures and personnel.
- D. Field Test Reports: Written reports of tests specified in Part 3 of this Section. Include the following:
  - 1. Test procedures used.
  - 2. Test results that comply with requirements.
  - 3. Failed test results and corrective action taken to achieve requirements.
- E. Maintenance Data: For hydronic specialties and special-duty valves to include in maintenance manuals specified in Division 23.
- F. Water Analysis: Submit a copy of the water analysis to illustrate water quality available at Project site.

#### 1.5 QUALITY ASSURANCE

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

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

## 1.6 COORDINATION

- A. Coordinate layout and installation of hydronic piping and suspension system components with other construction, including light fixtures, HVAC equipment, fire-suppression-system components, and partition assemblies.
- B. Coordinate pipe sleeve installations for foundation wall penetrations.
- C. Coordinate piping installation with roof curbs, equipment supports, and roof penetrations.
- D. Coordinate pipe fitting pressure classes with products specified in related Sections.
- E. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into base. Concrete, reinforcement, and formwork requirements are specified in Division 3 Sections.
- F. Coordinate installation of pipe sleeves for penetrations through exterior walls and floor assemblies. Coordinate with requirements for firestopping specified in Division 7 Section "Through-Penetration Firestop Systems" for fire and smoke wall and floor assemblies.

## 1.7 EXTRA MATERIALS

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

## PART 2 - PRODUCTS

### 2.1 MANUFACTURERS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Grooved Mechanical-Joint Fittings and Couplings:
    - a. Central Sprinkler Company; Central Grooved Piping Products.
    - b. Grinnell Mechanical Products.
    - c. Victaulic Company of America.
  - 2. Calibrated Balancing Valves:
    - a. Armstrong Pumps, Inc.
    - b. Flow Design, Inc.
    - c. Gerand Engineering Company.
    - d. Griswold Controls.
    - e. ITT Bell & Gossett; ITT Fluid Technology Corp.
    - f. Taco, Inc.
    - g. Tour Andersson supplied by Victaulic
  - 3. Pressure-Reducing Valves:
    - a. Amtrol, Inc.
    - b. Armstrong Pumps, Inc.
    - c. Conbraco Industries, Inc.
    - d. ITT Bell & Gossett; ITT Fluid Technology Corp.
    - e. Spence Engineering Company, Inc.

- f. Watts Industries, Inc.; Watts Regulators.
4. Safety Valves:
  - a. Amtrol, Inc.
  - b. Armstrong Pumps, Inc.
  - c. Conbraco Industries, Inc.
  - d. ITT McDonnell & Miller Div.; ITT Fluid Technology Corp.
  - e. Kunkle Valve Division.
  - f. Spence Engineering Company, Inc.
5. Automatic Flow-Control Valves:
  - a. Flow Design, Inc.
  - b. Griswold Controls.
6. Expansion Tanks:
  - a. Amtrol, Inc.
  - b. Armstrong Pumps, Inc.
  - c. ITT Bell & Gossett; ITT Fluid Technology Corp.
  - d. Taco, Inc.
7. Air Separators and Air Purgers:
  - a. Amtrol, Inc.
  - b. Armstrong Pumps, Inc.
  - c. ITT Bell & Gossett; ITT Fluid Technology Corp.
  - d. Taco, Inc.

## 2.2 PIPING MATERIALS

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

## 2.3 COPPER TUBE AND FITTINGS

- A. Drawn-Temper Copper Tubing: ASTM B 88, Type L.
- B. Annealed-Temper Copper Tubing: ASTM B 88, Type K.
- C. DWV Copper Tubing: ASTM B 306, Type DWV.
- D. Wrought-Copper Fittings: ASME B16.22.
- E. Wrought-Copper Unions: ASME B16.22.
- F. Solder Filler Metals: ASTM B 32, 95-5 tin antimony.
- G. Brazing Filler Metals: AWS A5.8, Classification BAg-1 (silver).

## 2.4 STEEL PIPE AND FITTINGS

- A. Steel Pipe, NPS 2 and Smaller: ASTM A 53, Type S (seamless) or Type F (furnace-butt welded), Grade B, Schedule 40, black steel, plain ends.
- B. Steel Pipe, NPS 2-1/2 through NPS 12: ASTM A 53, Type E (electric-resistance welded), Grade B, Schedule 40, black steel, plain ends.
- C. Steel Pipe, NPS 14 through NPS 18: ASTM A 53, Type E (electric-resistance welded) or Type S (seamless), Grade B, Schedule 30, black steel, plain ends.
- D. Steel Pipe, NPS 20: ASTM A 53, Type E (electric-resistance welded) or Type S (seamless),

Grade B, Schedule 20, black steel, plain ends.

1. Steel Pipe Nipples: ASTM A 733, made of ASTM A 53, Schedule 40, black steel; seamless for NPS 2 and smaller and electric-resistance welded for NPS 2-1/2 and larger.
- E. Cast-Iron Threaded Fittings: ASME B16.4; Classes 125 and 250.
- F. Malleable-Iron Threaded Fittings: ASME B16.3, Classes 150 and 300.
- G. Malleable-Iron Unions: ASME B16.39; Classes 150, 250, and 300.
- H. Cast-Iron Pipe Flanges and Flanged Fittings: ASME B16.1, Classes 25, 125, and 250; raised ground face, and bolt holes spot faced.
- I. Wrought-Steel Fittings: ASTM A 234/A 234M, wall thickness to match adjoining pipe.
- J. Wrought Cast- and Forged-Steel Flanges and Flanged Fittings: ASME B16.5, including bolts, nuts, and gaskets of the following material group, end connections, and facings:
1. Material Group: 1.1.
  2. End Connections: Butt welding.
  3. Facings: Raised face.
- K. Grooved Mechanical-Joint Fittings: ASTM A 536, Grade 65-45-12 ductile iron; ASTM A 47, Grade 32510 malleable iron; ASTM A 53, Type F, E, or S, Grade B fabricated steel; or ASTM A 106, Grade B steel fittings with grooves or shoulders designed to accept grooved end couplings.
- L. **Standard Mechanical Couplings, 2 inch through 12 inch:** Manufactured in two segments of cast ductile iron, conforming to ASTM A-536, Grade 65-45-12. Gaskets shall be pressure-responsive synthetic rubber, grade to suit the intended service, conforming to ASTM D-2000. (Gaskets used for potable water applications shall be UL classified in accordance with ANSI/NSF-61 for potable water service.) Mechanical Coupling bolts shall be zinc plated (ASTM B-633) heat treated carbon steel track head conforming to ASTM A-449 and ASTM A-183, minimum tensile strength 110,000 psi (758450 kPa).
- a. **Rigid Type:** Coupling housings with offsetting, angle-pattern bolt pads shall be used to provide system rigidity and support and hanging in accordance with ANSI B31.1, B31.9, and NFPA 13.
    1. 2 inch through 12 inch: Installation ready rigid coupling for direct stab installation without field disassembly. Gasket shall be Grade EPDM compound designed for operating temperatures from -30 deg F to +250 deg F. Gasket temperature rating shall be met without the use of special lubricants.
  - b. **Flexible Type:** Use in locations where vibration attenuation and stress relief are required. Flexible couplings may be used in lieu of flexible connectors at equipment connections. Three couplings, for each connector, shall be placed in close proximity to the vibration source.
    1. 2" through 8": Installation-ready flexible coupling for direct stab installation without field disassembly. Gasket shall be grade EPDM compound designed for operating temperatures from -30 deg F to +250 deg F. Gasket temperature rating shall be met without the use of special lubricants.
    2. 10" through 12": Standard flexible couplings. Gasket shall be Grade "E" EPDM compound designed for operating temperatures from -30 deg F to +230 deg F.
- M. Flexible Connectors: Stainless-steel bellows with woven, flexible, bronze, wire-reinforcing protective jacket; 150-psig minimum working pressure and 250 deg F maximum operating temperature. Connectors shall have flanged or threaded-end connections to match equipment connected and shall be capable of 3/4-inch misalignment.

- N. Spherical, Rubber, Flexible Connectors: Fiber-reinforced rubber body with steel flanges drilled to align with Classes 150 and 300 steel flanges; operating temperatures up to 250 deg F and pressures up to 150 psig.
- O. Packed, Slip, Expansion Joints: 150-psig minimum working pressure, steel pipe fitting consisting of telescoping body and slip-pipe sections, packing ring, packing, limit rods, flanged ends, and chrome-plated finish on slip-pipe telescoping section.
- P. Welding Materials: Comply with Section II, Part C, of the ASME Boiler and Pressure Vessel Code for welding materials appropriate for wall thickness and for chemical analysis of pipe being welded.
- Q. Gasket Material: Thickness, material, and type suitable for fluid to be handled; and design temperatures and pressures.

## 2.5 PLASTIC PIPE AND FITTINGS

- A. CPVC Plastic Pipe: ASTM F 441, Schedules 40 and 80, plain ends.
- B. PVC Plastic Pipe: ASTM D 1785, Schedules 40 and 80, plain ends.
- C. CPVC Plastic Pipe Fittings: Socket-type pipe fittings, ASTM F 438 for Schedule 40 pipe; ASTM F 439 for Schedule 80 pipe.
  - 1. CPVC Solvent Cement: ASTM F 493.
- D. PVC Plastic Pipe Fittings: Socket-type pipe fittings, ASTM D 2466 for Schedule 40 pipe; ASTM D 2467 for Schedule 80 pipe.
  - 1. PVC Solvent Cement: ASTM D 2564.

## 2.6 VALVES

- A. Gate, globe, check, ball, and butterfly valves are specified in Division 23 Section "Valves."
- B. Grooved-End Butterfly Valves
  - 1. 2" through 12" Sizes: 300 psi CWP suitable for bidirectional and dead-end service at full rated pressure. Body shall be grooved end black enamel coated ductile iron conforming to ASTM A536. Disc shall be electroless nickel plated ductile iron with blowout proof 416 stainless steel stem. Disc shall be offset from the stem centerline to allow full 360 degree circumferential seating. Seat shall be pressure responsive EPDM. Valve bearings shall be TFE lined fiberglass, and stem seals shall be of the same grade elastomer as the valve seat. Valve shall be complete with ISO flange for actuation mounting. Valve operators shall be lever handle or gear operator, available with memory stop feature, locking device, chainwheel, or supplied bare. (Valve with EPDM seat is UL classified in accordance with ANSI/NSF-61.)
- C. Grooved-End Check Valves
  - 1. 2 inch through 12 inch sizes: Spring Assisted: Black enamel coated ductile iron body, ASTM A-536, Grade 65-45-12, elastomer encapsulated ductile iron disc suitable for intended service, stainless steel spring and shaft, welded-in nickel seat, 300 psi. Valve with pre-tapped ports as available option.
- D. Refer to Part 3 "Valve Applications" Article for applications of each valve.
- E. Calibrated Balancing Valves, NPS 2 and Smaller: Bronze body, ball type, 125-psig working pressure, 250 deg F maximum operating temperature, and having threaded ends. Valves shall

have calibrated orifice or venturi, connections for portable differential pressure meter with integral seals, and be equipped with a memory stop to retain set position.

- F. Calibrated Balancing Valves, NPS 2-1/2 and Larger: Cast-iron or steel body, ball type, 125-psig working pressure, 250 deg F maximum operating temperature, and having flanged or grooved connections. Valves shall have calibrated orifice or venturi, connections for portable differential pressure meter with integral seals, and be equipped with a memory stop to retain set position.
- G. Pressure-Reducing Valves: Diaphragm-operated, bronze or brass body with low inlet pressure check valve, inlet strainer removable without system shutdown, and noncorrosive valve seat and stem. Select valve size, capacity, and operating pressure to suit system. Valve shall be factory set at operating pressure and have capability for field adjustment.
- H. Safety Valves: Diaphragm-operated, bronze or brass body with brass and rubber, wetted, internal working parts; shall suit system pressure and heat capacity and shall comply with the ASME Boiler and Pressure Vessel Code, Section IV.
- I. Automatic Flow-Control Valves: Gray-iron body, factory set to maintain constant flow with plus or minus 5 percent over system pressure fluctuations, and equipped with a readout kit including flow meter, probes, hoses, flow charts, and carrying case. Each valve shall have an identification tag attached by chain, and be factory marked with the zone identification, valve number, and flow rate. Valve shall be line size and one of the following designs:
  - 1. Gray-iron or brass body, designed for 175 psig at 200 deg F with stainless-steel piston and spring.
  - 2. Brass or ferrous-metal body, designed for 300 psig at 250 deg F with corrosion-resistant, tamperproof, self-cleaning, piston-spring assembly easily removable for inspection or replacement.
  - 3. Combination assemblies, including bronze ball valve and brass alloy control valve, with stainless-steel piston and spring, fitted with pressure and temperature test valves, and designed for 300 psig at 250 deg F.
- J. Plastic Ball Valves: 150-psig working pressure, 250 deg F maximum operating temperature, full port design, 1- or 2-piece body design, CPVC body and ball, polytetrafluoroethylene seats, EPDM seals, and tee handle; with threaded, socket, union, or flanged connections.
- K. Plastic Butterfly Valves: 150-psig working pressure, 250 deg F maximum operating temperature, PVC wafer body, polytetrafluoroethylene seats, lever lock handle, and wafer style for installation between flanges.

## 2.7 HYDRONIC SPECIALTIES

- A. Manual Air Vent: Bronze body and nonferrous internal parts; 150-psig working pressure; 225 deg F operating temperature; manually operated with screwdriver or thumbscrew; with NPS 1/8 discharge connection and NPS 1/2 inlet connection.
- B. Automatic Air Vent: Designed to vent automatically with float principle; bronze body and nonferrous internal parts; 150-psig working pressure; 240 deg F operating temperature; with NPS 1/4 discharge connection and NPS 1/2 inlet connection.
- C. Expansion Tanks: Welded carbon steel, rated for 125-psig working pressure and 375 deg F maximum operating temperature, with taps in bottom of tank for tank fitting and taps in end of tank for gage glass. Tanks shall be factory tested with taps fabricated and labeled according to the ASME Boiler and Pressure Vessel Code, Section VIII, Division 1. Include the following fittings and accessories:

1. Air-Control Tank Fitting: Cast-iron body, copper-plated tube, brass vent tube plug, and stainless-steel ball check, 100-gal. unit only; sized for compression-tank diameter. Design tank fittings for 125-psig working pressure and 250 deg F maximum operating temperature.
  2. Tank Drain Fitting: Brass body, nonferrous internal parts; 125-psig working pressure and 240 deg F maximum operating temperature; designed to admit air to compression tank, drain water, and close off system.
  3. Gage Glass: Full height with dual manual shutoff valves, 3/4-inch- diameter gage glass, and slotted-metal glass guard.
- D. Expansion Tanks: Welded carbon steel, rated for 125-psig working pressure and 375 deg F maximum operating temperature. Separate air charge from system water to maintain design expansion capacity by a flexible bladder securely sealed into tank. Include drain fitting and taps for pressure gage and air-charging fitting. Support vertical tanks with steel legs or base; support horizontal tanks with steel saddles. Factory fabricate and test tank with taps and supports installed and labeled according to the ASME Boiler and Pressure Vessel Code, Section VIII, Division 1.
- E. Tangential-Type Air Separators: Welded black steel; ASME constructed and labeled for 125-psig minimum working pressure and 375 deg F maximum operating temperature; perforated stainless-steel air collector tube designed to direct released air into expansion tank; tangential inlet and outlet connections; threaded connections for NPS 2 and smaller; flanged connections for NPS 2-1/2 and larger; threaded blowdown connection. Provide units in sizes for full-system flow capacity.
- F. In-Line Air Separators: One-piece cast iron with an integral weir designed to decelerate system flow to maximize air separation at a working pressure up to 175 psig and liquid temperature up to 300 deg F.
- G. Air Purgers: Cast-iron body with internal baffles that slow the water velocity to separate the air from solution and divert it to the vent for quick removal. Maximum working pressure of 150 psig and temperature of 250 deg F.
- H. Bypass Chemical Feeder: Welded steel construction; 125-psig working pressure; 5-gal. capacity; with fill funnel and inlet, outlet, and drain valves.
1. Chemicals: Specially formulated, based on analysis of makeup water, to prevent accumulation of scale and corrosion in piping and connected equipment.
- I. Diverting Fittings: 125-psig working pressure; 250 deg F maximum operating temperature; cast-iron body with threaded ends, or wrought copper with soldered ends. Indicate flow direction on fitting.
- J. Y-Pattern Strainers: 125-psig working pressure; cast-iron body (ASTM A 126, Class B), flanged ends for NPS 2-1/2 and larger, threaded connections for NPS 2 and smaller, bolted cover, perforated stainless-steel basket, and bottom drain connection.
- K. Grooved Y-Pattern Strainer: 2 inch through 18 inch sizes, 300 PSI Y-Type Strainer shall consist of ductile iron body, ASTM A-536, Grade 65-45-12, Type 304 stainless steel perforated metal removable baskets with 1/16" (1,6mm) diameter perforations 2"-3" strainer sizes, 1/8" (3,2mm) diameter perforations 4"-12" strainer sizes, and 0.156" (4mm) diameter perforations 14" -18" strainer sizes. Strainer basket shall be accessed by removal of mechanical coupling.
- L. Basket Strainers: 125-psig working pressure; high-tensile cast-iron body (ASTM A 126, Class B), flanged-end connections, bolted cover, perforated stainless-steel basket, and bottom drain connection.



- M. T-Pattern Strainers: 750-psig working pressure; ductile-iron or malleable-iron body, grooved-end connections, stainless-steel basket with 57 percent free area; removable access coupling and end cap for strainer maintenance.
- N. Grooved T-Pattern Strainer: 2" through 12" sizes, 300 PSI T-Type Strainer shall consist of ductile iron (ASTM A-536, Grade 65-45-12) body, Type 304 stainless steel frame and mesh removable basket with No. 12 mesh, 2"-3" strainer sizes, or No. 6 mesh, 4"-12" strainer sizes, 57% free open area. Strainer basket shall be accessed by removal of mechanical coupling.
- O. Flexible Connectors: Stainless-steel bellows with woven, flexible, bronze, wire-reinforcing protective jacket; 150-psig minimum working pressure and 250 deg F maximum operating temperature. Connectors shall have flanged- or threaded-end connections to match equipment connected and shall be capable of 3/4-inch misalignment.
- P. Spherical, Rubber, Flexible Connectors: Fiber-reinforced rubber body with steel flanges drilled to align with Classes 150 and 300 steel flanges; operating temperatures up to 250 deg F and pressures up to 150 psig.
- Q. Packed, Slip, Expansion Joints: 150-psig minimum working pressure, steel pipe fitting consisting of telescoping body and slip-pipe sections, packing ring, packing, limit rods, flanged ends, and chrome-plated finish on slip-pipe telescoping section.

### PART 3 - EXECUTION

#### 3.1 PIPING APPLICATIONS

- A. Heat Pump Water, NPS 2 and Smaller: Aboveground, use Type L drawn-temper copper tubing with soldered joints or Schedule 40 steel pipe with threaded joints. Belowground or within slabs, use Type K annealed-temper copper tubing with soldered joints. Use the fewest possible joints belowground and within floor slabs.
- B. Heat Pump Water, NPS 2-1/2 and Larger: Schedule 40 steel pipe with welded and flanged joints.
- C. Condensate Drain Lines: Type L drawn-temper copper tubing with soldered joints or Schedule 40, PVC pipe with solvent-welded joints.

#### 3.2 VALVE APPLICATIONS

- A. General-Duty Valve Applications: Unless otherwise indicated, use the following valve types:
  - 1. Shutoff Duty: Gate, ball, and butterfly valves.
  - 2. Throttling Duty: Globe, ball, and butterfly valves.
- B. Install shutoff duty valves at each branch connection to supply mains, at supply connection to each piece of equipment, unless only one piece of equipment is connected in the branch line. Install throttling duty valves at each branch connection to return mains, at return connections to each piece of equipment, and elsewhere as indicated.
- C. Install calibrated balancing valves in the return water line of each heating or cooling element and elsewhere as required to facilitate system balancing.
- D. Install check valves at each pump discharge and elsewhere as required to control flow direction.
- E. Install safety valves on hot-water generators and elsewhere as required by the ASME Boiler and Pressure Vessel Code. Install safety-valve discharge piping, without valves, to floor.

Comply with the ASME Boiler and Pressure Vessel Code, Section VIII, Division 1, for installation requirements.

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

### 3.3 PIPING INSTALLATIONS

- A. Refer to Division 23 Section "Basic Mechanical Materials and Methods" for basic piping installation requirements.
- B. Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.
- C. Install drains, consisting of a tee fitting, NPS 3/4 ball valve, and short NPS 3/4 threaded nipple with cap, at low points in piping system mains and elsewhere as required for system drainage.
- D. Install piping at a uniform grade of 0.2 percent upward in direction of flow.
- E. Reduce pipe sizes using eccentric reducer fitting installed with level side up.
- F. Unless otherwise indicated, install branch connections to mains using tee fittings in main pipe, with the takeoff coming out the bottom of the main pipe. For up-feed risers, install the takeoff coming out the top of the main pipe.
- G. Install strainers on supply side of each control valve, pressure-reducing valve, solenoid valve, in-line pump, and elsewhere as indicated. Install NPS 3/4 nipple and ball valve in blowdown connection of strainers NPS 2 and larger. Match size of strainer blowoff connection for strainers smaller than NPS 2.
- H. Anchor piping for proper direction of expansion and contraction.

### 3.4 HANGERS AND SUPPORTS

- A. Hanger, support, and anchor devices are specified in Division 23 Section "Hangers and Supports." Comply with requirements below for maximum spacing of supports.
- B. Install the following pipe attachments:
  1. Adjustable steel clevis hangers for individual horizontal piping less than 20 feet long.
  2. Adjustable roller hangers and spring hangers for individual horizontal piping 20 feet or longer. cal runs at roof, at each floor, and at 10-foot intervals between floors.

### 3.5 PIPE JOINT CONSTRUCTION

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

### 3.6 HYDRONIC SPECIALTIES INSTALLATION

- A. Install manual air vents at high points in piping, at heat-transfer coils, and elsewhere as required for system air venting.
- B. Install automatic air vents in mechanical equipment rooms only at high points of system piping, at heat-transfer coils, and elsewhere as required for system air venting.
- C. Install dip-tube fittings in boiler outlet. Install piping to expansion tank with a 2 percent upward

slope toward tank. Connect boiler-outlet piping.

- D. Install in-line air separators in pump suction lines. Install piping to compression tank with a 2 percent upward slope toward tank. Install drain valve on units NPS 2 and larger.
- E. Install combination air separator and strainer in pump suction lines. Install piping to compression tank with a 2 percent upward slope toward tank. Install blowdown piping with gate valve; extend to nearest drain.
- F. Install bypass chemical feeders in each hydronic system where indicated, in upright position with top of funnel not more than 48 inches above floor. Install feeder in bypass line, off main, using globe valves on each side of feeder and in the main between bypass connections. Pipe drain, with ball valve, to nearest equipment drain.
- G. Install expansion tanks above air separator. Install gage glass and cocks on end of tank. Install tank fitting in tank bottom and charge tank. Use manual vent for initial fill to establish proper water level in tank.
  - 1. Support tank from floor or structure above with sufficient strength to carry weight of tank, piping connections, and fittings, plus weight of a full tank of water. Do not overload building components and structural members.
- H. Install expansion tanks on floor. Vent and purge air from hydronic system, and ensure tank is properly charged with air to suit system design requirements.

### 3.7 TERMINAL EQUIPMENT CONNECTIONS

- A. Size for supply and return piping connections shall be same as for equipment connections.
- B. Install control valves in accessible locations close to connected equipment.
- C. Install bypass piping with globe valve around control valve. If multiple, parallel control valves are installed, only one bypass is required.
- D. Install ports for pressure and temperature gages at coil inlet connections.

### 3.8 CHEMICAL TREATMENT

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

### 3.9 FIELD QUALITY CONTROL

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

7. The grooved couplings gasket style and elastomeric material (grade) shall be verified as suitable for the intended service as specified.
8. Grooved couplings installation shall be complete when visual metal-to-metal contact is reached.

### 3.10 GROOVED PIPING TRAINING

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

## PART 4 - Testing

- A. Perform the following tests on hydronic piping:
  1. Use ambient temperature water as a testing medium unless there is risk of damage due to freezing. Another liquid that is safe for workers and compatible with piping may be used.
  2. While filling system, use vents installed at high points of system to release trapped air. Use drains installed at low points for complete draining of liquid.
  3. Check expansion tanks to determine that they are not air bound and that system is full of water.
  4. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the design pressure. Test pressure shall not exceed maximum pressure for any vessel, pump, valve, or other component in system under test. Verify that stress due to pressure at bottom of vertical runs does not exceed either 90 percent of specified minimum yield strength or 1.7 times "SE" value in Appendix A of ASME B31.9, "Building Services Piping."
  5. After hydrostatic test pressure has been applied for at least 10 minutes, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components and repeat hydrostatic test until there are no leaks.
  6. Prepare written report of testing.

### 4.8 ADJUSTING

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

### 4.9 CLEANING

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

END OF SECTION 232113

## SECTION 232115 – HOT WATER HEATING SYSTEM

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

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

#### 1.2 SUMMARY

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

### PART 2 - NOT USED

### PART 3 - EXECUTION

#### 3.1 INSTALLATION

- A. Ends of all pipe shall be reamed out before being made up into fittings.
- B. Use graphite and oil applied to male threads only in making up all pipe joint fittings.
- C. Install unions on downstream side of shut-off valves and specialty valves and meters. Also install unions on both ends of radiation piping where piping goes from floor level into steel pipe troughs in floor slab.
- D. Use teflon tape for lubricating threads on all threaded connections.

#### 3.2 PIPING GRADE

- A. Heating supply and return lines are to be graded up 1 inch to 40 feet, in the direction of flow with the high and low points in every case being in the boiler room to permit drainage.
- B. Provide an automatic air eliminator at the high of each circuit and on the heating coils.
- C. If it is necessary to change the grade of a flow main due to an obstruction, the high point shall be vented with an automatic air vent.
- D. All runouts shall be taken off the top of the main and at least three elbow joints used on the spring piece to provide for expansion and contraction.

#### 3.3 CLEANING SYSTEM

- A. Thoroughly clean all equipment, piping and all other material controlled under this contract free from rust, scale, and other dirt before any painting or covering is done or the system is put into operation.
- B. The heating system shall be thoroughly cleaned by operating at 10 psi for at least 6 hours.
  - 1. At end of run, the boiler is to be filled to the top with water and any film of oil or grease is to be washed over the top.
  - 2. Drain the boiler completely and refill to proper level with fresh water.
  - 3. Repeat this process three (3) times.

4. Use 1 pound tri-sodium phosphate for every 100 gallons of water during cleaning operation.

#### 3.4 FIELD QUALITY CONTROL

- A. Piping systems shall be subjected to the following tests and no piping shall be covered or concealed until it has been so tested, inspected, and approved by the Architect and any local inspector having jurisdiction.
  1. Heating piping shall be hydrostatically tested at 50 psi in excess of maximum working pressures, 100 psi minimum.
  2. Without connecting equipment items rated below 100 psi, pressure test system at 100 psi for two hours. Correct leaks and defective work and repeat test until no leaks appear.
  3. When so directed by Architect or Engineer, the Contractor shall conduct an operating test on any piece of equipment to demonstrate its capacity and/or operating characteristics.

END OF SECTION 232115

## SECTION 232116 – HOT WATER HEATING SYSTEM SPECIALTIES

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

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

#### 1.2 SUMMARY

- A. Furnish and install hot water heating specialties as described in Contract Documents.

### PART 2 - PRODUCTS

#### 2.1 MANUAL AIR VALVES

- A. On each coil or piece of equipment wherever an air pocket can form.
- B. On each high point of piping or as shown on plans.
- C. Approved Manufacturers:
  - 1. Hoffman #500 or equal complete with #550 air chamber.

#### 2.2 AUTOMATIC AIR ELIMINATORS

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

#### 2.3 BALANCING FITTINGS

- A. Automatic flow regulator kits complete with ball valve and strainer with capacity shown. Provide P/T test valves.
  - 1. Approved Manufacturers:
    - a. Griswold
    - b. Auto flow
- B. Manual balance valves with capacity shown. Provide with PT gage taps.
  - 1. Approved Manufacturers:
    - a. Bell & Gossett circuit setters
    - b. Armstrong

#### 2.4 COMPRESSION TANKS

- A. Welded steel compression tanks of sizes shown, ASME Code for 30 lb. W.P., made of steel plate.
- B. Provide a water column with water gauge and gauge cocks on ends of tanks.
- C. Tanks to be furnished with three 3/4 inch I.P.S. female thread connections, one at either end and one in the middle.
- D. Approved Manufacturers

1. B&G

## 2.5 AIR SEPARATORS

- A. Furnish and install as shown on plans, air separator with tangential nozzles. The air separator shall be fitted with an NPT vent connection to facilitate installation of piping to connect a compression tank.
- B. An NPT tapping shall be provided on the bottom of the air separator to facilitate blowdown.
- C. The air separator shall also be equipped with a steel system strainer with a free area of not less than four times the cross sectional area of the connecting piping.
- D. Air separators shall be fabricated steel with flanged connections, designed and constricted for 165 psig @ 375F, and in accordance with Section VIII Division I of ASME Boiler & Pressure Vessel Code.
- E. Approved Manufacturers
  1. B&G Rollairtrol
  2. Armstrong VAS

## 2.6 PRESSURE GAUGES

- A. Cases shall be black enameled cast aluminum with back flange for surface or line mounting.
- B. Gauges shall be of the repairable type with sturdy brass movements and phosphor bronze tubes.
- C. Range shall be selected so that normal operating pressure shall be approximately at the center of the dial.
- D. 3-1/2 inch figure bourdon tube type pressure gauge.
- E. Install on inlet of each pressure gauge a No. 38, 1/4 inch consolidated brass "T" handle gauge cock.
- F. Approved Manufacturers:
  1. U. S. Gauge
  2. Trefice

## 2.7 BOILER FITTINGS & COMPRESSION TANK FITTINGS

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



2.8 SELF-FILLING VALVES

- A. 3/4 inch reducing valves (self-filling)
- B. Brass body and bronze interior
- C. Install on water service to boiler.
- D. Approved Manufacturers:
  - 1. Bell & Gossett No. 12
  - 2. Or equal

2.9 BOILER RELIEF VALVE

- A. ASME Code relief valve.
- B. Approved Manufacturers:
  - 1. Bell & Gossett
  - 2. Or Equal

2.10 THERMOMETERS AND ACCESSORIES

- A. Red reading, mercury, separable socket, 7 inch cast, adjustable with 3 1/2 inch stem.
- B. Range: Heating 30 degrees to 240 degrees F.
- C. Provide other accessories as shown.
- D. Approved Manufacturers:
  - 1. Weiss
  - 2. Trerice
  - 3. Palmer

**PART 3 - EXECUTION**

3.1 INSTALLATION

- A. Install pressure gauges on each side of each pump and elsewhere as shown on plans.
- B. Install "T" handle gauge cock on the inlet of each pressure gauge.

END OF SECTION 232116

SECTION 232118 – BACKFLOW PREVENTER VALVE

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

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

PART 2 - PRODUCTS

2.1 MANUFACTURED UNITS

- A. Designed to provide separation of radiant hot water heating system water from domestic cold water supply in accordance with Code.
  - 1. Rated flow at 30 psi pressure drop rated for 175 psi inlet pressure and 140 deg. F maximum operating temperature.
  - 2. Brass body construction with 3/4 inch NPT connections.
- B. Approved Manufacturers:
  - 1. Beeco 12
  - 2. Watts 900
  - 3. Equal by Febco
  - 4. Equal by Conbraco

PART 3 - EXECUTION

3.1 INSTALLATION

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

END OF SECTION 232118

## SECTION 232123 – CIRCULATING PUMPS AND ACCESSORIES

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

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

#### 1.2 SUMMARY

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

### PART 2 - PRODUCTS

#### 2.1 SUSPENDED WET PIT PUMPS

- A. The pump casing shall have an integrally cast discharge flange. The suction strainer shall be fabricated 304 stainless steel with iron bottom plate.
- B. The impeller shall be semi-open and capable of passing 1 3/8" solids. The impeller shall contain a balancing ring and be cast in iron and be secured to shaft by taper fit, with Woodruff key, castellated nut, washer and cotter pin.
- C. All shafting shall be 316 stainless steel and shall be a minimum of 1 1/4" diameter between the coupling and the impeller. Column pipe shall be steel with welded flanges machined for registered fit.
- D. The pump bearing, located directly above impeller, shall be of bronze. Bearing housing shall be of 316 stainless steel.
- E. An intermediate bearing of the same materials as the pump bearing must be provided on pumps in excess of 6'-0" in length. On intermediate bearing for each additional 5'-0" pump length shall be furnished.
- F. Pump and intermediate bearings shall be water lubricated through separate lubrication lines terminating at the cover plate.
- G. The motor support shall be of cast iron, machined to assure positive alignment of motor and pump shaft, fitted with a high thrust angular contact bearing with moisture-proof enclosure and grease seals. External impeller and shaft axial adjustment shall be provided.
- H. Water make-up operation shall be controlled by a float operated switch. Float rod shall be fiberglass. Float shall be 304 stainless steel. Float stops shall be 304 stainless steel.
- I. The flexible coupling between the motor and pump shafts shall be Woods Sure-Flex spacer type coupling.
- J. Pumps shall be driven by a standard "C" face vertical electric motor.

#### 2.2 PUMP SUCTION DIFFUSERS:

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

drawings.

- B. Angle type body with inlet vanes and combination diffuser-strainer-orifice cylinder.
- C. Approved Manufacturers:
  - 1. Bell & Gossett
  - 2. Armstrong
  - 3. Or approved equal

### 2.3 TRIPLE DUTY VALVES

- A. Place on each pump discharge. Valve serves as a non-slam check valve with spring loaded disk check, calibrated adjustable and lockable balance valve and full shutoff valve with memory stop. Valve shall be back-seated so as to allow repacking under full line pressure.
- B. Cast iron body
- C. Bronze disk and seat with stainless steel stems and springs.
- D. Teflon packing
- E. Maximum valve working pressure of 175 psig and a maximum operating temperature of 300 deg. F.
- F. Approved Manufacturers:
  - 1. Bell & Gossett
  - 2. Armstrong

### 2.4 EXPANSION JOINT PUMP CONNECTORS

- A. Precision machine molded neoprene and nylon construction internal reinforced by means of steel wire.
- B. Cadmium steel floating flanges tapped to mate with 150# ASA companion flanges.
- C. Capable of operating at a temperature of 20 deg. F. thru 220 deg. F. and at a pressure ranging from 10" HG vacuum thru 150 psi working pressure.
- D. Capable of 15 deg. angular deflection.
- E. Twin quiet-sphere design with control rods.
- F. Approved Manufacturers:
  - 1. Vibration Mountings & Controls, Inc.
  - 2. Metraflex

### 2.5 IN-LINE CIRCULATORS

- A. Bronze fitted with ceramic seal, spring coupling, and 1750-rpm, drip-proof motor with overload protection.
- B. Substantially supported in piping with a full size leg to floor.
- C. Approved Manufacturers:
  - 1. Bell & Gossett

2. Armstrong
3. Grundfos

### PART 3 - EXECUTION

#### 3.1 INSTALLATION

- A. Install equipment in accordance with manufacturers instructions.
- B. Align pump and motor shafts in accordance with manufacturers requirements before starting equipment. Provide report in the M&O manual regarding pump alignment.
- C. Remove start-up filter screen on suction diffuser after system has been cleaned and flushed. Leave main filter screen in place.

END OF SECTION 232123

## SECTION 232166 - SPLIT SYSTEM HEAT PUMP UNITS

### PART 1 - GENERAL

#### 1.1 SUMMARY

- A. Includes But Not Limited To
  - 1. Furnish and install heat pumps as described in Contract Documents.
- B. Related Sections
  - 1. Section 23 0501 - Common HVAC Requirements

#### 1.2 SUBMITTALS

- A. [Quality Assurance / Control](#) - Equipment check-out sheets

#### 1.3 QUALITY ASSURANCE

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

#### 1.4 WARRANTY

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

### PART 2 - PRODUCTS

#### 2.1 MANUFACTURED UNITS

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

PART 3 - EXECUTION

3.1 FIELD QUALITY CONTROL

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

END OF SECTION 232166

## SECTION 232200 - WATER SOURCE HEAT PUMP SYSTEM

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

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

#### 1.2 SUMMARY

- A. Furnish and install water source heat pump system as described in Contract Documents.

#### 1.3 QUALITY ASSURANCE

- A. Units of the type furnished shall have been in successful operation at least five years.
- B. Units shall be UL listed and ARI certified, and shall be in accordance with the Canadian Standards Association (CSI).
- C. The units shall have ARI, UL, and CSI labels.
- D. All units shall be factory tested under normal operation conditions and normal water flow rates. Units that are tested without water flow are not acceptable.
- E. Units shall be Climate Master, Trane or Mammoth.

#### 1.4 WARRANTY

- A. Compressors shall be provided with five-year warranties.

### PART 2 - PRODUCTS

#### 2.1 GENERAL

- A. System shall consist of water-to-air reverse cycle air conditioning units of the type, size, capacity, and style scheduled on the drawings.
- B. Units shall be interconnected thru a non-refrigerated central water system, maintained within an approximate temperature range of 40 degrees F. to 110 degrees F. by means of a supplementary heat source and closed circuit evaporative type water cooler.
- C. Piping system shall be two-pipe reverse-return as shown on the plans complete with primary and standby circulating pumps.
- D. Individual room temperature control including necessary safety and operating controls shall be furnished as integral or accessory parts of the air conditioning units.

#### 2.2 ELECTRO-HYDRONIC WATER SOURCE HEAT PUMPS

- A. Refrigeration Circuit:
  - 1. Units shall have a sealed refrigerant circuit including:
    - a. A hermetic compressor.
    - b. A refrigerant metering device.
    - c. A finned tube refrigerant to air heat exchanger.



- d. A reversing valve.
  - e. A coaxial (tube in tube) refrigerant to water heat exchanger.
  - f. Safety controls including a high pressure switch, a low pressure sensor, and a low water temperature (thermostat) switch.
2. Access fittings shall be factory installed on high and low pressure refrigerant lines to facilitate field service.
  3. Activation of any safety device shall prevent compressor operation via a lock out relay. The lockout relay shall be reset at the thermostat or at the contract furnished disconnect switch. Units which may be reset at the disconnect switch only are not acceptable.
  4. Hermetic compressors shall be internally sprung, externally isolated, with thermal overload protection and shall be located in an insulated compartment to minimize sound transmission. Units above 15,000 BTUH shall have the compressor mounted on spring isolators to reduce noise and vibration transmission. Rubber mounts for these larger units are not acceptable.
  5. Refrigerant to air heat exchangers shall utilize enhanced aluminum fins and rifled copper construction rated to withstand 425 psi refrigerant working pressure.
  6. Refrigerant to water heat exchangers shall be of copper inner water tube and steel refrigerant outer tube design, rated to withstand 450 psi working refrigerant pressure and 400 psi working water pressure.
  7. Refrigerant metering shall be accomplished by capillary tubes for units intended for use in standard operating ranges, or expansion valves for units intended for use in expanded operating ranges.
  8. Reversing valves shall be four-way solenoid activated refrigerant valves which shall fail to heating operation should the solenoid fail to function.
- B. Fan and Motor Assembly:
1. Units rated 60,000 BTUH and under shall have a direct drive centrifugal fan. The fan motor shall be 3-speed permanently lubricated, PSC type with thermal overload protection. Units supplied without permanently lubricated motors must provide external oilers for easy service. The fan motor shall be isolated from the fan housing by torsionally flexible isolation. Units 72,000 BTUH and above shall have a belt drive fan assembly. The assembly shall include a forward curved fan wheel, housing, solid steel fan shaft encased in ball bearings, fan pulley and adjustable motor sheave. The motor shall be a three phase, open type with external thermal overload protection. The motor shall be mounted on an adjustable base for proper belt tension. The fan and motor assembly must be capable of overcoming the external static pressures as shown on the schedule. External static pressure rating of the unit shall be based on a wet coil. Ratings based on dry coil shall not be acceptable.
- C. Electrical:
1. A control box shall be located within the unit and shall contain a transformer, controls for compressor, reversing valve and fan motor operation and shall have a terminal block for low voltage field wiring connections. Open controls in the air stream will not be acceptable. Units shall be name plated for use with time delay fuses or HACR circuit breakers. Unit controls shall be 24 volts and shall provide heating or cooling as required by the wall thermostat. Two compressor units shall have a solid state time delay to prevent both compressors from starting simultaneously. Provide integral interface for DDC control.
- D. Solid State Control System:
1. Units shall have a solid state control system. The control shall interface with any type of wall thermostat mechanical or electronic. The control system shall have the following features:
    - a. Anti-short cycle time delay on compressor operation, time delay shall be five (5) minutes minimum.
    - b. Random start on power up mode or return from night setback.

- c. Minimized reversing valve operation for extended life and quiet operation.
- d. Night setback override from low temperature thermostat.
- e. Two (2) hour override initiated by a signal from wall thermostat.
- f. Low voltage protection.
- g. High voltage protection.
- h. Ability to work with any thermostat.
- i. Single grounded wire to initiate night setback, demand load shed, or emergency shutdown.
- j. Unit shutdown on high or low refrigerant pressures.
- k. Unit shutdown on low water temperature.
- l. Option to reset unit at thermostat or disconnect.
- m. Automatic intelligent reset. Unit shall automatically reset the unit 10 minutes after trip if the fault has cleared. Should a fault re-occur within 30 minutes after reset, the permanent lockout will occur.
- n. Ability to defeat time delays for servicing.
- o. Light emitting diodes (LED) to indicate high pressure, low pressure, low voltage, high voltage, freeze protection, condensate overflow and control voltage status.
- p. Control logic shall only move the reversing valve when cooling is called for the first time. The reversing valve shall be held in this position until the first call for heating. This scheme ensures quiet operation and increased valve life. Only control schemes that provide this reduced reversing valve operation will be accepted.
- q. Control board shall have an eight (8) pin plug to allow the future addition of RS485 DDC circuitry. Control boards that cannot be upgraded to DDC by plugging in a module shall not be allowed.
- r. Control board shall allow up to three (3) units to be operated from one thermostat without any auxiliary controls.
- s. Optional 24 volt relay shall be required to provide dry contact alarm when used with a DDC system.

E. Basic Construction:

- 1. Horizontal units shall be fabricated from heavy gauge (GS90) galvanized sheet metal. All interior surfaces shall be lined with 1/2 inch, 1 1/2 lb. acoustic type glass fiber insulation. All fiberglass shall be coated and have exposed edges tucked under flanges to prevent the introduction of glass fibers into the airstream. All insulation must be NFPA 90A. Vertical unit shall be as above except the cabinet will have a painted baked enamel finish.
- 2. All units must have an insulated panel separating the fan compartment from the compressor compartment. Units with the compressor in the airstream are not acceptable. Cabinets shall have separate holes and knockouts for entrance of line voltage and low voltage control wiring. Supply and return water connections shall be copper FPT fittings and shall be securely mounted flush to the cabinet allowing for connection to a flexible hose without the use of a back-up wrench. Water connections which protrude through the cabinet or require the use of a backup wrench shall not be allowed.
- 3. To facilitate installation in minimal space requirements, units rated 30,000 BTUH and under shall have all electrical and water connections on the end of the cabinet opposite the duct connections. Contractor shall be responsible for any extra costs involved in the installation of units which do not have this feature. Contractor must also ensure that non-specified units can be easily removed for servicing and coordinate locations of electrical conduit and lights with the electrical contractor.
- 4. Units shall have the air flow arrangements as shown on plans.
- 5. Sound attenuation:
  - a. All units 15,000 BTUH and up must have a compressor discharge muffler.
  - b. Compressor side panels and base pan must have closed cell insulation rated at 5 lb/cu. ft. density.

- c. All reciprocating compressors must have high density damping material applied to the compressor shell.
- d. All units 15,000 BTUH and up shall have the compressors mounted on springs.

F. Air Filters:

- 1. Units shall have a factory installed two (2) inch thick filter bracket for side filter removal. Units shall have a two (2) inch thick pleated 30% efficient filter. Contractor shall be furnished one (1) set of spare filters to be turned over to Owner on completion of start-up. Filters shall be standard filter sizes. If units utilize non-standard filter sizes, then the contractor shall provide 4 spare sets of filters for each unit.

G. Units shall be furnished with a condensate overflow switch.

H. Each individual horizontal or vertical heat pump will have a minimum EER of 13.0 or higher, and a heating COP of 4.3 or higher.

### 2.3 PIPING, PUMPS AND ACCESSORIES

A. Water piping system shall be installed in accordance with the accompanying drawings to provide a self-balancing two-pipe reverse return arrangement.

B. Piping shall be graded to prevent air pockets and to enable any entrained air to rise in the direction of flow. Provide air vents where there is a possibility of collecting air.

C. Provide supply and return connections at each air conditioning unit location shown, plus any possible future locations as shown, to permit expansion or normal relocation and remodeling requirements.

D. Provide and install two system pumps of capacity and head scheduled on the drawings; one for continuous operation with the other on standby.

E. Hose Kits:

- 1. All units 120,000 BTUH and below shall be connected with hoses. The hoses shall be two (2) feet long, metal braided, and fire rated to meet UL 94. Non fire rated hoses are not acceptable. The hose on the supply side of the unit will be complete with a ball valve and strainer. The hose on the return side will be complete with a ball valve and flow control valve that encompasses in one assembly an automatic flow control valve that will guarantee the specified flow rate plus or minus 5% over a wide pressure differential without having any external adjustments. The hose kit and flow control assembly shall be Griswold or Autoflow.

F. Provide PVC hose or insulated copper condensate connection of each air conditioner to pitched condensate drain system. Connect copper to unit with flexible connection.

G. Provide water makeup expansion tank, air separator, etc., as shown in Contact Documents.

### 2.4 CONTROLS

A. Manufacturer of electro-hydraulic system components shall furnish the minimum list of system operating and safety controls.

B. System Safety and Operating Controls:

- 1. Solid-state components
- 2. Factory-mounted and wired within a NEMA 1 enclosure with a locking front panel.

3. Controls will monitor the system water loop and protect against malfunction, requiring field installation of just one temperature sensor plus a flow switch.
4. The panel shall include:
  - a. Indicator lights
  - b. Temperature gage
  - c. Control relays
  - d. Alarm with silencer switch
  - e. Terminal board for convenient connection of all field wiring
  - f. Pump selector switch to equalize wear by interchanging operation of the primary pump and the standby pump.
5. Controls shall automatically start the standby pump upon failure of the primary pump, with a pilot light indicating that the standby pump is operating.
6. An alarm and pilot light will indicate loss of flow or extreme high or low system water temperature
7. A contact shall open which can be used in a control circuit to interrupt operation of the heat pumps.
8. Three stages of control shall be included to operate the heat rejecter in order to maintain a maximum system water temperature of approximately 90 deg. F.
9. The four stages of control shall be included to operate the water heater as required to maintain a minimum supply temperature to the heat pumps of 60 deg. F.

### PART 3 - EXECUTION

#### 3.1 FIELD QUALITY CONTROL

- A. Complete system shall be installed in accordance with manufacturer's approved instructions and shall be equipped with necessary system operating and safety controls as detailed elsewhere in these specifications.
- B. It is ESSENTIAL that the finished piping system be thoroughly flushed free of foreign material and construction debris.
  1. Install strainer in system line at pump section.
  2. Flush system prior to final connection to any electro-hydraulic conditioner by means of loop bypass between supply to return at each unit location.
  3. The hoses for final connection may first be used for the loop bypass.
- C. Provide factory start-up of each heat pump and factory system operation check out of complete system.

END OF SECTION 23 2200

## SECTION 232500 – CHEMICAL WATER TREATMENT

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

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

#### 1.2 SUMMARY

- A. Procure services of Water Treatment Service Organization which will:
  - 1. Furnish and install required chemical feeding equipment and perform other related services as described in Contract Documents.
  - 2. Perform initial cleaning and flushing procedures.
  - 3. Provide chemicals required for cleaning and flushing systems.
- B. Related Work Specified Elsewhere:
  - 1. Owner will supply operating chemicals after start-up chemicals have been exhausted.

#### 1.3 SUBMITTALS

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

#### 1.4 MAINTENANCE

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

### PART 2 - PRODUCTS

#### 2.1 HOT WATER SYSTEMS

- A. Two Gallon bypass feeder complete, including piping, valves, and accessories.
  - 1. Provide adequate supply of Dearborn Aqua-Serv B-547 liquid borate-nitrite based corrosion inhibitor.
- B. Approved Manufacturers:
  - 1. M. A. Fleckenstein
  - 2. Neptune
  - 3. Wingert

#### 2.2 COOLING TOWER SYSTEM

- A. Furnish and install a complete power pumped chemical feed system with water sensor, automatic control, feeder pump and 50 gallons of recommended chemical for use.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Provide initial start up and adjustment of all chemical systems.
- B. Provide instruction to owner in the use and operation of the test kit.
- C. Provide (2) two additional trips to the site during the warrantee period to check and adjust the chemical treatment system.

END OF SECTION 232500

## SECTION 232510 – GLYCOL SYSTEM

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

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

#### 1.2 SUMMARY

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

### PART 2 - PRODUCTS

#### 2.1 MATERIALS

- A. Chilled water system shall be a 50% glycol and water system. Furnish and install an automatic glycol pump and fill system and fill the chiller, coils and piping system with the solution.
- B. Coils, pumps, boiler and piping have been sized to handle the 50% solution.
- C. Glycol shall be of a permanent type with rust inhibitors and shall have an identifying odor and color.
  - 1. Approved Manufacturer:
    - a. Dowtherm Type SR-1.

#### 2.2 GLYCOL FEED PUMP

- A. Hydronic system feeder shall be AXIOM INDUSTRIES LTD.
- B. System shall include 65 liter (17 U.S. gallon) storage/mixing tank with molded-in level gauge, 125 mm (5") fill/access opening and cover; pump suction hose with inlet strainer and check valve; pressure pump with fuse protection; low fluid level pump cut-out float switch; manual diverter valve for purging air and agitating contents of storage tank; pressure switch with snubber, each individually adjustable from 70 kPa (10psig) to 170 kPa (25psig) cut-out pressure; factory cut-out pressure set to 115 kPa (17psig); and liquid filled pressure gauge.
- C. Unit to be complete with UL listed and fused power supply adapter with LED power indicator light, 115/60/1 to 24 VDC 50 watts AC, supplied loose for field installation.
- D. Feeder shall be compatible with glycol solutions of up to 50% concentration. Pump shall be capable of running dry without damage. Unit shall be completely assembled.
- E. RIA10-SAA – Low-level Alarm Panel complete with Remote Monitoring Dry Contacts and Selectable Audible Alarm.

### PART 3 - EXECUTION

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

END OF SECTION 232510

## SECTION 233114 - LOW-PRESSURE STEEL DUCTWORK

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

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

#### 1.2 SUMMARY

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

### PART 2 - PRODUCTS

#### 2.1 DUCTS

- A. Fabricate of zinc-coated lockforming quality steel sheets meeting requirements of ASTM 653A/653M, "Specification for Sheet Steel Zinc-Coated (Galvanized) by the Hot-Dip Process, Lock Forming Quality", with G 60 coating.
- B. Use of aluminum, non-metallic, or round ducts is not permitted. [Specification writer: Use of aluminum ducts in areas with high chlorine content (eg.: ventilation for pools, spas, etc.) should be considered on a per job basis.]

#### 2.2 DUCT JOINTS

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

#### 2.3 ACCESS DOORS IN DUCTS

- A. At each manual outside air damper and at each motorized damper, install factory built insulated access door with hinges and sash locks. Locate doors within 6 inches of installed dampers. Construction shall be galvanized sheet metal, 24 ga minimum.
- B. Fire and smoke damper access doors shall have a minimum clear opening of 12" x 12" or as specified on Drawings to easily service fire or smoke damper. Doors shall be within 6 inches of fire and smoke dampers and in Mechanical Room if possible.



- C. Identify each door with 1/2" high letters reading "smoke damper" or "fire damper".
- D. Approved Manufacturers:
  - 1. AirBalance - Fire/Seal #FSA 100
  - 2. Air Control Products - HAD-10
  - 3. Cesco-Advanced Air - HAD-10
  - 4. Elgen - Model 85 A
  - 5. Kees Inc - ADH-D.
  - 6. Louvers & Dampers - #SMD-G-F
  - 7. Nailor-Hart Industries Inc - Series 0831
  - 8. National Controlled Air Inc - Model AD-FL-1

#### 2.4 FLEXIBLE EQUIPMENT CONNECTIONS

- A. 30 oz closely woven UL approved glass fabric, double coated with neoprene.
- B. Fire retardant, waterproof, air-tight, resistant to acids and grease, and withstand constant temperatures of 250 deg F.
- C. Approved Manufacturers:
  - 1. Cain - N-100
  - 2. Duro Dyne - MFN
  - 3. Elgen - ZLN
  - 4. Ventfabrics - Ventglas

#### 2.5 CONCEALED CEILING DAMPER REGULATORS

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

#### 2.6 VOLUME DAMPERS

- A. In Main Ducts:
  - 1. 16 gauge galvanized steel, opposed blade type with 3/8 inch pins and end bearings. Blades shall have 1/8 inch clearance all around.
  - 2. Damper shall operate within acoustical duct liner.
  - 3. Provide channel spacer equal to thickness of duct liner.
  - 4. Approved Manufacturers:
    - a. Air Balance - Model AC-2
    - b. Air Control Products - CD-OB
    - c. American Warming - VC-2-AA
    - d. Greenheck - VCD-1100
    - e. NCA, Safe Air
    - f. Vent Products - 5100
- B. In Sheet Metal Branch Ducts:
  - 1. Extruded aluminum, opposed blade type. When in open position, shall not extend beyond damper frame.
  - 2. Maximum blade length 12 inches.
  - 3. Damper Regulator shall be concealed type with operation from bottom or with 90 deg miter gear assembly from side.

4. Approved Manufacturers:
  - a. Air Control Products - TCD-OB
  - b. Air Guide - OB
  - c. Arrow - OBDAF-207
  - d. CESCO - CDA
  - e. Reliable Metals - OBD-RO
  - f. Tuttle & Bailey - A7RDDM
  - g. Safe Air
  - h. Young - 820-AC

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

## 2.7 MOTORIZED OUTSIDE AIR DAMPERS

- A. Damper Blades:
  1. 18 gauge galvanized steel or equivalent aluminum with replaceable rubber blade edges, 9 inches wide maximum.
  2. End seals shall be flexible metal compression type.
  3. Opposed blade type.
- B. Make provision for damper actuators and actuator linkages to be mounted external of air flow.
- C. Approved Manufacturers & Models:
  1. Air Balance - AC-2
  2. American Warming - VC-2-AAVA
  3. Arrow - OBDAF-207
  4. Greenheck - VCD-2100
  5. Honeywell - D641
  6. Johnson - D1300
  7. Louvers & Dampers - TSD400
  8. Ruskin - CD36 or CD60
  9. Safe Air - 610
  10. Vent Products - 5800

## 2.8 BACKDRAFT DAMPER

- A. Backdraft blades shall be nonmetallic and shall be neoprene coated fiberglass.
- B. Stop shall be galvanized steel screen or expanded metal, 1/2 inch mesh.
- C. Frame shall be galvanized steel or extruded aluminum alloy.
- D. Approved Models & Manufacturers:
  1. Air Control Products - FBD
  2. American Warming - BD-15
  3. CESCO - FBD 101
  4. Ruskin - NMS2
  5. Safe Air

## 2.9 DUCT HANGERS

- A. 1" x 18 gauge galvanized steel straps or steel rods as shown on Drawings, and spaced not more than 8 feet apart. Do not use wire hangers.

- B. Attaching screws at trusses shall be 1-1/2 inch No. 10 round head wood screws. Nails not allowed.

## 2.10 DUCT SEALER

- A. Cain - Duct Butter or Butter Tak
- B. Design Polymerics - DP 1010
- C. DSC - Stretch Coat
- D. Duro Dyne - S2
- E. Hardcast - #601 Iron-Grip or Peel-N-Seal Tape
  - 1. Kingco - 15-325
  - 2. Mon-Eco - 44-41
  - 3. Trans-Continental Equipment Co - Multipurpose Duct Sealant
  - 4. United - Sheet Metal duct-sealer

## PART 3 - EXECUTION

### 3.1 INSTALLATION

- A. Ducts:
  - 1. Straight and smooth on inside with joints neatly finished unless otherwise directed.
  - 2. Duct panels through 48 inch dimension having acoustic duct liner need not be crossbroken or beaded.
  - 3. Crossbreak unlined ducts and duct panels larger than 48 inch or bead 12 inches on center.
  - 4. Securely anchor ducts to building structure with specified duct hangers attached with screws. Do not hang more than one duct from a duct hanger.
  - 5. Brace and install ducts so they shall be free of vibration under all conditions of operation.
  - 6. Ducts shall not bear on top of structural members.
  - 7. Make duct take-offs to branches, registers, grilles, and diffusers as detailed on Drawings.
  - 8. Ducts shall be large enough to accommodate inside acoustic duct liner. Dimensions shown on Drawings are net clear inside dimensions after duct liner has been installed.
  - 9. Properly flash where ducts protrude above roof.
  - 10. Install internal ends of slip joints in direction of flow. Make joints air tight using specified duct sealer.
  - 11. Cover horizontal and longitudinal joints on exterior ducts with two layers of Hardcast tape installed with Hardcast HC-20 adhesive according to Manufacturer's recommendations.
  - 12. Paint ductwork visible through registers, grilles, and diffusers flat black.
- B. Install flexible inlet and outlet duct connections to each furnace, fan, fan coil unit, and air handling unit.
- C. Install concealed ceiling damper regulators.
  - 1. Paint cover plates to match ceiling tile.
  - 2. Damper regulators will not be required for dampers located directly above removable ceilings or in Mechanical Rooms.
- D. Provide each take-off with an adjustable volume damper to balance that branch.
  - 1. Anchor dampers securely to duct.
  - 2. Install dampers in main ducts within insulation.

3. Dampers in branch ducts shall fit against sheet metal walls, bottom and top of duct, and be securely fastened. Cut duct liner to allow damper to fit against sheet metal.
  4. Where concealed ceiling damper regulators are installed, provide a cover plate.
- E. Install grilles, registers, and diffusers. Level floor registers and anchor securely into floor.
- F. Air Turns:
1. Permanently installed, consisting of single thickness curved metal blades with one inch straight trailing edge to permit air to make abrupt turn without appreciable turbulence, in 90 degree elbows of above ground supply and return ductwork.
  2. 4-1/2 inch wide minimum vane rail. Do not use junior vane rails.
  3. Double thickness vanes not acceptable.
  4. Quiet and free from vibration when system is in operation. See SMACNA Manual
- G. Install motorized dampers

END OF SECTION 233114

## SECTION 233123 - UNDERGROUND DUCTWORK

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

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

#### 1.2 SUMMARY

- A. Furnish and install underground ductwork as described in Contract Documents.

### PART 2 - PRODUCTS

#### 2.1 DUCTWORK

- A. Fiberglass-reinforced plastic duct system by Peabody Spunstrand Inc, 810 AGC Building, 1200 Westlake Avenue N, Seattle, WA 98109 (206) 282-5449
  - 1. Duct Tape - Sealtite PS401 sealing tape by Spunstrand Inc.
- B. PVS or PVC coated galvanized steel duct with 4 mil thick coating on outside and on inside.
  - 1. Duct shall have and bear mark of approval of building code (ICBO, BOCA, etc) in authority for this Project.
  - 2. Gauges shall be as follows and be marked on each duct section. Corrugate ducts 14 inches in diameter and larger.

<u>Size</u>	<u>Gauge</u>
4" to 8"	26
9" to 12"	24
14" to 22"	22
24" to 28"	20
30" to 40"	18

- 3. Make duct connections with Hardcast tape.

#### 2.2 JOINT SLEEVES

- A. Galvanized sheet metal. Galvanizing shall meet requirements of ASTM A 527-85, "Specification for Sheet Steel Zinc-Coated (Galvanized) by the Hot-Dip Process, Lock Forming Quality", G 60.

<u>Size</u>	<u>Gauge</u>	<u>Width</u>
4" to 12"	26	4"
14" to 24"	24	4"
26" to 36"	22	6"

#### 2.3 METAL BOOTS

- A. 20-gauge galvanized steel. Galvanizing shall meet requirements of ASTM A 527-85, "Specification for Sheet Steel Zinc-Coated (Galvanized) by the Hot-Dip Process, Lock Forming Quality", G 60.

### PART 3 - EXECUTION

#### 3.1 INSTALLATION

##### A. Spunstrand:

1. Join duct sections with galvanized sheet metal sleeve inside of duct secured with sheet metal screws.
2. Wipe joint area clean and apply one layer of tape. Tape shall cover all screw heads.
3. Construct sheet metal boot with 1-1/2 inch flange to fit against duct. Attach boot with self-tapping sheet metal screws, pulling boot flange snug to duct surface and tape joints. Tape shall cover screw heads.
4. Encase boot completely in concrete, covering well around and below taped joint.

##### B. PVS or PVC Covered Duct:

1. Install 6 mil polyethylene vapor barrier around duct.
2. Fittings shall be PVS or PVC.
3. Join duct sections, fittings, and boots with sheet metal screws as detailed on Drawings.
4. Wrap duct connections, including boot connections to ducts, with 2 layers of hardcast tape installed with Hardcast HC-20 adhesive in accordance with Manufacturer's recommendations. Cover screw heads with tape.
5. Encase boot completely in concrete, covering well around and below taped joint.
6. Where PVS or PVC coating has been scratched, scuffed, or peeled during shipping or installation, cover exposed metal with coating compound recommended by Manufacturer and in accordance with his recommendations.

END OF SECTION 233123

## SECTION 233346 - FLEX DUCT

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

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

#### 1.2 SUMMARY

- A. Furnish and install supply air branch duct runouts to diffusers as described in Contract Documents.

### PART 2 - PRODUCTS

#### 2.1 DUCTS

- A. Formable, flexible, circular duct which shall retain its cross-section, shape, rigidity, and shall not restrict air flow after bending.
- B. Nominal 1-1/2 inches thick, 3/4 lb/cu ft density fiberglass insulation with air-tight, polyethylene or polyester core, sheathed in seamless vapor barrier jacket factory installed over flexible assembly.
- C. Assembly, including insulation and vapor barrier, shall meet Class I requirement of NFPA 90A and be UL 181 rated, with flame spread of 25 or less and smoke developed rating of 50 or under.
- D. Length of flexible ductwork shall not exceed 8'-0".

#### 2.2 APPROVED MANUFACTURERS

- A. ANCO-FLEX - 4625
- B. Flex-Aire - PF/UPC #090
- C. Hart & Cooley - F114
- D. Thermaflex - G-KM

### PART 3 - EXECUTION

#### 3.1 INSTALLATION

- A. Install duct in fully extended condition free of sags and kinks.
- B. Make duct connections by coating exterior of duct collar for 3 inches with duct sealer and securing duct in place over sheet metal collar with 1/2 inch wide metal cinch bands and sheet metal screws.

END OF SECTION 233346

## SECTION 233400 - EXHAUST FANS

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

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

#### 1.2 SUMMARY

- A. Furnish and install exhaust fans as described in Contract Documents.

#### 1.3 QUALITY ASSURANCES

- A. Requirements of Regulatory Agencies:
  - 1. Bear AMCA seal and UL label.

### PART 2 - PRODUCTS

#### 2.1 CEILING MOUNTED EXHAUST FANS

- A. Acoustically insulated housings.
- B. Sound level rating of 4.6 sones maximum for fan RPM and CFM listed on Drawings.
- C. Include chatterproof integral back-draft damper with no metal to metal contact.
- D. True centrifugal wheels.
- E. Entire fan, motor, and wheel assembly shall be easily removable without disturbing housing.
- F. Suitably ground motors and mount on rubber-in shear vibration isolators.
- G. Provide wall or roof cap, as required.
- H. Approved Manufacturers:
  - 1. Cook-Gemini
  - 2. Greenheck Sp
  - 3. Pace
  - 4. Penn Zephyr
  - 5. Twin City

#### 2.2 ROOF MOUNTED EXHAUST FANS

- A. Direct drive or have adjustable pitch V-belt as noted on Drawings.
- B. Wheels shall be backward curved and housing shall be removable or hinged aluminum.
- C. Isolate motor with vibration dampeners.
- D. Provide quiet type back-draft dampers.
- E. Insulated, pre-fabricated metal roof curb shall be for flat or sloped roof as shown on Drawings.



- F. Approved Manufacturers:
  - 1. Fans:
    - a. Penn
    - b. Centri-Master
    - c. Cook
    - d. Greenheck G, GB
    - e. Twin City
  - 2. Standard curbs:
    - a. Penn
    - b. Cook
    - c. Greenheck
  - 3. Sound attenuating curbs:
    - a. Penn
    - b. Greenheck

### 2.3 FUME HOOD EXHAUST FANS

- A. Forward curve direct drive utility type fans.
- B. Fans shall be acid resistant cast iron or heavy steel with Kem-FP acid resisting coating.
- C. Blowers shall be completely factory assembled and tested as a unit, with electric motor.
- D. Fans shall be AMCA rated and tested.
- E. Motor base and outside housing shall be baked chemical resistant finish.
- F. Verify fan rotation and discharge to suit actual conditions.
- G. Housings shall be changeable in the field.
- H. Provide manual damper in discharge duct.
- I. Approved Manufacturers:
  - 1. Kewanee
  - 2. Champion
  - 3. Chicago Blower
  - 4. Twin City

## PART 3 - EXECUTION

### 3.1 INSTALLATION

- A. Anchor fan units securely to structure or curb.

END OF SECTION 233400

## SECTION 233713 - AIR OUTLETS & INLETS

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

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

#### 1.2 SUMMARY

- A. Furnish and install wall supply registers, transfer grilles, return air grilles, soffit grilles, ceiling diffusers, louvers connected to ductwork, and registers as described in Contract Documents.

### PART 2 - PRODUCTS

#### 2.1 GRILLES & REGISTERS

- A. Approved Manufacturers:
  1. Price
  2. Anemostat
  3. Krueger
  4. Titus
  5. Tuttle & Bailey

#### 2.2 SPIN-IN FITTINGS

- A. Low pressure round take-offs to diffusers shall be made with spin-in fittings. They shall incorporate a manual balancing damper. The damper shall be spring loaded and a positive locking wing nut shall secure the damper position.
- B. Approved Manufacturers:
  1. Sheet metal fittings: Genflex DB-1DEL, Hercules

#### 2.3 LOUVERS

- A. Extruded aluminum, with blades welded or screwed into frames and 1/2 inch mesh 16 gauge aluminum bird screen.
- B. Frames shall have mitered corners.
- C. Louvers shall be recessed, flanged, stationary, or removable as noted on Drawings.
- D. Approved Manufacturers:
  1. Airlite
  2. American Warming
  3. Arrow
  4. Industrial Louvers
  5. Ruskin
  6. Vent Products

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Anchor securely into openings.
- B. Install with screws to match color and finish of grilles and registers.
- C. Touch-up any scratched finish surfaces.
- D. Install in accordance with manufacturer's instructions.
- E. Check location of outlets and inlets and make necessary adjustments in position to conform with architectural features, symmetry, and lighting arrangement.
- F. Install diffusers to ductwork with air tight connection.
- G. Provide balancing dampers on duct take-off to diffusers, and grilles and registers, despite whether dampers are specified as part of the diffuser, or grille and register assembly.
- H. Paint ductwork visible behind air outlets and inlets matte black. Refer to Section 09 9000.

END OF SECTION 233713

SECTION 234100 – DISPOSABLE FILTERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Furnish and install filters used in mechanical equipment.

PART 2 - PRODUCTS

2.1 HEAT PUMP

- A. Filters shall be two inch thick throw-away type as recommended by Furnace Manufacturer.

END OF SECTION 234100

## SECTION 235315 – HEATING BOILERS

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

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

#### 1.2 SUMMARY

- A. Furnish and install heating boilers as described in Contract Documents.

#### 1.3 QUALITY ASSURANCE

- A. Boiler shall be AGA design certified for a minimum boiler efficiency of 80% and bear appropriate seal.
- B. Boiler shall meet requirements of ASME Boiler and Pressure Vessel Code for 160 psi working pressure and shall bear ASME seal and registration number of National Board of Boiler and Pressure Vessel Inspectors.

### PART 2 - PRODUCTS

#### 2.1 MANUFACTURED UNITS

- A. Equipped for natural gas.
- B. Designed specifically for hot water heating systems and specifically designated as such by manufacturer.
- C. Atmospheric type using titanium stainless steel burners.
- D. Shall not require blower motors to supply combustion air or to create venting action.
- E. Fuel-air mixture shall be factory set for maximum combustion efficiency and shall be tamper-proof in the field.
- F. Completely assembled with a built-in draft diverter.
- G. Heat Exchanger: Boiler shall be of straight tube design and shall have no blind passages or concealed pockets. Water containing parts shall be designed so they are continually scoured to prevent any build-up of sludge that would necessitate periodic blow down.
  - 1. Inspection covers permitting inspection of wet internal surfaces shall be provided on headers at each end and held in place by corrosion resistant steel cap screws. Waterways shall be copper or bear fused ceramic coating to positively protect boiler from corrosion.
  - 2. Entire wet section of boiler shall be removable and replaceable without damage or disassembly of combustion chamber and/or burner sections.
  - 3. Water tubes shall be made of integral-finned copper tubing of 7/8 inch I.D. x .065 wall thickness with fins of .40 inch minimum height spaced at 7 fins per inch. The tubes shall be rolled directly into an ASME header of grey cast iron protected by a ceramic coating fused into the metal at not less than 1300 deg. F. Non-metallic gaskets shall be exterior to jacket structure and combustion chamber to avoid deterioration from heat. Complete

heat transfer section shall be hydrostatically tested at 400 psi, be ASME inspected and approved, and protected by an ASME pressure relief valve.

- H. Combustion Chamber and Jacket: Combustion chamber shall be lined with a castable refractory approved for service temperatures at not less than 2100 deg. F. Outer jacket shall be unitized shell and frame construction fabricated of galvanized steel and finished with acrylic thermoset paint baked on at not less than 325 deg. F.
- I. Controls: Ignition safeguards shall be provided as follows:
  - 1. System 9 - Standard on natural gas units:
    - a. Electronic pilot flame supervision
    - b. Main gas shutdown 1 second after pilot failure
    - c. Automatic pilot ignition on start-up
    - d. Automatic pilot re-ignition if pilot is extinguished
    - e. Solid state components.
- J. Firing Option: Boiler shall be provided with 4-stage firing with automatic temperature reset control.
- K. Multimatic Sequence Control System for Input Modulation: Teledyne Laars Multimatic Sequence Control System is an electronic package that provides central control for a heating system. Simple wiring connections between panel and boilers will change individual boilers into a single, cohesive step control heating system.
  - 1. The heart of Teledyne Laars' Multimatic Sequence Control System is a versatile control panel made up of a solid state signal center with throttling range adjustment and system temperature reset ratio adjustment and a proportional staging control of four stages.
  - 2. Provide with Outdoor Reset: Multimatic Sequence Control System shall come with an electronic immersion sensor for mounting in system water line and an electronic outdoor temperature sensor.
- L. Approved Manufacturers:
  - 1. Teledyne Laars
  - 2. or approved equal

END OF SECTION 235315

SECTION 235415 – DUCT HEATER (SEPERATED COMBUSTION)

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Furnish and install packaged indoor heating units with separated combustion as described in Contract Documents.

1.3 QUALITY ASSURANCE

- A. Duct furnace shall be design-certified by the American Gas Association and bear the AGA label.

PART 2 - PRODUCTS

2.1 MANUFACTURED UNITS

- A. Units shall be separated combustion gas fired duct heaters arranged for ceiling suspension with threaded suspension couplings.
- B. Duct Heater shall be arranged for ducted inlet combustion air and flue gas exhaust.
- C. Cabinet shall be supplied with horizontal supply and inlet openings with duct flanges.
- D. Fabrication:
  - 1. Centrifugal blower
  - 2. Open drip-proof blower motor
  - 3. Adjustable belt drive, factory installed
  - 4. Controls, dampers, and inlets to provide an air control cycle
  - 5. Full cabinet insulation
  - 6. Equipped for use with natural or propane gas as identified
  - 7. (115V) supply voltage
  - 8. 24-volt control transformer
  - 9. Vertical concentric vent terminal assembly
  - 10. Motor contractor
  - 11. Intermittent spark pilot with timed lockout
  - 12. 100% safety shut off
  - 13. Heat exchanger:
    - a. Stainless steel
    - b. Aluminized steel
    - c. Die-formed burners of stainless steel drip pan
    - d. Automatic power venter with combustion air pressure switch
- E. Blower Motor (1/4 to 5 HP)
  - 1. Open dripproof, TEFC, or premium efficiency.
  - 2. Adjustable sheave and belt.
  - 3. Motor Contractor; IEC motor starter; or factory-installed variable frequency drive.
- F. Accessories:

1. Rack with 1" T/A filters
  2. Intake damper
- G. See drawings and schedules for sizes and capacities.
- H. Approved Manufacturers:
1. Reznor Series SCE
  2. Trane

END OF SECTION 235415



SECTION 235719 – PLATE AND FRAME HEAT EXCHANGERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Furnish and install heat exchanger as described in Contract Documents.

1.3 QUALITY ASSURANCE

- A. Construction shall conform to latest ASME Code for unfired pressure vessels.

PART 2 - PRODUCTS

2.1 MANUFACTURED UNITS

- A. Plate type heat exchangers with maximum pressure drop through heat exchanger of 5 psi.
- B. Framework, pressure plate and fixed plate shall be of heavy carbon steel painted with epoxy enamel.
- C. The heat exchanger corrugated channel plates shall be Type 304 stainless steel with nitrile gaskets. The gasket pattern on each channel plate distributes the fluid flow to alternate plate flow channels in the plate pack creating 100% counterflow resulting in high transfer effectiveness.
- D. Approved Manufacturers:
  - 1. Bell & Gossett
  - 2. Alfa-Laval

END OF SECTION 235719

SECTION 236210 - AIR-COOLED WATER CHILLERS

PART 1 GENERAL

1.1 SCOPE

- A. Section includes design, performance criteria, controls and control connections, chilled water connections, electrical power connections and refrigerants of the chiller package.

1.2 REFERENCES

- A. Products shall be designed, rated and certified in accordance with applicable sections of the following Standards and Codes:
1. To comply with the most recent versions of applicable Standards and Codes of Air-Conditioning, Heating & Refrigeration Institute (AHRI) 550 / 590.
  2. AHRI 370 - Standard for Sound Rating of Large outdoor Refrigerating and Air-conditioning Equipment.
  3. To comply with the most recent versions of applicable Standards and Codes of American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) 15.
  4. Units shall meet the efficiency standards of ASHRAE 90.1.
  5. To comply with seismic application in accordance with the most recent versions of the International Building Code (IBC).

1.3 QUALITY ASSURANCE

- A. Underwriters' Laboratories (UL) 1995 -- Standard for Heating and Cooling Equipment.
- B. Manufactured facility to be International Organization for Standardization (ISO) 9001.
- C. Factory Functional Test: The chiller shall be pressure tested, evacuated and fully charged with HFC-410A refrigerant and oil. In addition, a factory functional test to verify correct operation by cycling condenser fans, closing compressor contacts and reading data points from temperature and pressure sensors.
- D. Operational Test with Water: Chiller shall be functionally tested with power and water flowing through the chiller before shipment. A test report showing date and time of test shall be provided.
- E. Chiller manufacturer shall have a factory trained and supported service organization that is within a 150 mile radius of the site.
- F. Warranty: The manufacturer shall warrant all equipment and material of its manufacture against defects in workmanship and material for a period of one year from date of initial start-up or eighteen months from date of shipment; whichever occurs first.

1.4 SUBMITTALS

- A. Submit shop drawings and product data in accordance with the specifications.
- B. Submittals shall include the following:
1. Dimensioned plan and elevation view drawings, required clearances, and

location of all field connections.

2. Product data indicating rated capacities, weights, specialties and accessories, electrical requirements and wiring diagrams.

#### 1.5 OPERATION AND MAINTENANCE DATA

- A. Include manufacturer's descriptive literature, installation checklist, start-up instructions and maintenance procedure.

#### 1.6 DELIVERY, STORAGE, AND HANDLING

- A. Units shall be delivered to job site fully assembled and charged with refrigerant (unless selected with nitrogen charge) and oil by the manufacturer.
- B. Unit shall be stored and handled per manufacturer's instructions.
- C. During shipment, provide protective covering over vulnerable components. Fit nozzles and open pipe ends with enclosures.
- D. Unit controls shall be capable of withstanding 158F (70C) storage temperature in the control compartment for an indefinite period of time.

#### 1.7 WARRANTY

- A. Provide a full parts warranty for one year from start-up or 18 months from shipment, whichever occurs first.
- B. A 5-year motor/transmission/compressor warranty shall be provided based upon the RPM of the compressors as follows:

<b>Compressor RPM</b>	<b>Warranty Term</b>
0 - 5000	1 year from start-up
5001 - 10,000	5 years from start-up
10,001 and above	5 years plus annual oil analysis

### PART 2 PRODUCTS

#### 2.1 ACCEPTABLE MANUFACTURERS

- A. Trane [See drawings for capacity]
- B. Or Approved Equal from Carrier, or York
- C. Others require prior approval a minimum of 7 days prior to bid opening.

#### 2.2 GENERAL UNIT DESCRIPTION

- A. Factory assembled, single-piece chassis, air-cooled liquid chiller. Contained within the package shall be all factory wiring, piping, controls, and refrigerant charge (HFC-410A).

#### 2.3 CABINET

- A. Frame shall be heavy-gage, with a powder coated paint finish for both aesthetic appeal and to offer more resistance to corrosion.
- B. Units shall be constructed of a galvanized steel frame with galvanized steel panels and access doors. Component surfaces shall be finished with a powder-coated paint. The coating or paint system shall withstand a 500-consecutive-hour salt spray application in accordance with standard ASTM B117.

#### 2.4 COMPRESSORS

- A. Fully hermetic scroll type compressors with R410A optimized and dedicated scroll profile.
- B. Direct drive motor cooled by suction gas with only three major moving parts and a completely enclosed compression chamber which leads to increased efficiency.
- C. Each compressor shall have overload protection internal to the compressor
- D. Each compressor shall include: centrifugal oil pump, oil level sight glass and oil charging valve
- E. Each compressor will have crankcase heaters installed and properly sized to minimize the amount of liquid refrigerant present in the oil sump during off cycles.

#### 2.5 EVAPORATOR

- A. The evaporator shall be a high efficiency, brazed plate-to-plate type heat exchanger consisting of parallel plates. Braze plates shall be stainless steel with copper braze material.
- B. The evaporator shall be protected with an etched foil heater and covered with insulation. This combination shall provide freeze protection down to -20F (-6.67C) ambient temperatures while the heater is powered. Contractor shall provide separate power to energize heater and protect evaporator while chiller is disconnected.
- C. The water side working pressure shall be rated at 150 psig (10.3 bar) and tested at 1.5 times maximum allowable water side working pressure.
- D. The refrigerant side working pressure shall be rated at 460 psig (29.6 bars) and tested at 1.1 maximum allowable refrigerant side working pressure.

#### 2.6 CONDENSER

- A. Construct condenser coils of microchannel all aluminum brazed fin construction. The condenser coils shall have an integral sub-cooling circuit and shall be designed for at least 650 psig (44.8 bar) working pressure. Leak tested at 715 psig (49.3 bar). Coils can be cleaned with high pressure water.
- B. The maximum allowable working pressure of the condenser shall be 650 psig (44.8 bars). The condensers shall be factory proof and leak tested at 715 psig (49.3 bars).
- C. Low Sound Fans shall be dynamically and statically balanced, direct drive, corrosion resistant glass fiber reinforced composite blades molded into a low noise fan blade.

- D. Low speed fan motors shall be three-phase with permanently lubricated ball bearings and individually protected by circuit breakers.
- E. Unit shall be capable of starting and running at outdoor ambient temperatures from 32F to 125F (0C to 52C).
- F. Provide coil protection for shipping. Entire condenser coil shall be covered with heavy plastic to prevent inadvertent damage to coil during shipment or rigging.

## 2.7 ENCLOSURES

- A. Mount starters in a UL1995 rated panel for outdoor use.
- B. The starter shall be across-the-line configuration, factory-mounted and fully pre-wired to the compressor motor(s) and control panel.
- C. Unit shall have a single point power connection.
- D. A control power transformer shall be factory-installed and factory-wired to provide unit control power.
- E. Control panel shall be dead front construction for enhanced service technician safety.
- F. Power line connection type shall be standard with a terminal block.

## 2.8 REFRIGERATION COMPONENTS

- A. Each refrigerant circuit shall include a filter drier, electronic expansion valve with site glass, liquid line service valves and a complete operating charge of both refrigerant HFC-410A and compressor oil.
- B. Each refrigerant circuit shall include a discharge line service valve to allow the refrigerant to be isolated in the condenser.

## 2.9 CONTROLS, SAFETIES AND DIAGNOSTICS

- A. The microprocessor-based unit controller shall be factory-installed and factory-tested.
- B. Include Bacnet Gateway to communicate with the existing Johnson Controls Metasys ATC system.
- C. The unit display shall provide the following data:
  - 1. Water and air temperatures
  - 2. Refrigerant levels and temperatures
  - 3. Flow switch status
  - 4. Compressor starts and run times
- D. The unit controller shall provide chilled water reset based on return water as an energy saving option.
- E. Chilled water temperature control shall be microprocessor-based, proportional and integral controller to show water and refrigerant temperature, refrigerant pressure, and diagnostics.

This microprocessor-based controller is to be supplied with each chiller by the chiller manufacturer. Controls shall include the following readouts and diagnostics:

1. Low evaporator refrigerant temperature and/or pressure
  2. High condenser refrigerant pressure
  3. Motor current overload
  4. High compressor discharge temperature
  5. Electronic distribution faults: phase loss, phase imbalance, or phase reversal
- F. Unit shall be shipped with factory control and power wiring installed.
- G. On chiller, mount weatherproof control panel, containing starters, power and control wiring, factory wired with terminal block power connection. Provide primary and secondary fused control power transformer and a single 115 volt 60 Hz single phase connection for evaporator freeze protection heaters.
- H. Provide single 115 volt 60 Hz single phase connection for evaporator freeze protection heaters.
- I. The unit controller shall utilize a microprocessor that will automatically take action to prevent unit shutdown due to abnormal operating conditions associated with: evaporator refrigerant temperature, high condensing pressure and motor current overload.
- J. Provide the following safety controls with indicating lights or diagnostic readouts.
1. Low chilled water temperature protection.
  2. High refrigerant pressure.
  3. Low oil flow protection.
  4. Loss of chilled water flow.
  5. Contact for remote emergency shutdown.
  6. Motor current overload.
  7. Phase reversal/unbalance/single phasing.
  8. Over/under voltage.
  9. Failure of water temperature sensor used by controller.
  10. Compressor status (on or off).
- K. Provide the following operating controls:
1. Chilled water pump output relay that closes when the chiller is given a signal to start.
  2. High ambient pressure controller that shuts off a compressor to keep head pressure under control and help prevent high pressure nuisance trip outs on days when outside ambient is above design.
  3. Compressor current sensing limit that shuts off a compressor to help prevent current overload nuisance trips.
  4. Auto lead-lag functions that constantly even out run hours and compressor starts automatically. If contractor cannot provide this function then cycle counter and hour meter shall be provided for each compressor so owner can be instructed by the contractor on how to manually change lead-lag on compressors and even out compressor starts and running hours.
  5. Low ambient lockout control with adjustable setpoint.
- L. Provide user interface on the front of the panel. If display is on the inside of the panel, then a control display access door shall be provided to allow access to the display without removal of panels. Provide user interface with a minimum of the following features:

1. Leaving chilled water setpoint adjustment from LCD input
2. Entering and leaving chilled water temperature output
3. Percent RLA output for each compressor
4. Pressure output of condenser for circuits one and two
5. Pressure output of evaporator for circuits one and two
6. Ambient temperature output
7. Voltage output
8. Current limit setpoint adjustment from LCD input.

#### 2.10 CHILLED FLUID CIRCUIT

- A. Chilled fluid circuit shall be rated for 150 psig (1034 kPa) working pressure.
- B. Proof of flow switch shall be provided by the equipment manufacturer and installed the correct number of pipe diameters from any elbow and in the correct orientation.
- C. Flow switch shall be IFM flow monitor type.
- D. Units with brazed plate evaporators shall have a 16 mesh water strainer that is factory provided. It shall be installed with a blowdown valve to facilitate periodic cleaning of the strainer to prevent it from becoming clogged.

### PART 3 EXECUTION

#### 3.1 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Align chiller package on steel or concrete foundations.
- C. Install units on isolators.
- D. Connect to electrical service.
- E. Connect to chilled water piping.

#### 3.2 MANUFACTURER'S FIELD SERVICES

- A. OEM Startup is performed by factory trained and authorized servicing technicians confirming equipment has been correctly installed and passes specification checklist prior to equipment becoming operational and covered under OEM warranty.
  1. Included OEM Factory Startup:
    - a. Centrifugal, Rotary Screw, and Scroll Chillers
- B. Applied Chiller manufacturers shall maintain service capabilities no more than 150 miles from the jobsite.
- C. The manufacturer shall furnish complete submittal wiring diagrams of the package unit as applicable for field maintenance and service.

END OF SECTION 236210

## SECTION 236514 – COOLING TOWER

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

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

#### 1.2 SUMMARY

- A. Furnish and install Cooling Tower, Water Treatment, Remote Sump and Tower Pump as described in Contract Documents.

### PART 2 - PRODUCTS

#### 2.1 COOLING TOWER

- A. General:
  - 1. Fiberglass cooling tower.
  - 2. Unit shall be single cell, induced draft, vertical discharge, counter-flow design, utilizing fiberglass reinforced polyester (FRP) materials in basin and casing of cooling tower structure.
  - 3. Tower shall be supplied as a field erected package complete with assembly and necessary components and accessories as required for complete installation.
- B. Cold Water Basin:
  - 1. Cooling tower basin shall be molded of corrosion-resistant fiberglass reinforced polyester (FRP) material to assure durability and long life.
  - 2. Basin shall be a multi-segment structure, equipped with provisions for connections to hot water inlet, cold water outlet, and basin drain for remote sump application.
- C. Tower Casing:
  - 1. Cooling tower casing shall be molded of corrosion-resistant fiberglass reinforced polyester (FRP) material to assure durability and long life.
  - 2. Casing shall be a multi-segment type, providing easy access to the fill media.
  - 3. Casing panels shall be capable of withstanding wind loads of at least thirty (30) pounds per square foot.
- D. Fans:
  - 1. Fan blades shall be slow speed, aerodynamically designed, propeller type with adjustable pitch to provide efficient use of power and to assure quiet operation.
  - 2. Fan blades and related hub shall be constructed of a special cast aluminum alloy material for corrosion-resistance and maintenance free operation.
- E. Fan Motor/Drive System:
  - 1. Multi-blade propeller type fan blade shall be driven by a special V-belt reducer unit to provide proper speed and to assure constant air flow thru fill media.
  - 2. Reducer assembly shall have provisions for belt adjustment and related maintenance without disassembly of drive system.
  - 3. Fan motor shall be a single speed totally enclosed, air-over (TEAO), permanently lubricated, ball bearing type, with 1.15 service factor, suitable for outdoor service.
  - 4. Motor/V-belt reducer and fan assembly shall be supported on a structural steel support protected by hot-dip galvanized coating.



5. Suitable fan guard shall be included.
- F. Fill:
1. Cooling tower fill shall be PVC (polyvinyl chloride) of corrugated and embossed design to provide maximum air to water contact for optimum heat transfer efficiency.
  2. Fill shall be provided in a circular configuration to enable easy replacement if required.
  3. The PVC material shall be fire resistant, and shall meet the provisions of ASTM Standard E-84 with a flame spread rate of 25.
  4. Fill must withstand a maximum water temperature of 130 deg. F. and be resistant to rot, decay, or biological attack.
- G. Water Distribution: Water distribution shall be provided through a rotating sprinkler head system. Water from the inlet connection shall be forced thru the rotating sprinkler system under pump pressure and distributed evenly over the entire fill area. The rotating sprinkler head and related piping shall be non-ferrous, non-corrosive and self-rotating at low head loss. All sprinkler pipes shall have removable end caps for maintenance purposes.
- H. Eliminators: Special drift eliminators shall be attached to the sprinkler pipes to effectively reduce drift (carry-over) from the airstream. Drift loss shall be limited to 0.2 percent at design/operating conditions. Eliminators shall be of non-ferrous, non-corrosive materials.
- I. Hardware & Finish: All metal fasteners (nuts, bolts, washers) shall be stainless steel to resist corrosion. All supporting steel structure shall be Stainless Steel.
- J. All fiberglass reinforced polyester materials (FRP) shall contain UV (ultra-violet) inhibitors, fire retardant fillers to satisfy ASTM E-84-Class A and an exterior gel coat to protect the structural integrity of the basin and casing. Exterior surface shall have a cosmetically appealing surface that is durable, long lasting and eliminates the need for other finishing.
- K. The tower will be provided with an OSHA approved ladder adequate to allow inspection and accessibility to the fan/motor and upper portion of the tower cell. In addition, a suitable wire-grill fan guard will be provided. These items shall be protected with a hot-dip galvanized coating.
- L. Air inlet louvers of a PVC plastic material shall be provided to prevent objects from entering the water basin.
- M. Approved Manufacturers:
1. AMCOT
  2. RSD
  3. Protec
- N. Water Treatment:
1. Complete packaged water treatment system for the cooling tower.
  2. Submit with cooling tower submittal.
  3. Approved Manufacturers:
    - a. Chemicator system by V.O.P. with six refill tubes.

## 2.2 REMOTE SUMP

- A. All seams and fittings shall be welded inside and outside and be leak free. Heavy duty 3 inch angle iron shall be cut or rolled to fit top of tank and welded on top edge of tank for rigidity. Tank lids shall be the same thickness of material as the tank itself and shall extend to the outside edge of the 3 inch angle iron frame. Lids shall be cut in half and hinged with a heavy duty continuous hinge. The interior of the tank shall be coated with a 12 mill thickness of epoxy, manufactured specifically for water tanks. The exterior of the tank shall be coated the same as

the interior if the tank is mounted above ground. If the tank is to be below grade, the exterior shall be coated with a 12 mill coating of a cold tar epoxy. The lid shall be coated the same as the interior of the tank. All coatings shall be applied after all welding is done to insure a complete coverage of all metal, welds, fittings, flanges, hinges, handles, etc.

- B. All tanks shall be complete with a pedestal mounted float switch to sense low water, and a slow closing solenoid valve to automatically feed water when a low water condition is sensed.

END OF SECTION 236514

END OF DIVISION