23 00 00 HEATING, VENTILATING, AND AIR-CONDITIONING

23 20 00 HVAC PIPING AND PUMPS

23 30 00 HVAC AIR DISTRIBUTION

23 50 00 CENTRAL HEATING EQUIPMENT

23 65 00 COOLING TOWERS

23 80 00 DECENTRALIZED HVAC EQUIPMENT

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DIVISION 23 MECHANICAL

SECTION 23 05 01

COMMON HVAC REQUIREMENTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and General Provisions of Contract 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.

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

2.1 COMMON HVAC REQUIREMENTS

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

B. Duct Hangers:
1. One inch 25 mm by 18 ga 1.27 mm galvanized steel straps or steel rods as shown on Drawings, and spaced not more than 96 inches 2 400 mm apart. Do not use wire hangers.

2. Attaching screws at trusses shall be 2 inch 50 mm No. 10 round head wood screws. Nails not allowed.

PART 3 - EXECUTION

3.1 EXAMINATION

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

B. Drawings:
   1. Mechanical drawings show general arrangement of piping, ductwork, equipment, etc, and do not attempt to show complete details of building construction which affect installation. This Contractor shall refer to architectural, structural, and electrical drawings for additional building detail which affect installation of his work.
      a. Follow mechanical drawings as closely as actual building construction and work of other trades will permit.
      b. No extra payments will be allowed where piping and/or ductwork must be offset to avoid other work or where minor changes are necessary to facilitate installation.
      c. Everything shown on the mechanical drawings shall be the responsibility of Mechanical Contractor unless specifically noted otherwise.
   2. Consider architectural and structural drawings part of this work insofar as these drawings furnish information relating to design and construction of building. These drawings take precedence over mechanical drawings.
   3. Because of small scale of mechanical drawings, it is not possible to indicate all offsets, fittings, and accessories which may be required. Investigate structural and finish conditions affecting this work and arrange work accordingly, providing such fittings, valves, and accessories required to meet conditions. Do not scale drawings for locations of equipment or piping. Refer to large scale dimensioned drawings for exact locations.

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

3.2 PREPARATION

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

3.3 INSTALLATION

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

3.4 STORAGE AND PROTECTION OF MATERIALS:

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

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

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

3.5 EXCAVATION AND BACKFILL

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

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

3.6 COOPERATION

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

3.7 SUPERVISION

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

3.8 INSTALLATION CHECK:

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

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

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

3.9 CLEANING EQUIPMENT AND PREMISES

A. Properly lubricate equipment before Owner's acceptance.

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

C. Remove stickers from fixtures and adjust flush valves.

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

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

3.10 TESTS

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

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

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

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

3.11 WARRANTEE

A. Contractor shall guarantee work under Division 22 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.

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

3.12 SYSTEM START-UP, OWNER'S INSTRUCTIONS

A. Off-Season Start-up

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

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

3.13 PROTECTION

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

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

3.14 COMMON HVAC REQUIREMENTS:

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

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

END OF SECTION 23 05 01

SECTION 23 05 02

DEMOLITION AND REPAIR

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings, General Provisions of Contract and Section 23 05 01 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 - EXECUTION

2.1 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.

2.2 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.

2.3 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.

2.4 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 23 05 02

SECTION 23 05 14

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 05 01 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 _208/3_ 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 23 05 14

SECTION 23 05 48

SEISMIC AND VIBRATION CONTROL

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

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

1.3 REFERENCE STANDARDS

A. Uniform Building Code, Current Edition

B. NFPA Bulletin 90A, Current Edition

C. UL Standard 181

D. Tri-Services Manual, Fagel Et Al

E. MACNA Guidelines for Seismic Restraints of Mechanical Systems

1.4 SEISMIC REQUIREMENTS & QUALIFICATIONS

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

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

1.5 SUBMITTALS

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

PART 2 - PRODUCTS

2.1 RESTRAINT EQUIPMENT

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

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

2.2 INERTIA PADS

A. Reinforced concrete inertia bases, the steel members of which are designed and supplied by the isolator manufacturer. The concrete shall be poured into a welded steel frame, incorporating prelocated equipment anchor bolts, 1/2" diameter reinforcing bars on nominal 8" centers each way, and recessed isolator mounting brackets to reduce the mounting height of the equipment, but yet remain within the confines of the base. The thickness of the base shall be 6 inches, or as indicated on the drawings. Where inertia bases are used to mount pumps, the bases shall be wide enough to support piping elbows. Provide with 1 inch minimum deflection springs.

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

PART 3 - EXECUTION

3.1 SEISMIC REQUIREMENTS

A. All mechanical equipment, piping and ductwork shall be braced, snubbed or supported to withstand seismic disturbances and remain operational. Furnish all engineering, labor,

materials and equipment to provide protection against seismic disturbances as specified herein.

B. Isolated Equipment:
1. All vibration isolated equipment shall be mounted on rigid steel frames or concrete bases as described in the vibration control specifications unless the equipment manufacturer certified direct attachment capability. Each spring mounted base shall have a minimum of four all-directional seismic snubbers that are double acting and located as close to the vibration isolators as possible to facilitate attachment both to the base and the structure. The snubbers shall consist of interlocking steel members restrained by shock absorbent rubber materials.
2. Elastomeric material shall be replaceable and a minimum of 3/4" thick. Snubbers shall be manufactured with an air gap between hard and resilient material of not less than 1/8" nor more than 1/4". Snubbers shall be installed with factory set clearances. Snubbers shall be equal to Mason Z-1011.
3. A one "g" minimum vertical and lateral level shall be used in the design of all snubbers restraining isolated equipment.

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

D. Non Isolated Equipment:
1. The restraint systems for all non isolated equipment shall be designed according to Table 23J, sec. 2312 of the Uniform Building Code with an importance factor of 1.5, a site factor Z = 0.75 and a Cp = 0.3. Horizontal force factor for elements of structures. In addition, the vertical forces restraint requirement shall be computed as 1/2 the value of the horizontal forces. All equipment not anchored directly to floors shall be restrained by cables as designed and furnished by the Restraint Manufacturer.

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

3.2 VIBRATION ISOLATION REQUIREMENTS

A. All mechanical equipment 1 horsepower and over, unless otherwise noted, shall be isolated

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

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

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

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

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

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

END OF SECTION 23 05 48

SECTION 23 05 53

IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.2 RELATED DOCUMENTS

A. Drawings, General Provisions of Contract and Section 23 05 01 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. Steam Pipe, Gas, & Valve Identification –
      a. Identify specific pipe contents by stenciling pipe with written legend and placing of arrows to indicate direction of flow.

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

Symbol	Name	Color
STM	Steam Lines	Orange
COND	Steam Condensate Return Line	Lt Orange
HWH	Hot Water Heating	Green
NG	Natural Gas	Yellow

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

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

END OF SECTION 23 05 53

SECTION 23 05 93

TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 - GENERAL

1.1 SECTION REQUIREMENTS

A. Submittals:
1. Certified TAB reports.
2. Documentation of work performed per ASHRAE 62.1, Section 7.2.2 - "Air Balancing."
3. Documentation of work performed per ASHRAE/IESNA 90.1, Section 6.7.2.3 - "System Balancing."

B. TAB Firm Qualifications: NEBB certified. (CONTRACTED BY DPW)

C. TAB Report Forms: Standard TAB contractor's forms approved by Architect.

D. Perform TAB after distribution systems have been satisfactorily completed.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine the Contract Documents to become familiar with Project requirements and to discover conditions in systems' designs that may preclude proper TAB of systems and equipment.

B. Examine the approved submittals for HVAC systems and equipment.

C. Examine systems for installed balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers. Verify that locations of these balancing devices are accessible.

D. Examine system and equipment installations and verify that field quality-control testing, cleaning, and adjusting specified in individual Sections have been performed.

E. Examine HVAC equipment and filters and verify that bearings are greased, belts are aligned and tight, and equipment with functioning controls is ready for operation.

F. Examine terminal units, such as variable-air-volume boxes, and verify that they are accessible, and their controls are connected and functioning.

G. Examine automatic temperature system components to verify the following:
1. Dampers, valves, and other controlled devices are operated by the intended controller.
2. Dampers and valves are in the position indicated by the controller.

3. Integrity of dampers and valves for free and full operation and for tightness of fully closed and fully open positions. This includes dampers in multizone units, mixing boxes, and variable-air-volume terminals.
4. Automatic modulating and shutoff valves, including two-way valves and three-way mixing and diverting valves, are properly connected.
5. Thermostats and humidistats are located to avoid adverse effects of sunlight, drafts, and cold walls.
6. Sensors are located to sense only the intended conditions.
7. Sequence of operation for control modes is according to the Contract Documents.
8. Controller set points are set at indicated values.
9. Interlocked systems are operating.
10. Changeover from heating to cooling mode occurs according to indicated values.

H. Report deficiencies discovered before and during performance of test and balance procedures.

3.2 GENERAL PROCEDURES FOR TESTING AND BALANCING

A. Perform testing and balancing procedures on each system according to the procedures contained in NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems and in this Section.

B. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary for TAB procedures. After testing and balancing, patch probe holes in ducts with same material and thickness as used to construct ducts. Install and join new insulation that matches removed materials. Restore insulation, coverings, vapor barrier, and finish.

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

D. Take and report testing and balancing measurements in inch-pound (IP) units.

3.3 GENERAL PROCEDURES FOR BALANCING AIR SYSTEMS

A. Prepare schematic diagrams of systems' "as-built" duct layouts.

B. For variable-air-volume systems, develop a plan to simulate diversity.

C. Determine the best locations in main and branch ducts for accurate duct airflow measurements.

D. Verify that motor starters are equipped with properly sized thermal protection.

E. Check for airflow blockages.

F. Check condensate drains for proper connections and functioning.

G. Check for proper sealing of air-handling unit components.

H. Check for proper sealing of air duct system.

3.4 TOLERANCES

A. Set HVAC system airflow and water flow rates within the following tolerances:
   1. Supply, Return, and Exhaust Fans and Equipment with Fans: Plus or minus 10 percent.
   2. Air Outlets and Inlets: Plus or minus 10 percent.

END OF SECTION 23 05 93

SECTION 23 07 12

MECHANICAL INSULATION AND FIRE STOPPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings, General Provisions of Contract and Section 23 05 01 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. Steam and Condensate Pipe Insulation
   2. How Water Supply and Return Pipe Insulation
   3. Refrigeration Pipe Insulation
   4. Ductwork Insulation
   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 23 07 12

SECTION 23 07 14

PREMOLDED ONE PIECE PVC FITTINGS INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and General Provisions of Contract and Section 23 05 01 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

MANUFACTURED UNITS

A. Approved Manufacturers:
   1. Zeston

PART 3 - EXECUTION

3.1 INSTALLATION

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

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

END OF SECTION 23 07 14

SECTION 23 07 15

HOT WATER HEATING AND RETURN PIPING INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

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

PART 2 - PRODUCTS

2.1 MATERIAL

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

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

PART 3 - EXECUTION

3.1 INSTALLATION

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

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

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

indicated on contract drawings:

1. Metal jacketing shall be 0.016" (0.4 mm) minimum aluminum or stainless steel with moisture barrier, secured in accordance with the jacket manufacturer's recommendations. Joints shall be applied so they will shed water and shall be sealed completely.
2. UV resistant PVC jacketing may be applied in lieu of metal jacketing provided jacketing manufacturer's limitations with regard to pipe size, surface temperature, and thermal expansion and contraction are followed.
3. Fittings shall be insulated as prescribed above, jacketed with preformed fitting covers matching outer jacketing used on straight pipe sections, with all joints weather sealed.
4. On outdoor chilled water and refrigerant lines, the insulation system shall be completely vapor sealed before the weather-resistant jacket is applied. The outer jacket shall not compromise the vapor barrier by penetration of fasteners, etc. Vapor stops at butt joints shall be applied at every fourth pipe section joint and at each fitting to provide isolation of water incursion.

END OF SECTION 23 07 15

SECTION 23 07 16

DUCTWORK INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings, General Provisions of Contract and other Division 1 Specification Sections, and Section 23 05 01 apply to this Section.

1.2 SUMMARY

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

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

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

PART 2 - PRODUCTS

2.1 INSULATION

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

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

PART 3 - EXECUTION

3.1 INSTALLATION

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

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

C. Completely seal joints.

END OF SECTION 23 07 16

SECTION 23 07 17

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 05 01 apply to this Section.

1.2 SUMMARY

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

1.3 QUALITY ASSURANCE

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

PART 2 - PRODUCTS

2.1 MANUFACTURED UNITS

A. Fiberglass blanket insulation

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

PART 3 - EXECUTION

3.1 INSTALLATION

A. Insulate round air supply ducts.

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

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

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

E. Insulate attenuators.

F. Insulate high and low pressure flex ducts.

END OF SECTION 23 07 17

SECTION 23 07 18

DUCT LINING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings, General Provisions of Contract and other Division 1 Specification Sections, and Section 23 05 01 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

1.3 SYSTEM DESCRIPTION

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

1.4 RATINGS:

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

PART 2 - PRODUCTS

2.1 DUCT LINER

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

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

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

2.2 ADHESIVE

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

6. Techno Adhesive - 133

B. Solvent Base (non-flammable) Type:
1. Cain - Safetak
2. Duro Dyne - FPG
3. Kingco - 15-137
4. Miracle - PF-91
5. Mon-Eco - 22-24
6. Techno Adhesive - 'Non-Flam' 106

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

2.3 FASTENERS

A. Adhesively secured fasteners not allowed.

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

PART 3 - EXECUTION

3.1 INSTALLATION

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

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

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

3.2 FIELD QUALITY CONTROL

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

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

3.3 ADJUSTING, CLEANING

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

END OF SECTION 23 07 18

SECTION 23 07 20

REFRIGERANT PIPING INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

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

1.3 QUALITY ASSURANCE

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

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

PART 2 - PRODUCTS

2.1 FLEXIBLE FOAMED PIPE INSULATION

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

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

2.2 JOINT SEALER

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

2.3 MANUFACTURED UNITS

A. Nominal 3/4" wall thickness

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

PART 3 - EXECUTION

3.1 INSTALLATION

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

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

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

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

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

F. Stagger joints on layered insulation.

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

H. Seal joints in insulation.

I. Insulate flexible pipe connectors.

J. Insulate thermal expansion valves with insulating tape.

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

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

END OF SECTION 23 07 20

SECTION 23 07 68

STEAM SUPPLY AND CONDENSATE RETURN PIPING INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings, General Provisions of Contract and other Division 1 Specification Sections, and Section 23 05 01 apply to this Section.

1.2 SUMMARY

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

PART 2 - PRODUCTS

2.1 MATERIAL

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

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

PART 3 - EXECUTION

3.1 INSTALLATION

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

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

END OF SECTION 23 07 68

SECTION 23 07 75

FIRE STOPPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

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

1.3 QUALITY ASSURANCE

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

PART 2 - PRODUCTS

2.1 MANUFACTURED UNITS

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

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

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

PART 3 - EXECUTION

3.1 INSTALLATION

A. Follow manufacturer's installation instructions explicitly.

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

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

END OF SECTION 23 07 75

SECTION 23 08 00

COMMISSIONING OF HVAC SYSTEMS

PART 1 - GENERAL

1.1 Summary

A. Attention is directed to the printed form of Contract and General Conditions and Supplementary Conditions which are hereby made a part of this Section of the Specifications.

B. Commissioning: Commissioning (Cx) is a quality-oriented process for achieving, verifying, and documenting that the performance of facilities, systems, and assemblies meet the defined objectives and criteria set by the Owner.

C. Commissioning Team: The members of the Cx team consist of the owner's contracted commissioning authority (CxA), the owner's representative or construction manager (CM), the general contractor (GC), the architect (Arch) and the design engineers (Engs), the mechanical Contractors (MC), the electrical contractor (EC), the testing and balancing (TAB) contractor, the control contractor (CC), the facility operating staff, and any other subContractors or suppliers of equipment. The CxA directs and coordinates the project Cx activities and reports to the owner. All team members work together to fulfill their contracted responsibilities and meet the objectives of the contracted documents. Commissioning Shall:

1. Verify that applicable equipment and systems are installed according to the contract documents, manufacturer's recommendations, and industry accepted minimum standards and that they receive adequate operational checkout by installing Contractors.
2. Verify and document proper performance of equipment and systems.
3. Verify that O&M documentation left on site is complete.
4. Verify that the owner's operating personnel are adequately trained.

D. The Cx process does not take away from or reduce the responsibility of the system designers or installing Contractors to provide a finished and fully functional product. Furthermore it doesn't not remove any responsibilities, products or requirements of other specification sections.

E. The general or HVAC contractors are not required to provide the CxA. An independent, third party commissioning agent has been retained by the State of Idaho. Though the contractor is not required to provide a commissioning agent, requirements for participation in the commissioning process are included in this specification.

1.2 DESCRIPTION OF WORK

A. The work of this Section shall include and provide all labor, tools, materials and equipment necessary for the CxA to verify installation and performance of the MEP systems. The following systems shall be commissioned.

1. Energy Recovery Units
2. Pool dehumidification units
3. Steam to hot water heat exchangers
4. Circulating pumps and coils
5. Heat recovery VRF units

1.3 REFERENCE STANDARDS

A. ASHRAE Standard 202-2013

B. Idaho State Commissioning Guidelines

1.4 DEFINITIONS

A. Commissioning Plan: The detailed process of checking and testing procedures, sequences of events, schedules, staffing plans, and management or administrative procedures required to provide a comprehensive coordinated approach for commissioning the systems and equipment described herein.

B. CxA: Commissioning Authority. The Commissioning Representative of the Owner. The Commissioning Authority will manage all commissioning activities on behalf of the Owner and will serve as the Owner's agent in review and approval of commissioning related services.

C. Systems, Subsystems, Equipment, and Components: Where these terms are used together or separately, they shall mean "as-built" systems, subsystems, equipment, and components.Commissioning Representatives: Those members of the Contractor's staff, Sub-contractor's staff, Owner's staff, Architect's staff, or Owner's independent contractor assigned to participate in the commissioning process.

D. Commissioning Manager: The Commissioning Representative of the Contractor and/or commissioning team, to manage and lead the commissioning effort on behalf of the Contractor and/or commissioning team.

E. Commissioning Procedures: A series of checks, tests, and operational procedures, applied in specific sequences, to each system or equipment component to be commissioned and intended to demonstrate full system installation, performance, and functionality, in accordance with the design intent. The term "procedures" shall be used throughout this specification and the Project Commissioning Plan in reference to these checking, testing, and operational procedures.

F. Systems Functional Performance Test: A test, or tests, of the dynamic function and operation of equipment and systems using manual (direct observation) or monitoring methods. Systems Functional Performance Testing is the dynamic testing of systems (rather than just components) under full operation (e.g., the chiller pump is tested interactively with the chiller functions to see if the pump ramps up and down to maintain the differential pressure setpoint) performed by the Commissioning Agent with support from the contractor as needed. Systems are tested under various modes, such as during low cooling or heating loads, high loads, component failures, unoccupied, varying outside air temperatures, fire alarm, power failure, etc. The systems are run through all the control system's sequences of operation and components are verified to be responding as the sequences state. Traditional air or water test and balancing (TAB) is not considered Systems Functional Performance Testing. TAB's primary work is setting up the system flows and pressures as specified, while System Functional Performance Testing is verifying that the system has already been set up properly and is functioning in accordance with the Construction Documents. The Commissioning Agent develops the Systems Functional Performance Test Procedures in a sequential written form, coordinates, witnesses, and documents the actual testing. Systems Functional Performance Testing is performed by the Contractor. Systems Functional Performance Tests are performed after startups, control systems are complete and operational, TAB functions and Pre-Functional Checklists are complete.

G. Pre-Functional Checklist: A list of items provided by the Commissioning Agent to the Contractor that require inspection and elementary component tests conducted to verify proper installation of equipment. The contractor is required to perform this work, populate checklist forms and submit them to the Commissioning Authority prior to scheduling functional testing. Pre-Functional Checklists are primarily static inspections and procedures to prepare the equipment or system for initial operation (e.g., belt tension, oil levels OK, labels affixed, gages in place, sensors calibrated, etc.). However, some Pre-Functional Checklist items entail simple testing of the function of a component, a piece of equipment or system (such as measuring the voltage imbalance on a three-phase pump motor of a chiller system). The term "Pre-Functional" refers to before Systems Functional Performance Testing. Pre-Functional Checklists augment and are combined with the manufacturer's startup checklist and the Contractor's Quality Control checklists.

1.5 INTENT

A. It is the intention of this Specification is to require the Contractors performing work to cooperate with the CxA, to furnish all labor and equipment and measuring devices, to perform required measurements and tests to verify that the installed equipment and systems are performing in accordance with the construction documents.

B. The CxA is not responsible for design concept, design criteria, compliance with codes, design or general construction scheduling, cost estimating or construction management.

C. HVAC system installation, start-up, testing and balancing, preparation of O&M manuals, and operator training are the responsibility of the HVAC Contractor, with coordination by the General Contractor, Construction Manager or other entity acting under the requirements of Division 1. Observation, verification and Cx are the responsibility of the CxA who is to be assisted by installing Contractors in system operation as needed. The Cx process does not relieve Contractors from the obligations to complete all portions of work in a satisfactory and fully operational manner, nor does Cx remove any obligation the trades have for operation and maintenance manuals and training.

1.6 HVAC CONTRACTOR REQUIREMENTS

A. Cx, Pre-Functional and Functional testing as defined by ASHRAE standard 202-2013 are mandatory requirements of this project. All equipment and systems installed in connection with the section listed above shall be put in operation in the presence of duly authorized representatives with 24-hour notice given to the CxA.

B. All applicable equipment submittals shall be forwarded to the CxA for review.

C. GC shall sign-off on all CxA site visits, whether or not Contractors meet their commitments with regard to inspection and testing.

D. No Functional Testing shall commence until the completion and submission of the manufacturer startup checklists and populated pre-functional checklists to the CxA. The CxA will provide blank pre-functional testing forms for the contractor to populate. Pre-functional testing forms shall be provided to the CxA in submittal form.

E. No Functional Testing shall commence until all systems TAB is complete. Functional testing may commence, at the discretion of the CxA, once TAB is complete however only conditional acceptance can be achieved until the final TAB report is provided by the contractor to the CxA for review. Only after review and acceptance of the TAB report and tested values can final acceptance be achieved. The owner may elect to wait until final acceptance is achieved to consider the project substantially complete.

1.7 RESPONSIBILITIES OF THE MECHANICAL CONTRACTORS AND CXA

A. The Cx responsibilities applicable to mechanical contractor and appropriate subcontractors are as follows:

1. Provide startup for all equipment in the contracted scope
2. Assist and cooperate with the Testing and Balancing (TAB) contractor and the CxA by:
    a. Putting all equipment and systems into operation and continuing the operation during each working day of TAB and Cx as required.
    b. Providing temperature and pressure taps according to the Construction Documents for TAB and Cx testing.
    c. Assist the TAB in the location and operation of all balancing equipment
3. List and clearly identify on the as-built drawings the locations of all P/T plugs, meters, sensors and all other such measure and verification devices.

4. Prepare a preliminary schedule for all pipe system testing, flushing and cleaning, equipment start-up and TAB start and completion for use by the CxA. Update the schedule as appropriate.
5. Notify the GC when pipe system testing, flushing, cleaning, lighting panel testing, fixture testing, power distribution and startup of each piece of equipment and TAB will occur. Be responsible to notify the GC, ahead of time, when Cx activities not yet performed or not yet scheduled will delay construction. Be proactive in seeing that Cx processes are executed and that the CxA and GC both have the scheduling information needed to efficiently execute the Cx process.
6. In each purchase order or subcontract written, include requirements for submittal data, Cx documentation, O&M data and training.
7. Attend Cx scoping meetings and other meetings necessary to facilitate the Cx process.
8. Provide a copy of the O&M manuals and submittals of commissioned equipment, through normal channels, together during equipment submittals to the CxA for review and approval. See this specification section for additional information and requirements for the O&M manuals.
9. Contractors shall assist (along with the design engineers) in clarifying the operation and control of commissioned equipment in areas where the specifications, control drawings or equipment documentation is not sufficient for writing detailed testing procedures.
10. Review test procedures to ensure feasibility, safety and equipment protection and provide necessary written alarm limits to be used during the tests.
11. Develop a full start-up and initial checkout plan using manufacturer's start-up procedures and populate the PFTs from the CxA for all commissioned equipment. Submit to CxA for review and approval prior to startup.
12. During the startup and initial checkout process, execute the MEP-related portions of the PFTs for all commissioned equipment. Perform and clearly document all completed startup and system operational checkout procedures, providing a copy to the CxA.
13. Address current outstanding punch list items before functional testing. Water Pressure Testing and Water Testing and Balancing (TAB) shall be completed with discrepancies and problems remedied before functional testing of the respective air- or water-related systems. Fire protection piping pressure testing shall be completed with discrepancies and problems remedied before functional testing of the respective air- or water-related systems.
14. Complete Prefunctional Test Checklists (PFTs) provided by the CxA and return these to the CxA. After the contractors have completed the PFTs and returned them to the CxA, the CxA will back-check a percentage for accuracy. If the actual field work is not in agreement with the sheets, the contractor will be required to make corrections at their expense. After completion of corrective work, the CxA will review another section of the work and check for agreement with the checklists. The contractor(s) will be back charged for this, and all additional, checks required to verify checklists and complete the prefunctional phase of commissioning.
15. Provide access for equipment to be tested, such as removing ceiling tiles.
16. Provide skilled technicians to execute starting of equipment and to execute the functional performance tests. Ensure that they are available and present during the agreed upon schedules and for sufficient duration to complete the necessary tests, adjustments and problem solving.
17. Provide skilled technicians to assist with functional performance testing under the direction of the CxA for specified equipment outlined in the Cx Plan. Assist the CxA in interpreting the monitoring data, as necessary.
18. Correct deficiencies (differences between specified and observed performance). The CxA will provide one (1) functional retest of commissioned equipment at no additional charge to the contractor(s). If repeated failures of the equipment and/or system require retest beyond the first retest, the contractor(s) will be back charged for the time of the CxA required to complete the additional retesting.

19. Prepare O&M manuals according to the Contract Documents, including clarifying and updating the original sequences of operation to as-built conditions. Provide assistance, cooperate and provide required materials to others as directed by the GC (and CxA) in the compilation of the O&M manuals. Prepare draft versions of the O&M Manual for use as the training syllabus.
20. During construction, maintain as-built red-line drawings for all drawings and final CAD as-builts for contractor-generated coordination drawings. Update after completion of Cx (excluding deferred testing).
21. Provide Training Plan and training of the Owner's operating staff using expert qualified personnel, as specified. Use the draft O&M manual as the training manual.
22. Coordinate with equipment manufacturers to determine specific requirements to maintain the validity of the warranty.
23. Attend Cx coordination meetings and provided assistance and cooperate in the preparation of a Cx schedule with the GC and CxA.
24. Cx Tasks shall be performed by the same personnel who were involved in the installation and are familiar with the equipment.
25. During the Warranty Period execute seasonal or deferred functional performance testing, witnessed by the CxA, according to the specifications and correct deficiencies and make necessary adjustments to O&M manuals and as-built drawings for applicable issues identified in any seasonal testing.

B. The Cx responsibilities applicable to the TAB Contractor in addition to those which apply in (A) are as follows:

1. Prior to starting TAB, submit to the GC the qualifications of the site technician for the project. The owner or CxA will approve the site technician's qualifications for this project.
2. Meet with the CxA and GC and submit the outline of the TAB plan and approach for each system and component to the CxA, GC and the controls contractor prior to starting TAB. The submitted plan will include:
    a. Certification that the TAB contractor understands the Cx requirements.
    b. An explanation of the intended use of the building control system for TAB. The controls contractor will comment on feasibility of the plan.
    c. All field checkout sheets and logs to be used that list each piece of equipment to be tested, adjusted and balanced.
    d. Discussion of what notations and markings will be made on the duct and piping drawings during the process.
    e. Final test report forms to be used.
    f. Procedures for TAB work for each system and issue: terminal flow calibration (for each terminal type), diffuser proportioning, branch / submain proportioning, total flow calculations, rechecking, diversity issues, expected problems and solutions, etc. Criteria for using air flow straighteners or relocating flow stations and sensors will be discussed. Provide the analogous explanations for the water side.
    g. Details of how *total* flow will be determined
    h. The identification and types of measurement instruments to be used and their most recent calibration date.
    i. Specific procedures that will ensure that water systems are operating at the lowest possible pressures and provide methods to verify this.
    j. Details regarding specified deferred or seasonal TAB work.
    k. Details of any specified false loading of systems to complete TAB work.

l. Plan for hand-written field technician logs of discrepancies, deficient or uncompleted work by others, contract interpretation requests and lists of completed tests (scope and frequency).

3. Provide a draft or preliminary TAB report within two weeks of completion. A copy will be provided to the CxA. The report will contain a full explanation of the methodology, assumptions and the results in a clear format with designations of all uncommon abbreviations and column headings. The report should follow the latest and most rigorous reporting recommendations by AABC, NEBB or ASHRAE Standard 111.

4. Provide the CxA with any requested data, gathered, but not shown on the draft reports.

5. Provide a final TAB report for the CxA with details, as in the draft.

C. The Cx responsibilities applicable to the Owner or Owner's Representative are as follows:

1. Provide the OPR documentation (if applicable) to the CxA and the Cx Team for use in developing the Cx plan; systems manual; operation and maintenance training plan; and testing plans and checklists

2. Assign operation and maintenance personnel and schedule them to participate in Cx team activities including, but not limited to, the following:

a. Coordinate Meeting

b. Training in operation and maintenance of systems, subsystems, and equipment.

c. Testing meetings.

d. Demonstration of operation of systems, subsystems, and equipment.

3. Provide utility services required for the Cx process.

4. Provide the BOD documents(if applicable), prepared by Architect and approved by Owner, to the CxA and the Cx Team for use in developing the Cx plan, systems manual, and operation and maintenance training plan.

D. The Responsibilities of the Commissioning Authority (CxA) during design, construction and acceptance phases are:

1. Organize and lead the Cx team.

2. Prepare a construction-phase Cx plan. Collaborate with Contractors and with subContractors to develop test and verification procedures. Include design changes and scheduled Cx activities coordinated with overall Project schedule. Identify Cx team member responsibilities, by name, firm, and trade specialty, for performance of each Cx task.

3. Review and comment on submittals from Contractors for compliance with the OPR, BOD, Contract Documents, and construction-phase Cx plan. Review and comment on performance expectations of systems and equipment and interfaces between systems relating to the OPR and BOD.

4. Convene Cx team meetings for the purpose of coordination, communication, and conflict resolution; discuss progress of the Cx processes. Responsibilities include arranging for facilities, preparing agenda and attendance lists, and notifying participants. The CxA shall prepare and distribute minutes to Cx team members and attendees within five workdays of the Cx meeting.

5. At the beginning of the construction phase, conduct an initial construction-phase coordination meeting for the purpose of reviewing the Cx activities and establishing tentative schedules for operation and maintenance submittals; operation and maintenance training sessions; TAB Work; and Project completion.

6. Observe and verify construction and report progress and deficiencies. In addition to compliance with the OPR, BOD, and Contract Documents, verify systems and equipment installation for adequate accessibility for maintenance and component replacement or repair.

7. Prepare project-specific test and verification procedures and checklists.
8. Schedule, direct, witness, and document tests and verifications.
9. Compile test data, verification reports, and certificates and include them in the systems manual and Cx report.
10. Develop custom pre-functional testing protocol for review by interested parties.
11. Perform functional testing with assistance by appropriate contractors
12. Certify date of acceptance and startup for each item of equipment for start of warranty periods.
13. Review project record documents for accuracy. Request revisions from Contractor to achieve accuracy. Project record documents requirements are specified in Division 1.
14. Review and comment on operation and maintenance documentation and systems manual outline for compliance with the OPR, BOD, and Contract Documents. Operation and maintenance documentation requirements are specified in Division 1 Section "Operation and Maintenance Data."
15. Review operation and maintenance training program and provide assessment and feedback on the completeness of the maintenance training program requirements. Operation and maintenance training is specified in Division 1, Section 01 79 00 "Demonstration and Training".
16. Prepare Cx reports.
17. Assemble the final Cx documentation, including the Cx report and Project Record Documents.

E. The Cx responsibilities applicable to the Controls Contractor are as follows:

1. Integration of existing DDC interface with new equipment as required to fully control new equipment per design requirements.
2. Assist in equipment startup as required by mechanical contractor.
3. Assist in TAB as required by the TAB contractor.
4. Perform point-to-point checkouts prior to scheduling any functional testing with all interested parties.
5. Support CxA as needed and provide access to final control systems in collaboration with owner representatives to ensure functional testing can be performed.
6. Control equipment as needed to simulate loads or other implement testing protocols required for functional testing.
7. Provide CxA with control based point-to-point checkout documentation.
8. Notify CxA of training dates for O&M personnel at hand-off.

F. The following systems shall receive commissioning services. The Cx Process in general shall cover all activities required by ASHRAE Standard 202-2013. The extent and scope of commissioning services for this section includes:

1. HVAC System
    1. Energy Recovery Units
    2. Pool dehumidification units
    3. Steam to hot water heat exchangers
    4. Circulating pumps and coils
    5. Heat recovery VRF units
    6. Overall HVAC Functionality

G. No Functional Testing shall commence until all Prefunctional Checklists are completed and returned to the CxA.

1.8 RECORD DRAWINGS

A. Record drawings shall be kept on the job site and up dated continuously by the Contractor as the work progresses

B. Record drawings shall show exact locations and sizes of all the work to be concealed. Especially note the location of the valves, volume dampers, fire dampers, etc.

C. Non-availability of the updated record drawings or inaccuracies therein shall be grounds for cancellation and/or postponement of any final verification by the engineer.

1.9 COMMISSIONING APPROACH

A. General

1. The commissioning approach shall include a series of checks, tests, and operational procedures, applied in specific sequences, to each system or equipment component to be commissioned.

2. The contractor shall perform startup tests in accordance with manufacturer's requirements and pre-functional testing in accordance with Commissioning Authority supplied checklists utilizing members of the construction staff and representatives of the equipment and system manufacturer's who are fully knowledgeable of the equipment and systems installation and operation.

3. The HVAC contractor is required to fill out the pre-functional testing forms provided by the Commissioning Agent. The Commissioning agent may observe certain pre-functional tests and their discretion.

4. The specific commissioning procedures required are described in the Project Commissioning plan to be provided after contract and award. These procedures shall be performed in a specific sequence as described in the Project Commissioning Plan. The sequenced application of the procedures is intended to provide a step-wise development, proceeding from the individual component level, to the system level, and ultimately to the multiple integrated level of system operation. This sequencing approach will require certain procedures to be performed earlier in the construction process than for non-commissioned construction, and is intended to help ensure that the installation is free of defects at the earliest opportunity, allowing increased time for correction or modification if defects or performance issues are found.

PART 2 - (Not Used)

PART 3 - EXECUTION

3.1 SUBMITTALS

A. Contractors shall provide submittal documentation for systems to be commissioned indicated herein and in the Cx Plan.

B. Contractor shall provide populated prefunctional checklists.

3.2 PRE-COMMISSIONING work SESSION & Kickoff meeting

A. The GC shall schedule and chair a pre-commissioning work session to review the CxA's developing Commissioning Plan. The work session shall be held prior to HVAC rough-in.

B. The work session shall be held at the Contractor's principle place of business or at the job site. The

GC, CxA, appropriate subcontractors and representatives of the owner shall be scheduled for attendance as a minimum. Sub-contractor representatives of the principle trades involved in the commissioning process should also be in attendance and may be scheduled for attendance at the discretion of the CxM.

C. The GC shall record participant comments and distribute minutes of the meeting to all parties involved.

D. The GC shall schedule and chair a commissioning kickoff meeting review the CxA's testing protocols, revisit the commissioning plan and review scheduling for upcoming testing. The work session shall be prior to startup of major equipment.

E. The GC shall schedule and the appropriate subcontractors shall participate in the kickoff meeting held separately from the work session.

F. Mechanical contractor(s) shall participate in both the work session and kickoff meeting.

3.3 START-UP

A. The HVAC contractor(s) shall follow the start-up and initial checkout procedures listed in the Responsibilities list in this section and in the Cx Plan. Division 22, 23 and 26 has start-up responsibility and is required to complete systems and sub-systems so they are fully functional, meeting the design objectives of the Contract Documents and manufacturer requirements. The Cx procedures and pre-functional and functional testing do not relieve or lessen this responsibility or shift that responsibility partially to the CxA, GC or Owner.

3.4 CONTROLS TESTING PREPERATION AND VERIFICATION

A. The Cx responsibilities of the Controls Subcontractor in preparation for Functional Testing are:

1. Sequences of Operation Submittals: The Controls Contractor shall send to the CxA complete controls submittals. Submittals of control drawings shall include complete detailed sequences of operation for each piece of equipment, regardless of the completeness and clarity of the sequences in the specifications. See Division 1 for complete details.
2. Points List: The Controls Contractor shall send to the CxA a draft points list as soon as it is available but no later than two months prior to occupancy. This shall be updated as often as required. A complete "as-built" points list shall be sent at the end of the project. See Division 1 for complete required contents of the points list.
3. Point-To-Point Checks – The Controls Contractor is required to perform their own point-to-point checks and provide verification to the CxA prior to the HVAC contractor scheduling functional testing.
4. Notification of Operation: The Controls Contractor shall notify the CxA when each piece of equipment, panel or sub-panel is under automatic control and may be viewed in operation, prior to final functional testing.
5. The Controls Contractor shall review all CxA provided functional test procedures. The receipt of the procedures by the contractor constitutes certification that the contractor has reviewed the procedures and confirmed they are safe and will not harm any equipment or systems. Any subsequent damage incurred as a result of conducting the documented verification shall be the responsibility of the contractor.

3.5 TAB

A. Refer to the TAB responsibilities above and in the specification section of TAB. TAB shall be completed prior to functional testing unless otherwise determined by the CxA.

3.6 PRE-FUNCTIONAL TESTING

A. Prior to the beginning of the commissioning and testing specified under this section, the HVAC subcontractor adjust and check operation and performance of the systems and equipment installed under their respective sections.

B. At the discretion of the CxA the sub systems may be required to be tested prior completion of the entire system. This particularly applies to hydronic systems pressure testing.

C. Submit to the CxA all the testing logs.

D. Without limiting the following work shall be performed:

1. Verify and document that the systems and equipment are installed and functioning in accordance with the OPR and contract documents. The as-built drawings and operating manuals reflect the as built conditions.

2. The systems shall be started and their performance shall be checked and compared with the manufacturers requirements as well as design documents.

3. Blank Pre-functional checklists shall be provided by the CxA.

4. Any system or equipment which is does not pass manufacturer startup requirements and Pre-functional testing shall be repaired and replaced at no cost to the owner. The contractor shall retest the system at their own cost until the manufacturers startup requirements and pre-functional testing criteria are met.

E. Pre-functional Checklist (PFC) - a list of items to verify and elementary component tests to conduct to verify proper installation of equipment, provided by the CxA to the appropriate contractor. Pre-functional checklists are primarily static verifications and procedures to prepare the equipment or system for initial operation (e.g., lighting and power connections, belt tension, oil levels OK, labels affixed, gages in place, sensors calibrated, etc.). However, some pre-functional checklist items entail simple testing of the function of a component, a piece of equipment or system (such as measuring the voltage imbalance on a three phase pump motor of a chiller system). The word pre-functional refers to before functional testing. Pre-functional checklists augment and are combined with the manufacturer's start-up checklist. The CxA requires that completed manufacturer startup sheets and pre-functional checklists be provided in submittal form prior to requesting and scheduling a date to start functional testing.

3.7 FUNCTIONAL TESTING

A. After review and acceptance of the manufacturer startup forms and pre-functional checklists, the CxA will schedule dates to begin functional testing.

B. Functional testing is intended to begin upon completion of a system installation, startup and pre-functional testing. Functional testing may proceed prior to the completion of systems or sub-systems at the discretion of the CxA and Owner. Beginning system testing before full completion does not relieve the Contractor from fully completing the system, including all PFTs as soon as possible.

C. Functional Performance Test (FT) - test of the dynamic function and operation of equipment and systems using manual (direct observation) or monitoring methods. Functional testing is the dynamic testing of systems by the CxA (rather than just components) under full operation (e.g., the lighting panel interacts with daylight sensors, or the chiller pump is tested interactively with the chiller functions to see if the pump ramps up and down to maintain the differential pressure setpoint). Systems are tested under various modes, such as during low cooling or heating loads, high loads, component failures, unoccupied, varying outside air temperatures, fire alarm, power failure, etc. The systems are run through all the control system's sequences of operation and components are verified to be responding as the sequences state. Traditional air or water test and balancing (TAB)

is not considered functional testing as required by the Cx process. TAB's primary work is setting up the system flows and pressures as specified, while functional testing is verifying that which has already been set up. The CxA develops the functional test procedures in a sequential written form, coordinates, oversees and documents the actual testing, which is usually performed by the installing contractor or vendor. Functional Tests are performed after PFTs and start-up are complete.

D. Procedure Acceptance

1. On-Site Conditional Acceptance
2. Upon satisfactory completion of each commissioning procedure and completion of the procedure close-out meeting, the CxA shall provide conditional acceptance of the procedure.
3. Conditional acceptance shall indicate that the related installation work checked by the procedure and the related performance verified by the procedure is satisfactory, and that the required procedure has been completed, only.
4. Conditional acceptance shall not imply that the equipment and systems involved with the procedure are fully approved and have been provided with final acceptance. Conditional acceptance shall additionally be subject to all notes and comments included in the field notes or test forms, and subject to the satisfactory demonstration that all associated pre-testing, special testing, special testing reports, or alignment reports have been fully completed.
5. Conditional acceptance shall be indicated by the signature of the CxA on the functional testing form.

E. On-Site Procedure Rejection

1. The CxA shall have the authority to reject a procedure in its entirety or to cause the procedure to be stopped if in the opinion of the CxA, any of the following conditions exist:
   a. The pre-procedure review meeting is incomplete.
   b. Appropriate or sufficient contractor staff is not available or required commissioning representatives are not present.
   c. Required pre-testing or report data, such as point-to-point control verifications, alignment reports, and trend log data is not available or is incomplete.
   d. The installation is insufficient or incomplete as required for the procedure or not in compliance with the Contract Documents.
   e. Numerous checks or tests fail or cannot be accomplished.
   f. Installation and/or operation of equipment or systems beyond or in advance of the commissioning requirements.
   g. Installation, operation, or commissioning not in compliance with the sequencing requirements.
   h. Indication of improper maintenance or operation.
   i. Inadequate instrumentation
2. The CxA shall additionally reject a procedure and require the equipment operation or procedure to be stopped if in the opinion of the CxA unsafe conditions to either staff or equipment exist. Consideration of safety issues by the CxA shall not in any way relieve the Contractor from his sole responsibility for job site safety and protection of the equipment.

3. Direction to stop the procedure or halt the operation of equipment will be given verbally. Upon notification the Contractor shall immediately stop the procedure and restore the system or equipment to a safe condition.
4. At the discretion of the CxA, the Contractor may be afforded the opportunity to correct the conditions indicated by the CxA and resume the procedure.
5. If in the opinion of the CxA corrections cannot be implemented in a satisfactory manner, within the scheduled time available for the procedure and with sufficient time available to complete the procedure, the procedure shall be stopped and rescheduled by the CxM. The CxA shall provide the CxM with written notification of procedure rejection stating the cause of the action.
6. The Contractor shall be liable for all actual costs associated with the required attendance by the CxA, the Owner's and A/E's commissioning representatives, and required outside agents, resulting from rejected procedure.
7. Actual costs shall include:
    a. Cost for the CxA and for each Owner's and A/E's commissioning representative, which are comprised of contractual billing rate as defined in the respective organization's agreement for such work, including overhead and profit. For CxA and A/E's commissioning representatives, these rates may be found in the A/E schedule for additional services.
    b. Travel-related expenses for the CxA and for each Owner's or A/E's commissioning representative, where such staff is required to be in attendance and not headquartered within the city limits, which are comprised of compensation for actual travel time, with an established minimum of 5 hours, and mileage rates, billed at the prevailing national government rate.
    c. Costs assessed for required outside agents, contractors, or specialists employed by the Owner or A/E at the actual contractual billing rates as defined in the respective organization's agreement for such work.
    d. Equipment rentals, special tools, and related material fees associated with the participation of contracted outside organizations and specialists. The costs assessed will be documented by the CxA and will be deducted from the Contractor's fees or progress payments at the time of occurrence.

3.8 CHANGES TO THE WORK

A. Changes to the work shall be as directed by Change Order, Construction Change Directive, or Order for Minor Change as defined in the General Conditions of the Contract.The CxA shall have authority to issue Orders for Minor Change, on behalf of the Owner and the Engineer, on-site, in conjunction with the commissioning activities. Such directions to the contractor will be provided in writing and will be signed and dated by the CxA.

B. The Contractor CxM shall have authority to accept Orders for Minor Change on behalf of the Contractor. The CxM, if in agreement with the Order for Minor Change, shall sign and date the Order and provide one copy to the CxA for record purposes.

C. All changes to the work shall be attached to the related procedures and shall be included as attachments to the submittals and to the final Project Commissioning Record.

D. If in the opinion of the CxA, Change Orders or Construction Change Directives are required, or other special provisions are necessary to resolve a commissioning, construction, or performance issue, the issue and recommendations will be documented by the CxA and submitted to the Architect’s construction administration staff for disposition. If the continuation of a commissioning procedure is affected by the issue, the procedure will be continued to the extent possible or as determined appropriate by the CxA. The CxA shall have full authority to stop or postpone any procedure pending disposition of commissioning, construction, or performance issues.

3.9 FINAL ACCEPTANCE

A. Final acceptance will be contingent upon satisfactory completion of all commissioning tasks and submittals, with final review and approval by the Commissioning Authority.

B. Where specific components, equipment, or system elements are unable to comply with the specified requirements due to improper or incomplete installation, product defect, or failure of a device to perform to the manufacturer's published or advertised capabilities, final acceptance will be contingent on repair, replacement, and correction of the deficiencies by the Contractor and satisfactory completion of the commissioning procedures.

C. Where specific components, equipment, or system elements are demonstrated to comply with the specified requirements and perform to the manufacturer's published or advertised capabilities, but are demonstrated not to provide the performance as required by the Contract Documents and the commissioning procedures, disposition of the issue and/or related modifications shall be provided as directed by the Architect. Final acceptance shall be contingent on the completion of any resulting correction work and related commissioning requirements determined as necessary in final disposition of the issue.

D. Upon satisfactory completion of all commissioning work and resolution of all related issues, the CxA shall provide the Owner, Contractor, and the Architect with a final report documenting recommendation for final acceptance. Recommendation for final acceptance by the CxA shall indicate that in the opinion of the CxA, and as demonstrated within the extent and scope of the commissioning process, the equipment and systems have been installed in compliance with, and function as required by the Contract Documents.

E. The Owner may accept the recommendation of the CxA and provide final acceptance by providing the appropriate authorized signature and by providing copies of the signed acceptance to all parties involved. The Owner's final acceptance of the commissioning work shall indicate that Owner accepts that the systems and equipment, as demonstrated within the extent and scope of the commissioning process, have been installed in compliance with, and function as required by, the Contract Documents. The Owner's acceptance shall not constitute agreement that all contractual obligations are fulfilled and does not constitute final acceptance of the project under the terms and conditions of the Contract Documents.

END OF SECTION 23 08 00

SECTION 23 09 53

TEMPERATURE CONTROLS

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 Reed Gymnasium for integration into the current ISU 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
3. Johnson Controls

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. Energy Recovery Ventilators
B. Dehumidifiers Units

C. Individual control modules for all non unitary air handlers or package units:
1. Dry Coolers

D. General purpose modules for control of central fan, pump, chiller, boiler or tower operation:
2. Hot Water Systems
3. Steam Systems
4. Heat Pump Loop Circulation 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.

D. 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.

E. 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.

F. 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.

C. 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
   2. 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		Services >	
	Binary Input		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. 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.

F. 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.

G. 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

4.1. BACnet COMPATIBILITY

A. 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):

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 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.

4.2 MULTIPLE OPERATING PLATFORMS

A. 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.

4.3. GRAPHICAL PROGRAMMING

A. 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.

B. 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.

4.4. GRAPHICAL INTERFACE SOFTWARE

A. 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.

B. 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.

C. 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.

4.5 FACILITY MANAGEMENT AND ENERGY MANAGEMENT FUNCTIONS

A. 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.

B. 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.

4.6. ALARMS, TRENDS AND REPORTS

A. 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.

B. 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.

C. 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

5.1. GENERAL

A. 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 Adjustable Parameters
1. All numeric values in the Sequence of Operation are adjustable parameters that can be modified without program changes or re-downloading that would interrupt system operation.

C. Power Loss to Control Modules
1. All control modules are equipped with battery backup and will retain programming, including time of day, upon loss of power. On return of power control functions will return to normal operation based on scheduling and time of day with no operator interface. Delay on start parameters can be setup at random intervals to prevent demand surges on restart.

D. Power Loss to Server
1. On loss of power to the server only the EMCS will continue to run as normal. The EMCS human interface software, WebCTRL, is a network service and will automatically restart and connect to the system when power is restored.

D. Trends
1. Trending is available, by default, on any BACnet I/O point. Trends can also be added for any digital or analog value in the program.
2. Trending will be setup for all significant I/O points.
   a. Analog values will be set to log every 5 minutes and store 288 data points for live retrieval.
   b. Binary points will be set to trend on Change of Value (COV) and to store 100 COV trend samples live.
   c. Sample frequency and quantity of stored data are adjustable within the memory limits of each module. e.g.

d. Trends can set to be logged every 5 minutes with 288 trend points allocated so that the live display will show 24 hours of trend data.

3. Extended trending is available by archiving trends using Trend Historian for server storage.

E. Schedules

1. Schedules can be set for all systems in a customer database, or for a single building, a single floor, or for an individual zone.

2. Additionally, groups of equipment can be assembled in Schedule Groups for single entry scheduling of multiple zones for specific functions.
   a. For example a Gym Activities Group could be used for single entry scheduling for practices, ball games etc.
   b. Another example would be a group of rooms occupied by a single tenant who has frequent need for space conditioning during otherwise unoccupied times.

3. Schedules can be set for weekly reoccurring occupancy, dated weekly, date, date range, wildcard or continuous and can be set for multiple years in advance.

4. Occupancy schedules will initiate from the zone level.
   a. Air handling units, chillers, boilers, pumps etc. whose operation is intended to provide air or water flow to zones will function based on Run Requests, Cooling Requests or Heating Requests from the zones they serve. These central systems will not have separate scheduling capability.

F. Optimal Start:

1. The microblock will use an optimal start algorithm to adjust the zone setpoint before the zone is occupied, ensuring that the zone temperature is within the occupied setpoints by the time the zone is occupied.

G. Learning Adaptive:

1. Adjusts (learns) zone heating and cooling capacities based on optimal start system performance.
2. Learning will be disabled automatically after the first 12 months of operation. (Adjustable)

H. Outside Air Conditions

1. Outside air temperature will be monitored.
2. Outside air conditions can be mapped to any controller for use for local control sequencing.

I. Alarming

1. All alarms generated by WebCTRL may be setup for the following actions:
   a. Alarm Popup
   b. Send E-Mail
   c. Write to File
   d. Send as Text
2. All alarms may be enabled or disabled by the operator without program change or memory download.

5.2 AIR COOLED FLUID COOLER CH-1

A. Off/Auto:

1.Chilled water secondary pump manual mode shall be controlled thru the vfd (if available).

2. Chilled water secondary pump automatic control:
   a. The two secondary chilled water pumps shall operate alternately to maintain system differential pressure with one pump as the lead pump and the other pump as the lag pump. Only one pump shall run at a time.
3. Lead and lag status shall be alternated weekly.
4. The lead pump shall operate when cooling is enabled.
5. Failure of the lead pump to provide flow when on shall initiate an alarm and alternate the lead pump to backup status and the backup pump to lead status.
6. The new lead pump shall then be enabled on.
7. The lead pump shall then remain in the lead status until the alarm status for the failed pump is manually reset.
8. When on, the speed of the lead pump shall be varied to maintain the secondary chilled water pressure
9. Set-point of 15 psi (adjustable).

5.3 HEAT RECOVERY UNIT AND STEAM COIL:

A. Auto/Off:
   1. Fans shall be Automatically Enabled during occupied times and shall run continuously as described below with dampers open. When in off position fans shall shut down and exhaust and outside air damper shall close. Dampers and actuators provided with unit.

B. Setpoints:
   1. Occupied supply air pressure: 0.75 WC (Adjustable). Occupied ventilation exhaust pressure: 1.0” WC (Adjustable).
   2. During occupied times the exhaust fan and the supply fan shall vary the fan RPM to maintain pressure Setpoints.

C. The damper MD-1
   1. shall modulate to maintain a differential air flow thru the ERU of 2400cfm. Damper MD-1 shall not begin to open unit the return airflow thru the unit is above 2400cfm.

D. Occupied time:
   1. Contractor shall coordinate with end user.
   2. Contractor shall coordinate the number of FC-X Units with outside air dampers open to avoid pulling building negative.

E. Control system shall monitor the following points:
   1. Dirty Filter alarm for outside air and exhaust air. Set at 0.5”wc (Adjustable)
   2. DDC system shall provide an active display of the outside air and exhaust air flow rates.
   3. Contractor shall coordinate number and type of points shown in the DDC system with the contracting officer.

F. Additional points
   1. Refer to specification section 23 82 19.00 40 for additional control points to monitor or controls that are furnished as part of the unit control system.

G. Heating Coil:

1. The heating and cooling coils shall work together without overlapping (Reheating) to maintain the following leaving air temperatures.

5.4 DEHUMIDIFIER/MAKE-UP AIR UNIT:

A. Run Conditions
1. Zone shall have independent schedule capability.
a. Scheduling shall be from a global schedule input, from local schedule or from a group schedule.
b. Contractor shall coordinate initial schedules with end user.
2. Outside air temperature shall be available from a global broadcast for local control options.

B. Zone Setpoint Control
1. Zone sensor shall include set point adjustment and timed local override at the sensor.
a. Set Point Adjust - the occupant will be able to adjust the zone temperature heating and cooling setpoints at the zone sensor. Initial limits will be +-2°F for non-Common areas and +-0°F for common areas.
b. Timed local override control will allow an occupant to override the schedule and place the unit into an occupied mode for an adjustable period of time. At the expiration of this time, control of the unit will automatically return to the current schedule. Initially TLO will be in 30-minute increments with a maximum TLO time of 2 hours.

C. Zone set point control
a. . A Zone dual PID control loop will provide separate heating and cooling control outputs that will be used to enable heat or cool modes and reset supply air setpoints separately for heat and cool modes.
b. A heating control output greater than 0% for more than 5 minutes will place unit in heating mode. Heating supply air setpoint will reset from 70°F to 90°F as heating control output rises from 0% to 100%
c. A cooling control output greater than 0% for more than 5 minutes will place unit in cooling mode. Cooling supply air setpoint will reset from 65°F to 55°F as cooling control output rises from 0% to 100%.
d. On initial startup or any loss of power event the zone will immediately restart in heating mode if outside air is less than 60°F or invalid.
e. Zone high or low zone temperature alarms will be available. When enabled, Zone Temperature alarms will be disabled during Optimal Start, 1st 30 minutes of scheduled occupancy or during Setback override.

C. Zone Temperature Setpoints

	Occupied		Unoccupied	
Zone Type	Heating	Cooling	Heating	Cooling
Temperature	70°F	74°F	60°F	80°F

Zone Humidity Setpoints

	Occupied		Unoccupied	
Zone Type	Minimum	Maximum	Minimum	Maximum
Humidity	40%	50%	NA	NA

A. Supply Fan Control
1. The supply fan will be enabled to run continuously whenever zone is operating in an occupied mode and will cycle on for cooling and heating to maintain unoccupied zone setpoints and night purge.
2. Fan motor status will be monitored. If supply fan has been commanded to run by the DDC system and the fan status is not indicated, the DDC system will generate an alarm.

B. Cooling and heating will be disabled until fan status is proven Occupied mode temperature:
1. During cooling mode:
   a. Cooling supply air PID control loop shall modulate the Cooling water valve to maintain cooling supply air setpoint.
   b. The hot water valve shall remain closed.
2. During heating mode:
   a. Heating supply air PID control loop shall modulate the Heating water valve to maintain heating supply air setpoint.
   c. Cooling valve shall remain closed.
3. Outside Air:
   a. Outside air damper shall remain open during occupied times and closed during unoccupied times.
4. Occupied mode humidification:
   a. When humidity in the space drops below setpoint the associated humidifier shall be enabled.
   b. The DDC shall modulate the humidifier humidity levels to maintain room setpoint.
   c. Do not let humidity levels in the supply ductwork to rise above 75%.
5. Occupied mode Dehumidification:
   a. When the humidity levels rise above room setpoint the cooling coil shall open to reduce the leaving air temperature to control room humidity levels.
   b. The Re-heat coil shall modulate as required to avoid over cooling space.
6. Note: Provide an active temperature and humidity readout in respective rooms.

C. Filter differential pressure
1. Filter differential pressure shall be monitored, and a high differential pressure alarm shall be available.

D. Supply Air Temperature Monitor and Alarming
1. Supply air temperature will be monitored.
2. High and Low SAT differential from SAT setpoint Alarms will be provided.
3. Differential initially set at 5°F with a 5-minute time delay.
4. SAT alarms will be disabled when heating source is failed/off and for 15 minutes after normal operation of heat source.

5.5. DISTRIBUTED CONTROL

A. 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.

5.6 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.

5.7. 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.

END OF SECTION 23 09 53

SECTION 23 21 12

STEAM AND CONDENSATE PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings, General Provisions of Contract and other Division 1 Specification Sections, and Section 23 05 01 apply to this Section.

1.2 SUMMARY

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

1.3 QUALITY ASSURANCE

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

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

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

PART 2 - PRODUCTS

2.1 MANUFACTURED UNITS

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

B. Condensate Piping:
1. Schedule 80 black steel piping.
2. Pipe ends shall be reamed out before being made up into fittings.
3. Use graphite and oil applied to male threads only in making up pipe joint fittings.

4. Fittings shall be standard weight 300 lb. malleable iron screwed pattern up to 2 1/2 inches.
5. Piping over 2 1/2 inches shall be welded with full weld fittings.

PART 3 - EXECUTION

3.1 INSTALLATION

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

B. Pipe ends shall be reamed and burrs removed.

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

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

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

F. Keep as close to the ceiling as possible.

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

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

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

END OF SECTION 23 21 12

SECTION 23 21 13

HYDRONIC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings, General Provisions of Contract, including General and Supplementary Conditions and other Division 1 Specification Sections, and Section 23 05 01 apply to this Section.

1.2 SUMMARY

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

PART 2 - PRODUCTS

2.1 MANUFACTURED UNITS

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

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

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

c. Equals by Crane, Jenkins, Lunkenheimer, or Walworth.

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

E. Steam Coil Vacuum Breakers:
1. Furnish and install on all steam coils with automatic valves a 1/2 inch vacuum breaker rated at 100 psig maximum pressure and 300 deg. F. maximum temperature.
2. Vacuum breaker shall be all brass housing with stainless steel valve, seat and spring.
3. Approved Manufacturers:
   a. Sarco Model 1821
   b. Barnes & Jones Model VB3856
   c. or approved equal

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

END OF SECTION 23 21 13

SECTION 23 21 15

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 05 01 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 - EXECUTION

2.1 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.

2.2 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.

2.3 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.

2.4 FIELD QUALITY CONTROL

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

END OF SECTION 23 21 15

SECTION 23 21 16

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 05 01 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 @ 375°F, and in accordance with Section VIII Division I of ASME Boiler & Pressure Vessel Code.

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

2.6 PRESSURE GAUGES

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

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

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

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

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

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

2.7 BOILER FITTINGS & COMPRESSION TANK FITTINGS

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

B. Compression Tank Fittings:
   1. Install according to detail and manufacturer's instructions.
   2. Fitted for diameter tanks shown.

3. Tank fittings to be connected with 1 inch black pipes pitched up to tanks.
4. Compression tanks fitted with 3/4 inch drain piped to floor of boiler room to permit draining of tanks.
5. Approved Manufacturers:
   a. Bell & Gossett ATFL Airtrol

2.8 SELF-FILLING VALVES

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

B. Brass body and bronze interior

C. Install on water service to boiler.

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

2.9 BOILER RELIEF VALVE

A. ASME Code relief valve.

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

2.10 THERMOMETERS AND ACCESSORIES

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

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

C. Provide other accessories as shown.

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

PART 3 - EXECUTION

3.1 INSTALLATION

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

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

END OF SECTION 23 21 16

SECTION 23 21 18

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

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

PART 2 - EXECUTION

2.1 INSTALLATION

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

END OF SECTION 23 21 18

SECTION 23 21 23

CIRCULATING PUMPS AND ACCESSORIES

PART 1 - GENERAL

2.2 RELATED DOCUMENTS

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

2.3 SUMMARY

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

PART 2 - PRODUCTS

2.1 BASE MOUNTED PUMPS

A. Packless flexible coupled, end suction vertically split case design to facilitate servicing all internal components without disturbing pump, volute or motor. The pump volute shall be supplied with plugged vent, drain, and gage tappings. The pump casing shall be of Class 30 cast iron, suitable for 175 PSI working pressure.

B. The pump and motor shall be mounted or a common base plate of heavy structural steel design and securely welded cross members and open grouting area. Securely bolted to isolation base as specified and to the 6-inch high concrete base. Weight of piping shall not be supported on pumps. The pump shall be factory tested before shipment.

C. The motor shall beet NEMA specifications and shall be the size, voltage and enclosure called for on the plans. Pump and motor shall be factory aligned, and shall be realigned by the Contractor after installation prior to start up.

D. 1750 rpm with bronze impeller, wearing rings, stainless steel shaft, and ceramic seal. The pump bearings shall be the regreasable camlock ball bearing type with provision for purging or flushing through the bearing surface, and capable of being inspected by removing the bearing cover. The shaft shall be of 18-8 stainless steel on standard mechanical seal models.

E. Internally-flushed seals shall be mechanical type with ceramic seal and carbon ring, suitable for continuous operation at 225 deg. F. The seals shall be capable of being serviced without disconnecting the pump from piping.

F. Impeller shall be of the enclosed end-suction type in bronze construction and shall be dynamically balanced for quiet operation. Impeller shall be shaved to provide exact operating point specified on drawings. Motor size shall be as shown on drawing but if an alternate pump is supplied that could operate in the overload range, a large motor shall be furnished. Motor shall not operate overloaded. Any additional electrical cost for oversized motor shall be borne by pump manufacturer’s representative.

G. A flexible, Center Drop-out spacer type coupler, capable of absorbing torsional vibration, shall

be employed between the pump and motor. Coupler shall be shielded by a Coupler Guard securely fastened to the base.

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

2.2 PUMP SUCTION DIFFUSERS:

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

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

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

2.3 TRIPLE DUTY VALVES

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

B. Cast iron body

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

D. Teflon packing

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

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

2.4 EXPANSION JOINT PUMP CONNECTORS

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

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

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

D. Capable of 15 deg. angular deflection.

E. Twin quiet-sphere design with control rods.

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

2.5 IN-LINE CIRCULATORS

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

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

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

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install equipment in accordance with manufacturers instructions.

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

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

END OF SECTION 23 21 23

SECTION 23 21 25

CLEANING AND FLUSHING STEAM AND WATER CIRCULATING SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

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

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

1.3 QUALITY ASSURANCE

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

PART 2 - EXECUTION

2.1 FIELD QUALITY ASSURANCE

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

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

C. Side Stream Filtration and Flushing Valves
1. The Mechanical Contractor shall install a bag style side stream filter in the main mechanical room. This filter shall be furnished with 12 clean polyester bags with a filtration rating of 5 micron. The filter shall be sized to provide a pressure drop equal to the pressure drop of the parallel component with 80% flow through the primary component and 20% through the filter. Minimum filter size shall be 18” high and 6” in diameter. If this minimum size allows excessive flow through the side stream filter a balance valve shall be installed to insure sufficient flow through the primary central plant component.
2. Ball valves of full line size shall be installed at the end of each primary run. The valves shall have a nipple and cap installed.

D. Hydronic Heat Pump Closed Loop Cleaning
1. Prior to any introduction of fluids to the closed loop system the Mechanical Contractor shall close isolation valves at each heat pump and open the bypass valve to prevent flow

through the strainer, flow control device and heat pump during the initial flushing and subsequent cleaning. The side stream filter bag shall be removed during the initial flushing process.

2. The Mechanical Contractor shall fill each hydronic system with clean fresh water prior to cleaning and thoroughly leak check system piping. A cleaning and passivating agent supplied by the Chemical Treatment Contractor shall be added to the system at the direction of the Treatment Contractor during the leak check process to minimize initial corrosion. If the system is filled multiple times during the leak check and repair process the Mechanical Contractor shall coordinate with the Treatment Contractor to maintain this initial protection. The Treatment Contractor is responsible for providing chemical for up to two refills of the system. If additional chemical is required due to multiple refillings the Mechanical Contractor shall be responsible for the additional time and chemical.
3. Following leak check the closed system shall be flushed by the Mechanical Contractor until the leaving water runs clear. All primary runs shall be flushed at their ends to obtain maximum sweep of debris from the system. The inlet screens on the circulating pumps must be kept clear during this initial cleaning process and inspected following cleaning. When flushing is complete the system is to be left full.
4. Prior to flushing the Mechanical Contractor shall coordinate with Treatment Contractor so that the Treatment Contractor can be available immediately following flush and final refill to add cleaning chemical within 4 hours to prevent initial corrosion.
5. Following initial flushing the Chemical Treatment Contractor shall refill all systems with cleaning and passivating agents raising the PH to a minimum of 10, circulate and flush until thoroughly clean. All primary piping runs shall be flushed at the ends during this cleaning process. When boiler operation is available the loop temperature should be raised to 110 to 120° to accelerate cleaning. Cleaning with availability of boiler operation should be anticipated to last 7 to 10 days or longer depending on initial loop conditions. If boiler operation is unavailable loop cleaning duration should be expected to double. The Chemical Treatment Contractor shall verify and adjust cleaning chemistry, and inspect side stream filter bags at a minimum of every two days, exception for weekends. Filter bags shall be changed as required during this cleaning process. Cleaning shall continue until these bags no longer show signs of debris.
6. Following cleaning process the Treatment Contractor shall close the bypass valves at each heat pump and open isolation valves for normal operation and check for leaks of local piping connections. Any leaks found shall be referred to the Mechanical Contractor for repair. The bypass valve handle shall be removed and tied to the valve. The system shall then be charged with final operating chemical to control long term corrosion and a clean bag filter shall be installed in the system.
7. The Treatment Contractor shall provide final inspection report for inclusion in the Operation and Maintenance Manual. Additionally the Treatment Contractor shall take loop samples approximately 12 months following completion, add or adjust chemical as required and provide a post construction report to the owner prior to warranty closeout. Chemical required is the responsibility of the Treatment Contractor.

E. Fluid Cooler Chemical Treatment Station

1. A chemical treatment station shall be provided by the Treatment Contractor in a 24” x 24” locked cabinet. Station shall include LMI DC4000-1-1 conductivity meter with sensor and A-17-1-1351S chemical pump, or approved equal. The chemical station shall be located inside the mechanical room. Mechanical Contractor shall provide ¾” PVC piping from the discharge of the spray pump of the fluid cooler to the station enclosure with T’s for installation of the conductivity sensor and for chemical injection. This contractor shall also provide return piping back to the fluid cooler sump at the opposite end from the spray pump pickup. The Treatment Contractor shall install the conductivity sensor and injection fitting in the T’s provided and set up initial treatment.

2. Under the scope of this specification the Treatment Contractor shall monitor the tower sump and adjust feed and bleed to maintain proper control of scale and corrosion for a period of one year. At a minimum tower treatment shall be check monthly from May until October. The Treatment Contractor shall provide all chemical required during the first year of operation

END OF SECTION 23 21 25

SECTION 23 23 00

REFRIGERANT PIPING SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

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

1.3 QUALITY ASSURANCE

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

PART 2 - PRODUCTS

2.1 REFRIGERANT PIPING

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

B. Do not use pre-charged refrigerant lines.

2.2 REFRIGERANT FITTINGS

A. Wrought copper with long radius elbows.

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

2.3 CONNECTION MATERIAL

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

2.4 FLUX

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

PART 3 - EXECUTION

3.1 INSTALLATION

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

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

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

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

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

3.2 FIELD QUALITY CONTROL

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

END OF SECTION 23 23 00

SECTION 23 23 10

REFRIGERANT SPECIALTIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

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

PART 2 - PRODUCTS

2.1 EXPANSION VALVES

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

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

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

2.2 FILTER-DRIER

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

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

C. Size shall be full line size.

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

2.3 SIGHT GLASS

A. Combination moisture and liquid indicator with protection cap.

B. Sight glass shall be full line size.

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

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

2.4 MANUAL REFRIGERANT SHUT-OFF VALVE

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

B. Valve shall have cap seals.

C. Valves with hand wheels are not acceptable.

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

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

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

PART 3 - EXECUTION

3.1 INSTALLATION

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

END OF SECTION 23 23 10

SECTION 23 25 10

GLYCOL SYSTEM

PART 1 - GRENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

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

PART 2 - PRODUCTS

2.1 MATERIALS

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

B. Coils, pumps, 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:
      1. Dowtherm Type SR-1.

2.2 HYDRONIC MINI SYSTEM FEEDER

A. Hydronic system feeder shall be AXIOM INDUSTRIES LTD. Model MF300.

B. System shall include 64 litre (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 (10 psig) to 170 kPa (25 psig) cut-out pressure; factory cut-out pressure set to 115 kPa (17psig); and liquid filled pressure gauge.

C. Unit to be c/w 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. RIA10-1-SAA – Low level Alarm Panel c/w 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 23 25 00

SECTION 23 26 00

CONDENSATE DRAIN PIPING

PART 1 - GENERAL

1.1 SUMMARY

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

B. Related Requirements:
1. Section 23 05 01: Common HVAC Requirements.

1.2 REFERENCES

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

PART 2 - PRODUCTS

2.1 SYSTEMS

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

PART 3 - EXECUTION

3.1 INSTALLATION

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

END OF SECTION 23 26 00

SECTION 23 31 14

LOW-PRESSURE STEEL DUCTWORK

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings, General Provisions of Contract and Section 23 05 01 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 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.

2.9 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:
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.
4-1/2 inch wide minimum vane rail. Do not use junior vane rails.
Double thickness vanes not acceptable.
Quiet and free from vibration when system is in operation. See SMACNA Manual Install motorized dampers

END OF SECTION 23 31 14

SECTION 23 31 84

FABRIC DUCT

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 05 01 apply to this Section.

1.2 DESCRIPTION OF WORK

A. Non-metal ductwork as indicated on drawings and by requirements of this section.

B. Required type of non-metal ductwork for this project is a: Fabric Air Dispersion System.

1.3 QUALITY ASSURANCE AND CODE COMPLIANCE

A. Quality Assurance:
1. Manufacturer must be a UL Registered Firm.
2. Any production facility used by manufacturer must be Registered by Underwriters Laboratories Inc. to the International Organization for Standardization (ISO) 9000 Series Standards
3. Fabrics used must be produced in environmental friendly factories only. The actual production site for each individual fabric must be Oeko-Tex certified by Oeko-Tex International – Association for the Assessment of Environmental Friendly Textiles.

B. Codes and Standards:

1. Product must be classified in accordance with the 25/50 flame spread/smoke development requirements of UL723 based on NFPA 90A - 1993, "Installation of Air Conditioning and Ventilating Systems".

1.4 SUBMITTALS

A. Submit a copy of UL Registered Firm certificate.

B. Submit documentation for UL723 in accordance to NFPA-90A.

C. Submit manufacturer's drawings indicating size and placement of dispersion units, and mounting instructions.

D. Submit manufacturer’s technical product data for fabric dispersion units.

E. Submit manufacturer's performance data for each fabric duct system, including airflow rate, inlet velocity, static pressure and exit velocity out of duct system.

F. Submit manufacturer's maintenance data.

1.5 WARRANTY

A. Manufacturer must provide a 5 Year Non-Prorated Warranty. Prorated warranties are not accepted.

1.6 DELIVERY, STORAGE AND HANDELING

A. Protect FabricAir® systems from damage during shipping, storage and handling.

B. Store products inside and protect from weather.

PART 2 - PRODUCTS

2.1 MANUFACTURER

A. Manufacturer must comply with all previous described requirements. Approved manufacturers:

1. FabricAir, Inc., 211 East Ontario Street, 18th Floor Chicago, IL 60611, Phone: (502) 493-2210, Fax: (502) 493-4002, E-mail: info@fabricair.com
2. Duct Sox, 4343 Chavenelle Rd., Dubuque, IA, 52002, Phone: (563) 589-2777, Fax: (563) 589-2754, E-mail: www.ductsox.com.
3. Or Approved Equal.

2.2 FABRIC AIR DISPERSION SYSTEM

A. Fabricair Dispersion System shall be constructed of FabricAir® Basic fabric. The fabric is a woven fire retardant and permeable fabric complying with the following characteristics:

1. Fabric: 100% Flame Retardant Polyester
2. Weight: 7.2 oz./yd² per ASTM D3776
3. Shrinkage: Max. 0,5% per DIN EN 26 630
4. Color: 6500 white or custom
5. Temperature Range: -40°F to +140°F
6. Permeabilities: per design: 2,11,18,36 or 66 (+/- 5%) per ASTM D737, Frazier
7. Fire Retardancy: Must meet the requirements in NFPA 90-A

2.3 SYSTEMS FABRICATION REQUIREMENTS

A. Air dispersion accomplished by dispersion through permeable fabric. Due to exact requirements of draft and noise alternative flow models are not acceptable.

B. The system is made of permeable fabric.

C. Provide system in sections optimized for maintenance, connected by zippers. Zippers must provide closure completely around the circumference to prevent leakage. Required number of zippers as specified by manufacturer.

D. Each section to have a unique tag including information about: manufacturers order number, position, diameter of section, length of section, maintenance instruction, code compliance and contact details for spare parts.

E. Fabric system shall include connectors to attach to suspension system listed below.

2.4 DESIGN PARAMETERS

A. Use fabric air diffusers only for positive pressure air distribution.

B. Do not use fabric air diffusers in concealed locations.

C. Fabric diffusers shall be designed from minimum 0.25” water gage to 3” as the Maximum – 0.5” being the standard.

D. Design temperatures between –40°F and 140°F

E. Manufacturer shall approve all technical design parameters.

2.5 HANGERS AND SUPPORT (must specify only one of the below system types)

A. Type 1: One row cable system located 1.5” above 12 o’clock of FabricAir® system. FabricAir® system to be attached to hardware using one single row of plastic hooks located 12 o’clock spaced 20 inches. Hardware to include cable, cable clamps, turnbuckles, and tie down straps as required.

1. Hardware options – (please select one)
Plastic Coated Stainless Steel Cable – all other components Stainless Steel

2.6 AIR HANDLER REQUIREMENTS

A. Provide adequate pre-filtering (minimum F85) prior to the fabric duct system, all according to manufacturers specifications.

B. Provide fans supplying constant static pressure.

PART 3 - INSTALLATION

3.1 INSTALLATION OF FABRICAIR® SYSTEM

A. Examine area and conditions under which the FabricAir® system are to be installed. Do not continue any installation until unsatisfactory conditions have been corrected.

B. Install chosen suspension system in accordance with the requirements of the manufacturer. Installation instructions to be provided by the manufacturer with product.

C. Coordinate layout with suspended ceiling, lighting layouts, and similar finished work.

3.2 CLEANING

A. Clean air handling unit and other ductwork prior to the FabricAir® system as it is installed. Make sure that all dust from installation are removed from the air handling unit and other ductwork before connecting the FabricAir® system.

B. If the FabricAir® system becomes soiled during the installation, it should be removed and cleaned following the manufacturers cleaning instructions.

END OF SECTION 23 31 14

SECTION 23 33 46

PART 1 - FLEX DUCT

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

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

PART 2 - PRODUCTS

2.1 DUCTS

A. Formable, flexible, circular duct which shall retain its cross-section, shape, rigidity, and shall not restrict air flow after bending.

B. Nominal 1-1/2 inches thick, 3/4 lb/cu ft density fiberglass insulation with air-tight, polyehtylene or polyester core, sheathed in seamless vapor barrier jacket factory installed over flexible assembly.

C. Assembly, including insulation and vapor barrier, shall meet Class I requirement of NFPA 90A and be UL 181 rated, with flame spread of 25 or less and smoke developed rating of 50 or under.

D. Length of flexible ductwork shall not exceed 8'-0".

2.2 APPROVED MANUFACTURERS

A. ANCO-FLEX - 4625

B. Flex-Aire - PF/UPC #090

C. Hart & Cooley - F114

D. Thermaflex - G-KM

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install duct in fully extended condition free of sags and kinks.

B. Make duct connections by coating exterior of duct collar for 3 inches with duct sealer and securing duct in place over sheet metal collar with 1/2 inch wide metal cinch bands and sheet metal screws.

END OF SECTION 23 33 46

SECTION 23 34 00

EXHAUST FANS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

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

QUALITY ASSURANCES

B. 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

PART 3 - EXECUTION

3.1 INSTALLATION

A. Anchor fan units securely to structure or curb.

END OF SECTION 23 34 00

SECTION 23 37 13

AIR OUTLETS & INLETS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

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

PART 2 - PRODUCTS

2.1 GRILLES & REGISTERS

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

2.2 SPIN-IN FITTINGS

A. Low pressure round take-offs to diffusers shall be made with spin-in fittings. They shall incorporate a manual balancing damper. The damper shall be spring loaded and a positive locking wing nut shall secure the damper position.

B. Approved Manufacturers:
1. Sheet metal fittings: Genflex DB-1DEL, Hercules

2.3 LOUVERS

A. Extruded aluminum, with blades welded or screwed into frames and 1*/*2 inch mesh 16 gauge aluminum bird screen.

B. Frames shall have mitered corners.

C. Louvers shall be recessed, flanged, stationary, or removable as noted on Drawings.

D. Approved Manufacturers:
1. Airolite
2. American Warming
3. Arrow
4. Industrial Louvers
5. Ruskin
6. Vent Products

2.4 ROOF MOUNTED INLETS AND OUTLETS

A. FABRICATION
1. Penthouse type of extruded aluminum complete with roof curb to fit slope of roof and ½ inch mesh 16 gauge aluminum bird screen.

B. APPROVED MANUFACTURERS & MODELS
1. Tiered Type:
    1. Model TRE extruded aluminum ventilator by Loren Cook Company, Springfield Missouri
2. Louvered Penthouse
    1. Penn “Penhouse”
    2. Model WRH by Greenheck Fan Corporation, Schofield, WI
    3. Model MPH by Jenn-Air Industries Inc., Indianapolis, IN

END OF SECTION 23 37 13

SECTION 23 57 20

ENERGY REVOCERY VENTILATORS

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 05 01 apply to this Section.

1.2 SUMMARY

A. Furnish and install energy recover ventilator unit as described in Contract Documents.

1.3 SUBMITTALS

A. Energy Efficiency:
1. Indicate Energy Efficiency Rating (EER) for equipment provided under work of this section
2. Submit documentation for Energy Star qualifications for equipment provided under work of this Section.

B. Submit environmental data in accordance with Table 1 of ASTM E2129 for products provided under work of this Section.

C. Reports for aquatic toxicity testing of lubricants in accordance with ASTM D6081.

1.4 QUALITY ASSURANCE

A. Energy Efficiency: Meet or exceed ASHRAE 90.1.

B. Indoor Environmental Quality:
1. Ventilation: Meet or exceed ASHRAE 62 and all published addenda.
2. Filtration: Meet or exceed ASHRAE 52.
3. Thermal Comfort: Meet or exceed ASHRAE 55.
4. Maintain positive pressure within the building.

PART 2 - DESCRIPTION

2.1 SYSTEM DESCRIPTION

A. Units capable of transferring sensible energy as listed to the equipment schedule.

B. Flat plate heat exchanger to be factory installed in unit.

C. Unit is designed to be used as a stand-alone heat recovery ventilator or as a heat recovery component in a dedicated HVAC system or as a complete ventilation HVAC unit.

2.2 QUALITY ASSURANCE

A. Unit shall be constructed in accordance with CSA C22.2 and UL 1812 and shall carry the (C)UL or (C) ETL label of approval.

B. Insulation shall comply with NFPA 90A requirements for flame spread and smoke generation.

C. Airflow data shall comply with AMCA 210 method of testing.

2.3 DELIVERY, STORAGE, AND HANDLING

A. Unit shall be stored and handled per unit manufacturer's recommendations.

2.4 WARRANTY

A. Unit shall have a 2 year warranty on all parts not including flat plate heat exchanger.

B. Flat plate heat exchanger shall have a 15 year warranty.

C. Manufacturers without a 15 year warranty shall supply an extra flat plate heat exchanger for the entire unit. Plat plate heat exchanger to be turned over to the Owner at the time of delivery for stocking purposes.

PART 3 - PRODUCTS

3.1 EQUIPMENT

A. General
1. Packaged, heat recover ventilator consisting of flat plate heat exchanger, ventilation air fan, exhaust air fan, necessary dampers, temperature sensors, and microprocessor controls.

B. Unit Cabinet
1. Cabinet shall be constructed of 20 gauge G-90 galvanized steel with 12 or 16 gauge galvanized frame.

C. Access
1. Access to all components that require servicing shall be provided through sealed and easily removable access panels(s).
2. Flat plate heat exchanger shall be easily removable from the unit.
3. All parts must be serviceable in less than 7 minutes.

D. Flat Plate Heat Exchanger
1. Aluminum flat plate heat exchanger designed to meet NFPA 90A requirements for smoke development and flame spread.
2. Energy recovery effectiveness values shall be tested in accordance with ASHRAE 84 and ARI Standard 1060.

E. Operating Characteristics
1. Unit shall be capable of providing a constant volume of air at a specified external static pressure at all fan operating speeds.

F. Blowers
1. Fan ratings are based on tests made in accordance with AMCA Standard 210.
2. Blowers must be selected to operate on a stable efficient part of the fan curve when delivering air quantities scheduled against static of the system.
3. Fan blades shall be statically and dynamically balanced and tested prior to shipment.
4. Fan shall be provided with internal vibration isolation mounts.

5. Fan discharge shall be as noted on the plans.
6. Fans shall have sealed ball bearings with L10 life expectancy for belt drive units.

G. Motors
1. Motors shall be continuous duty, permanently lubricated, and matched to the fan loads.
2. Motors shall meet new EPAC regulations for efficiency and shall have inverter spike resistance wire for protection.
3. Motor selection must include a 15% service factor.

H. Electrical Requirements
1. Units shall have single point power connection only.
2. All controls shall be factory mounted and wired, requiring only field installation of remote sensing devices and wiring to unit mounted terminal strips.

I. Filters
1. Toxicity/IEQ: Provide filtration media with a Minimum Efficiency Reporting Value (MERV) of 13 as determined by ASHRAE 52.2. Coordinate with work of Section 01352 - IAQ Management.
2. Biobased Content: Minimum 95 percent biobased material.

3.2 CONTROLS

A. General
1. Unit shall be provided with a factory mounted and factory wired microprocessor control.
2. All service connectors shall be quick disconnect type.
3. Unit circuitry shall allow the following operational characteristics:
Dry contacts for occupancy control
Remote fan interlock on call for ventilation
Selection of low or high speeds
Remote wall control contacts
Unoccupied recirc contacts

3.3 OPTIONS

A. Defrost
1. Damper/Recirculation Defrost Cycle - unit shall be equipped with recirculation defrost from forming on the flat plate heat exchanger and prevent negative pressure from occurring in building envelope.

B. Double Wall Construction
1. Cabinet shall be insulated throughout and lined with a 26 gauge galvanized wall for easy cleaning, prevention of potential for microbial growth, and elimination of potential puncture of insulation membrane.

C. Pre-paint Cabinet
1. Unit cabinet shall be minimum 20 gauge pre-painted galvanized steel.

D. Access Panels
1. Unit shall have quick opening type fasteners to allow for easy access.

3.4 ACCESSORIES

A. Night Set Back

1. 24 hour programmable timer shall be included for occupied/unoccupied time settings.

B. CO_2 Controller
1. Non-dispersed infra-red control shall be provided to trigger ventilation at levels above 1000 ppm of CO_2

3.5 ACCEPTABLE MANUFACTURERS

A. Venmar

B. Greenheck

C. Semco

PART 4 - EXECUTION

4.1 FILTERS

A. Provide one extra set of filters.

END OF SECTION 23 57 20

SECTION 23 65 33

FLUID COOLER

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Furnish and install fluid cooler unit as described in Contract Documents.

1.3 SUBMITTALS

A. Energy Efficiency:
   1. Indicate Energy Efficiency Rating (EER) for equipment provided under work of this section

B. Submit environmental data in accordance with Table 1 of ASTM E2129 for products provided under work of this Section.

C. Reports for aquatic toxicity testing of lubricants in accordance with ASTM D6081.

1.4 QUALITY ASSURANCE

A. Energy Efficiency: Meet or exceed ASHRAE 90.1.

PART 2 - DESCRIPTION

2.1 SYSTEM DESCRIPTION

A. Units capable of transferring sensible energy as listed to the equipment schedule.

B. Flat plate heat exchanger to be factory installed in unit.

C. Unit is designed to be used as a stand-alone heat recovery ventilator or as a heat recovery component in a dedicated HVAC system or as a complete ventilation HVAC unit

2.2 QUALITY ASSURANCE

A. Unit shall be constructed in accordance with CSA C22.2 and UL 1812 and shall carry the (C)UL or (C) ETL label of approval.

B. Insulation shall comply with NFPA 90A requirements for flame spread and smoke generation.

C. Airflow data shall comply with AMCA 210 method of testing.

1.2 DELIVERY, STORAGE, AND HANDLING

A. Unit shall be stored and handled per unit manufacturer’s recommendations.

1.3 WARRANTY

A. Unit shall have a 2 year warranty on all parts not including flat plate heat exchanger.

B. Flat plate heat exchanger shall have a 15 year warranty.

C. Manufacturers without a 15 year warranty shall supply an extra flat plate heat exchanger for the entire unit. Plat plate heat exchanger to be turned over to the Owner at the time of delivery for stocking purposes.

PRODUCTS

1.4 EQUIPMENT

A. General
1. Packaged, heat recover ventilator consisting of flat plate heat exchanger, ventilation air fan, exhaust air fan, necessary dampers, temperature sensors, and microprocessor controls.

B. Unit Cabinet
1. Cabinet shall be constructed of heavy gauge corrosion resistant galvanized steel for maximum casing rigidity.
All multiple fan units shall be divided full width baffles to separate and provide additional casing reinforcement.
2. All end panels, center supports, and partitions shall have collared tube holes for increased tube life.
3. Unit shall be provided with lifting eyes for rigging.
4. Units shall have 10-gauge galvanized steel legs.
5. Units can be arranged for vertical or horizontal airflow. Airflow must be specified for the header to have the correct connection location.

C. Fluid Coil
1. Coils shall be constructed of ½ inch O.D. seamless copper tubing on a staggered pattern. Tubes shall be mechanically expanded into continuous full-collard plate type aluminum (or optional copper) fins for permanent metal-to-metal contact.
2. Headers shall be supplied with vents and drains. All coils shall be factory pressure and leak tested at 400 PSI.

1.5 FANS

A. General
1. All fans shall be aluminum propeller blade type with painted steel hubs. Fans shall be dynamically balanced, and factory tested before shipping to ensure quiet operation. Fans shall have dual square headset screws spaced 90 degrees apart which seat onto one flat and one keyway on the motor shafts. Fan diameters shall not exceed 30 inches.

1.6 FAN GUARDS

A. General
1. Fan guards shall be heavy gauge. Close-meshed steel wire with vinyl coating for maximum rigidity, long life, and attractive appearance.
2. All motors shall be factory wired with leads terminating in a weather tight enclosure located opposite the header end of the unit. Leads on units having five or more fans shall terminate at a power block.

END OF SECTION 23 65 33

SECTION 23 81 29

VARIABLE REFRIGERANT FLOW HVAC SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. The manufacturer shall provide published outdoor unit performance data in table format which states the product heating and cooling capacities expressed in British thermal units per hour (BtuH) and power consumption expressed in kilowatts (kW) at a minimum of 8 possible combinations of allowed conditions between 50% and 130% connection ratio (VRF systems).

B. Possible combinations of allowed condition variables include Combination Ratios expressed as a percentage value, Outdoor Ambient Temperature expressed in degrees Fahrenheit (°F), and indoor unit Entering Air wet and dry bulb temperature expressed in degrees Fahrenheit (°F).

C. Any product whose system design and engineering manuals or guides where published data tables are expressed in units other than these specified will not be accepted.

D. Any product whose published documentation requires the design engineer to apply a correction factor derived from a published curve or tabular data for combination ratio, outdoor ambient temperature, and/or entering air temperature against rated conditions to obtain performance at any possible combination of allowed conditions will not be accepted.

1.3 SUBMITTALS

A. A complete submittal package shall be compiled and 10 copies shall be forwarded to the general contractor who shall supply the architect with the submittals for dissemination to all parties. The submittal shall be a collection of documents that represent the technical aspects of each product or collection of products to be used on the project. All performance submissions shall be calculated at the design temperatures, Nominal performance data shall not be accepted. The submission and approval of said submittals does not relieve the contractor of supplying all requirements set forth in the specification and drawings. Any substitutions offered by the contractor shall include, as a separate document, any and all differences between the submitted products and the specified products including but not limited to, all dimensions, electrical, control, weights, warranties, country of origin.

B. If submittals contain any proposed alternate equipment specifications, calculations, dimensions, electrical specifications, sound specifications or any other mandated submission which are not accepted, are noted or rejected for any reason the contractor shall be allowed to correct any deficiency and re-submit a second time. Should there be any irregularities found on second submission, the contractor will be directed to and agrees to submit on the original specified products, including any changes or revisions, and provide those specified products without any additional compensation

1.4 DELIVERY, STORAGE AND HANDLING

A. Provide a dry and clean place for the products. Comply with manufacturer's instructions on handling to prevent products from damaging. If product is damaged upon arrival, reject the shipment. If hidden damage is found after removing the product from the container, retain container and all packing material. Contractor is responsible for filing a claim with the freight carrier.

1.5 UPON JOB COMPLETION

A. Provide the owner with an LG tablet containing a copy of approved submittal, LGMV Mobile (VRF system service diagnostics) software, project mechanical and control drawings, all as-built piping drawings, seismic data certificates, installation, operation and maintenance manuals, troubleshooting guides, service manuals and engineering manuals in PDF format.

B. Provide the owner with an LG tablet containing a copy of the approved submittal package, a full set of drawings and specifications, on boarding software, custom documents, such as control drawings, shop drawings, wiring diagrams, BMS software, GUI image files, commissioning reports, refrigerant charge calculations, refrigerant piping design and as-built reports, O&M's, troubleshooting guides, service manuals, and equipment engineering manuals in .pdf format. Tablet shall also include a licensed copy of deluxe version of the VRF equipment manufacturer's service diagnostics.

PART 2- STANDARDS/CERTIFICATIONS

2.1 CERTIFIED PRODUCT PERFORMANCE RATINGS

A. All VRF (Variable Refrigerant Flow) and VSMS (Variable Speed Multi-Split and Mini-Split) products shall have published performance ratings certified by AHRI (Air-Conditioning, Heating, and Refrigeration Institute) and listed in the AHRI certified product directories available at www.ahridirectory.org.

2.2. PRODUCTION FACILITY CERTIFICATIONS

A. All system components shall be manufactured in production facilities maintaining the following ISO certifications:
1. ISO 9001 Quality Management System
2. ISO 14001 Environmental Management System

2.3 UL COMPLIANCE

A. All system shall comply with Underwriters Laboratories (UL) 1995 5th edition of the Standard for Safety for Heating and Cooling Equipment Standard for Safety and bear the Electrical Testing Laboratories (ETL) and/or Canadian Standards Association (CSA) mark on the product name plate.

2.4 ELECTRICAL STANDARDS

A. All system electrical power wiring shall be installed in accordance with the NFPA 70 National Electrical Code (NEC) or applicable state and local building codes.

2.5 CORRSION QUALITY CONTROL

A. Outdoor unit painted surfaces shall be factory tested for a minimum of 1000 hours using the accelerated salt spray test procedure as documented in ASTM Standard B-117 using the Surface Scratch Test Procedure. Photographic evidence shall be available upon request by the Engineer of Record.

B. Photographic evidence shall include images of the test sample showing the surface scratch area at zero (0) hours, 400 hours, and 1000 hours. Post-test images of the sample must show no significant deterioration of the coating material, blistering, flaking, peeling, or rust formation along the test scratch.

2.6 BUY AMERICAN

A. Product manufacturer shall provide documentation, approved for Buy American Act BAA) and Trade Agreement Act (TAA), signed by the company's legal agent that certifies that none of the proposed/supplied equipment and control devices were manufactured or assembled in China/Thailand or any other non-WTO original signatory country.

PART 3 - GENERAL

3.1 CEILING CASSETT-4 WAY

A. Unit shall be manufactured by LG.

B. Unit shall be designed to be installed for indoor application.

C. Unit shall be designed to mount recessed in the ceiling and has a surface mounted grille on the bottom of the unit.

D. The unit shall be available in both nominal 2' x 2' and 3' x 3' chassis.

3.2 CASING/PANEL

A. Unit case shall be manufactured using galvanized steel plate.

B. The unit panel shall be provided with an off-white or black Acrylonitrile Butadiene Styrene (ABS) polymeric resin grille.

C. The grille shall have a tapered trim edge, and a hinged, spring clip (screw-less) return air filter-grille door.

D. Unit shall be provided with metal ears designed to support the unit weight on four corners.

E. Ears shall have pre-punched holes designed to accept field supplied all thread rod hangers.

F. Unit shall be supplied with snap off access panels to facilitate leveling of unit without removing the grille.

3.3 CABINET ASSEMBLY

A. Unit shall have four supply air outlets and one return air inlet.

B. The supply air outlet shall be through four directional slot diffusers each equipped with independent oscillating motorized guide vanes designed to change the airflow direction.

C. The grille shall have a discharge range of motion of 40° in an up/down direction with capabilities of locking the vanes.

D. The unit shall have a guide vane algorithm designed to sequentially change the predominant discharge airflow direction in counterclockwise pattern.

E. Guide vanes shall provide airflow in all directions.

F. Unit shall be equipped with factory installed temperature thermistors for:

1. Return air
2. Refrigerant entering coil
3. Refrigerant leaving coil

G. Unit shall have a factory assembled, piped and wired electronic expansion valve (EEV) for refrigerant control.

H. Unit shall have a built-in control panel to communicate with other indoor units and to the outdoor unit.

I. The unit shall have factory designated branch duct knockouts on the unit case.

J. The unit shall have provision of fresh air ventilation through a knock-out on the cabinet.

K. The branch duct knockouts shall have the ability to duct up to 1/2 the unit airflow capacity.

L. The branch duct cannot be ducted to another room.

M. Unit shall have the following functions as standard:

1. Self-diagnostic function
2. Auto addressing
3 Auto restart function
4. Auto changeover function (Heat Recovery system only)
5. Auto operation function
6. Child lock function
7. Forced operation
8. Dual thermistor control
9. Sleep mode
10. Dual set point control
11. Multiple aux heater applications

12. Filter life timer

13. External on/off input

14. Wi-Fi compatible

15. Auto fan operation

16. Leak detection logic

3.4 FAN ASSEMBLY

1. The unit shall have a single, direct-drive turbo fan made of high strength ABS HT-700 polymeric resin.

2. The fan impeller shall be statically and dynamically balanced.

3. The fan motor is Brushless Digitally commutated (BLDC) with permanently lubricated and sealed ball bearings.

4. The fan motor shall include thermal, overcurrent and low RPM protection.

5. The fan/motor assembly shall be mounted on vibration attenuating rubber grommets.

6. The fan speed shall be controlled using microprocessor based direct digitally controlled algorithm that provides a minimum of four pre-programed fan speeds in the heating mode and fan only mode and five speeds in the cooling mode. The fan speed algorithm provides a field selectable fixed speed.

7. A field setting shall be provided to vary air throw pattern to compensate for high ceiling installations.

8. In cooling mode, the indoor fan shall have the following settings: Low,Med, High, Super high, Power Cool, and Auto.

9. In heating mode, the indoor fan shall have the following settings: Low,Med, High, Super high and Auto**.**

10. Unit shall have factory installed motorized louver to provide flow of air in up and down direction for uniform airflow.

3.5 FILTER ASSEMBLY

1. The return air inlet shall have a factory supplied removable, washable filter.

2. The filter access shall be from the bottom of the unit without the need for tools.

3. The nominal 3’x3’ cabinet unit shall have provision for an optional auto elevating grille kit designed to provide motorized ascent/descent of the return air grille/pre filter assembly.

A. The ascent/descent of the return air grille shall be up to a distance of 14-3/4 feet allowing access to remove and clean the filter.

B. The auto-elevating grille shall have a control algorithm to accept up, down and stop control commands from the controller.

C. The auto-elevating grille shall have a control to stop the descent automatically if a contact is made with any obstacle.

3.6 COIL ASSEMBLY

1. Unit shall have a factory built coil comprised of aluminum fins mechanically bonded on copper tubing.

2. The copper tubing shall have inner grooves to expand the refrigerant contact surface for high efficiency heat exchanger operation.

3. Unit shall have a minimum one or two row coil, 18-19 fins per inch.

4. Unit shall have a factory supplied condensate drain pan below the coil constructed of EPS (expandable polystyrene resin).

5. Unit shall include an installed and wired condensate drain lift pump capable of providing minimum 27.5 inch lift from bottom surface of the unit.

6. The drain pump shall have a safety switch to shut off the unit if condensate rises too high in the drain pan.

7. Unit shall have provision of 45° flare refrigerant pipe connections.

8. The coil shall be factory pressure tested at a minimum of 550 psig.

9. All refrigerant piping from outdoor unit to indoor unit shall be field insulated. Each pipe should be insulated separately. Thickness and heat transfer characteristics shall be determined by the design engineer and shall meet all code requirements.

3.7 MICROPRESSOR CONTROL

1. The unit shall have a factory installed microprocessor controller capable of performing functions necessary to operate the system.

2. The unit shall be able to communicate with other indoor units and the outdoor unit using a field supplied minimum of 18 AWG, two core, stranded, twisted and shielded communication cable.

3. The unit controls shall operate the indoor unit using one of the five operating modes:

A. Auto changeover (Heat Recovery System only)

B. Heating

C. Cooling

D. Dry

E. Fan only

4. The unit shall be able to operate in either cooling or heating mode for testing and/or commissioning.

5. The unit shall be able to operate with the fan turned off during system cooling thermal off.

6. The unit shall have adjustable, multi-step cooling and heating mode thermal on/off temperature range settings.

7. The system shall include a product check function to access and display indoor unit type and capacity from a wired programmable thermostat controller.

8. Unit shall have a field settable method to choose auto fan speed change operation based on mode of operation, on/off fan operation based on mode of operation, or continuous minimum set fan speed operation.

3.8 ELECTRICAL

1. The unit electrical power shall be 208-230/1/60 (V/Ph/Hz).

2. The unit shall be capable of operating within voltage limits of +/- 10% of the rated voltage.

3.9 CONTROLS

1. Unit shall use controls provided by the manufacturer to perform all functions necessary to operate the system effectively and efficiently and communicate with the outdoor unit over an RS-485 daisy chain.

3.10 SEISMIC INSTALLATIONS

1. Provide with submittal: 1) OSHPD Special Seismic Certification Preapproval (OSP) documents for certified product list of VRF equipment to be installed in high seismic risk areas. 2) Equipment installation documents in conformance with CBC 2013, 2016 and 2019 California Building Code and IBC 2012, 2015 and 2018 International Building Code.

3.11 WARRANTY

1. Please refer to the respective outdoor unit for applicable warranty

PART 4- GUIDE SPECIFICATIONS

4.1 PRODUCT DESIGN

1. Variable Refrigerant Flow (VRF) HVAC system shall be a variable capacity, direct expansion (DX) <heat pump> or <heat recovery> engineered system (Water Source VRF System).

2. Each water source VRF system may consist of one to three water source unit frames(s) that circulate refrigerant to/from multiple VRF Indoor Units (IDUs) strategically located throughout the conditioned space via a field supplied, assembled and insulated refrigerant piping system.

3. Each water source VRF system has the ability to reject heat to or absorb heat from a common condenser water loop. Other traditional HVAC equipment that may be

connected to the condenser water loop including one or more water pumps(s), boiler(s), cooling tower(s), and/or geothermal heat sink(s). These traditional heat generation/transfer devices provide supplemental heat to the condenser water loop or remove heat from the loop as necessary to maintain an acceptable water loop temperature necessary for stable water source VRF system operation.

4.2 OPERATING CONDITIONS

1. The VRF systems shall be capable of providing continuous compressor operation at listed water flow conditions. VRF products with submittal or technical performance data that does not guarantee continuous compressor operation shall not be acceptable.

2. The water source unit's required minimum operating range is:

A. All IDUs in cooling mode

B. Entering water temperature:

1. 59°F to 113°F

2. 23°F up to 59°F (with optional flow control kit)

C. Heat exchanger design: Water side

1. Flow: 1.4 to 5.0 GPM/ton

2. Pressure: 640 PSIG

D. All IDUs in heating mode

1. Entering water temperature:

2. 23°F to 113°F

E. Heat exchanger design: Water side

1. Flow: 1.4 to 5.0 GPM/ton

2. Pressure: 640 PSIG

F. Simultaneous heating and cooling (Heat Recovery Models Only)

1. Entering water temperature:

2. 59°F to 113°F

3. 23°F up to 59°F (with optional flow control kit)

G. Heat exchanger design: Water side

1. Flow: 1.4 to 5.0 GPM/ton

2. Pressure: 640 PSIG

4.3 ELECTRICAL

1. ALL water source heat pump and heat recovery frame(s) shall be designed and electrically protected to maintain stable continuous compressor operation when provided with <460/60/30> <208-230/60/3> power with the following specifications:

   A. <460/60/3>

2. Voltage tolerance between 414V and 528V

   B. <208-230/60/3>

3. Voltage fluctuation of ± 10%

   C. Phase to phase voltage imbalance of up to two percent;

   D. Power surge of up to 5kA RMS Symmetrical.

4.4 GENERAL FEATURES

1. Heat Recovery System Specific Architecture

   A. LG Multi V Water IV heat recovery system(s) shall be capable of imultaneously providing heat to some zone(s) while removing heat (cooling) from other zone(s) irrelevant of the position of the reversing valve of the water source unit frames. When the multiple water source frames are present, the reversing valve in each frame shall act independent of the other frames to optimize the simultaneous heating and cooling capacity and range of operation.

2. Heat recovery units (HRUs) shall be provided by the VRF manufacturer. HRUs that have one or more parts made in China (or unit assembly completed in China) are not acceptable. The refrigerant piping system shall be comprised of three (3) parallel pipes between the water source unit, HRUs and two (2) parallel pipes between the HRU and each IDU. Each pipe shall be individually insulated. Each IDU port on the HRU shall be equipped with a dedicated independent refrigerant flow control apparatus that serves the connected indoor unit(s) with liquid refrigerant or super-heated refrigerant vapor.

3. Heat recovery units shall be engineered for installation in a semi-conditioned space where temperature and humidity is maintained between N.A DB / N.A. % RH and N.A DB / N.A. % RH. Heat recovery unit's case and internal components where surface temperatures may operate below dew point shall be factory insulated. Heat recovery units that condense and require condensate drain shall not be acceptable.

4. Each of the three (3) parallel pipes connected to the water source unit shall be dedicated duty. One each to transport refrigerant in the following state and quality: 1) high pressure liquid; 2) high pressure superheated vapor; 3) low pressure vapor. Each pipe of the refrigerant network shall be individually insulated. VRF systems designed to transport, low quality, mixed state refrigerant are not acceptable.

4.5 HEAT PUMP SYSTEM SPECIFIC ARCHITETURE

A. LG Multi V Water IV heat pump system(s) shall be capable of providing cooling OR heating to all conditioned spaces served. The VRF system's mode of operation (i.e. cooling or heating decision) is directly controlled by the position of the reversing valve in the water source unit. When the multiple water source frames are present, the reversing valve in each frame shall operate in parallel and shall be controlled by the microprocessor controller of water source unit frame designated as the "Master" frame.

B. The refrigerant piping system shall consist of two (2) parallel pipes between the water source unit frame(s) and each indoor unit. While operating in heating mode, the water source unit(s) shall provide superheated refrigerant vapor to the indoor units. During cooling mode operation the water source unit(s) shall provide high pressure subcooled liquid refrigerant to the indoor units. Each pipe of the refrigerant network shall be individually insulated. VRF systems designed to supply, low quality, mixed state refrigerant to the indoor units are not acceptable.

1. All three-phase water source units provided, irrelevant of the Heat Pump or Heat Recovery models, shall be the same generation and provide with most up to date firmware version at the time of delivery. Manufacturers commissioning agents shall identify the software version revision in the commissioning report and assure the owner that the latest software version has been installed.

2. If the plans and/or specifications include both heat pump and heat recovery outdoor models, the manufacturer shall provide the most recent generation equipment only. Old stock, obsolete models or a mixture of design generations

3. Will not be accepted. Products sourced from the internet and not from the manufacturer's authorized Applied Representative or authorized distributer with territorial responsibility for the quality of the VRF system installation will not be accepted.

4. The water source unit shall be shipped from the factory fully assembled including internal refrigerant piping, compressor, contacts, relay(s), as well as an onboard, self-contained, stand-alone VRF system control.

5. The water source unit shall be matched with VRF components from the same manufacturer consisting of the water source unit, indoor units; factory designed and supplied Y-branches and/or Headers, zone controls, and an array of optional central control devices.

6. Direct communication between the water source unit and indoor units shall be provided over a field supplied RS-485 twisted wire pair. Systems requiring intermediary protocol translators, signal boosters, integration with a third party building management systems (BMS) or any other device required for communication to occur between VRF system refrigerant bearing components shall not be accepted.

7. The water source unit shall be designed to be placed in a room where the ambient temperature may vary between 33°F and 104°F without condensation forming on the exterior surface of the unit case.

4.6 REFRIGERATION CIRCUIT::

1. The water source unit refrigeration circuit shall be equipped from the factory with a minimum of these components:

A. Refrigerant strainer

B. Check valves

C. Oil separator

D. Accumulator

E. Hot gas bypass valve

F. 4-way reversing valve

G. Electronic expansion valve(s)

H. Sub-cooler

I. Service valves with Schrader ports

4.7 REFRIGERAANT AND LUBRICANTS

1. Refrigerant

A. The water source unit shall be supplied from the manufacturer with refrigerant R-410a. Any system that utilizes an alternate refrigerant must obtain prior approval to bid a minimum of 10 days prior to bid date from the Engineer of Record. Manufacturer shall provide with their request MSDS sheet(s), and ASHRAE sourced documentation that declares the alternate refrigerants ozone depletion potential and flammability classifications using ASHRAE Standard 15.

B. All proposed VRF systems that utilize a refrigerant with a flammability classification of “A” will not be accepted.

2. Refrigeration Oil

A. Each compressor shall ship from the factory with a full charge of Polyvinylether (PVE) refrigerant oil. Any additional oil required by manufacturer to initially commission the system shall be provided and shipped to the jobsite by the VRF manufacturer at no charge to the installer.

B. The refrigerant oil supplied shall have a flash point rating of no less than 395°F.

C. VRF systems that utilize refrigerant oils that can “hydrolyze” and result in capillary tube or strainer blockage when mixed with water vapor, such as Polyol Ester (POE), are not acceptable.

4.8 REFRIGERAANT/WATER HEATER EXCHANGER FREEZE PROTECTION

1. The microprocessor control shall be provided with freeze protection logic that attempts to minimize the potential of forming ice in the heat exchanger by monitoring:

A. Loss of flow below the minimum required.

B. Reduction in water temperature leaving the heat exchanger.

2. The water source unit shall have a field provided and wired flow detection device designed for stable operation and suitable for the location where it is installed.

3. On Multi-frame VRF Systems, provide an independent dedicated flow detection device

for each water source unit frame.

4. The flow detection device shall be field calibrated prior to commissioning. Flow detection device shall provide a stable signal without fluttering across the VRF manufacturer's acceptable water flow range.

4.9 REFRIGERANT SYSTEM CYCLE AND CONTROL

1. The mass flow rate of refrigerant between components shall be accomplished using the compressor(s) and a sub-cooler without the assistance of any type of intermediary mass flow booster devices.

2. The refrigerant cycle operation core logic shall establish and maintain target evaporating temperature (Te) to be constant in cooling mode and condensing temperature (Tc) constant in heating mode and maintain system stable operation while operating compressors across the published acceptable entering water temperature range. Specified entering water temperature range must fall in the manufacturers' performance tables that guarantees continuous compressor operation. "Reference data" is not acceptable.

3. VRF system refrigerant cycle core logic shall be able to dynamically modify the target evaporator and condenser temperatures to maximize energy savings when system is operating at part load conditions.

4.10 VRF SYSTEM WATER FLOW MANAGEMENT

1. Constant Flow (2-position shut-off valve and valve operator provided by others)

   A. Multi-frame VRF water source systems shall be provided with an independent dedicated field provided water shut-off valve and valve operator for each frame.

2. The temperature of the water entering the heat exchanger shall be maintained above 59°F at all times.

3. The field provided shut-off valve and valve operator shall be provided to:

   A. Prevent heat exchanger from freezing while unit is not operating.

   B. Prevent refrigerant migration while VRF system in not operating.

   C. Save pumping energy (2-way valve installations only)

4. VRF water source unit shall:

   A. Open the valve on a compressor start and shall close the valve when compressor operation is halted.

   B. Be provided with screw terminals to accept 208-220/60/1 field provided wiring to valve operator. Current draw from field provided valve operator shall not to exceed one (1) Ampere.

5. The field provided water shut-off valve shall be:

   A. Three-way configuration.

B. Normally closed to the water source unit frame.

C. Fail closed to the water source unit frame.

D. Full port (full throat) design.

6. The field provided valve operator(s) shall:

A. Conform to the VRF water source unit manufacturer's electrical *specifications. 220/60/1*

B. *Maximum current rating of less than one (1) Ampere at 220v.*

7. Variable Flow (0-10VDC variable position valve by others)

A. If the mechanical equipment schedule shows an entering water temperature to the water source unit below 60°, the VRF manufacturer shall provide an optional variable water flow control kit to be field installed and wired.

B. The Variable Flow Control Kit, valve, and valve operator assembly shall be provided to:

C. Maintain stable refrigerant cycle head pressure

D. Sustain the ability of IDUs to deliver quality heated air that exceeds 105°F year round;

E. Save pumping energy (on variable primary and/or secondary flow designs only).

8. Multi-frame VRF water source systems shall be provided with an independentdedicated Water Flow Control Kit, field provided valve and field provided valve operator for each frame.

9. VRF manufacturer's Variable Water Flow control kit shall be provided with the following components for field mounting by the installer.

A. Valve control interface printed circuit board to provide an analog 0-10 VDC valve position control signal.

B. Valve control interface printed circuit board mounting bracket(s).

C. Interface cable between the valve control interface printed circuit board and the water source unit main microprocessor control board.

10. The field provided water flow control valve shall be:

A. <Two-way><Three-way> configuration.

B. Normally closed to the water source unit frame.

C. Fail closed to the water source unit frame.

D. Full port (full throat) design.

11. The field provided water flow control valve operator(s) shall:

    A. Conform to the VRF water source unit manufacturer's electrical specifications.

12. Water to Refrigerant Heat Exchanger

    A. The water source unit shall be provided with an internally factory mounted heat exchanger manufactured with 316 stainless steel. Heat exchanger shall be a brazed plate design with a cross flow, micro-channel heat exchanger high efficiency surface.

    B. Heat exchanger shall be designed for operating at a continuous water and/or refrigerant side pressure of up to 640 PSIG.

    C. The heat exchanger pipe connections shall be capped at the factory and shall remain in place during project construction until such time the field piping is connected.

    D. Pipe specialties shall be field provided and installed by others or optionally purchased as pre-manufactured assemblies (see next section). Piping specialties shall include the following components:

        Mandatory field provided piping specialties will include:

        1. Outlet pipe water flow adjustment device or circuit setter

        2. Inlet & outlet isolation ball valves

        3. Inlet pipe strainer (50 MESH or finer)

        4. Inlet & outlet PT service ports

        5. Water flow control valve and operator (see VRF System Water Flow Management section for details).

    E. Optional recommended additional field provided piping specialties:

        1. Inlet & outlet water pressure gauges

        2. Inlet & outlet water temperature gauges

        3. Inlet and outlet braided stainless steel flexible connector

    F. VRF manufacturer shall make available to the installer pre-engineered piping packages complete with high pressure stainless steel flexible hoses, shutoff valves, strainer, flow control valve, coupling die-electric unions, circuit setter (or balancing valve) purchased through and manufactured by Hayes Fluid Products or equal.

4.11 SUB-COOLING CONTROL::

A. The water source unit shall have a spiral tube-in-tube or plate type sub-cooling device with automatic self-adjusting refrigerant flow control. Field mounted remote located sub coolers shall not be accepted

B. The amount of refrigerant used by the sub cooler shall dynamically vary and be held at the minimum required to maintain the target temperature of liquid refrigerant.

C. The water source unit shall have an algorithm embedded on the main microprocessor that monitors and adjusts in real time the target temperature of the liquid refrigerant supplied to the evaporator. The algorithm shall consider the following pipe system architectural variables to assure that refrigerant remains in 100% saturated state when the refrigerant enters EEV(s) at the indoor unit.

1. Maximum length of liquid pipe considering elbows and fittings (i.e. Equivalent feet length).

2. Water source unit heat exchanger entering water temperature.

3. Indoor unit (as an evaporator) refrigerant entering pipe temperature.

4.12 WIRELESS SERVICE COMMUNICATION

A. The water source unit manufacturer shall make available an optional plug-n-play field installed Wi-Fi communication kit that enables service personal wireless access at a minimum of 20 feet away to the operating system diagnostics and monitoring functions.

B. Service software shall be able to provide:

1. Collection of point in time (snapshot) information including all current outdoor unit operating conditions and each indoor unit, system EEV and solenoid valves, sensors, compressor speed, and refrigerant operating pressures and temperatures.

2. Real-time system operation monitoring with the ability to capture refrigerant cycle operating data for a field determined period of time and save it to an operating log file on a service providers personal computer or equal.

3. Transfer the saved operating log file into *.csv file format.

4.13 MICROPROCESSOR CONTROLLER

A. The water source unit shall have factory installed and programmed microprocessor controls necessary to efficiently control and operate the VRF system without the use of third party control products or building management interface.

B. All printed circuit boards (PCBs) surfaces shall be coated on both sides with a polymer based sealant designed to protect from corrosion and solder joint deterioration.

C. Communication between all products, devices, or elements of the VRF system and other products provided by the VRF manufacturer on the project shall communicate using the same protocol. Intermediary signal boosters or auxiliary protocol translators (i.e. gateways or bridges) of any kind are not allowed.

D. Power interruption: The VRF system shall be capable of operating indefinitely during a partial power outage which is defined as a power loss to one or more indoor units. Following a building (or whole system) power outage and subsequent power restoration, the VRF system shall automatically restart and continue with operation as it was prior to the outage without manual intervention to resume normal operation.

E. Communications interruption: The VRF system shall be capable of operating indefinitely if communication is lost between one or more indoor units and the water source unit. VRF systems that cannot continue to operate normally during a prolonged communication loss to one or more indoor units that cause the water source unit to cease operation are not acceptable. After communication is re-established, the VRF system shall automatically recognize the components and proceed to operate normally without requiring maintenance personnel intervention to cycle power or to reboot the microprocessor controller.

F. The water source unit shall be provided with a human interface display that is visible without removing major service panel(s). The human interface shall at a minimum provide a trained service technician with visual codes, graphics, or English verbiage that reports systems operation status, malfunction, and/or warn of unsafe operating condition.

G. The water source unit processor shall be provided with easy to use customization features that assist the commissioning agent to adjust system operating parameters to optimize efficient operation and stabilize refrigerant cycle operation at specified conditions. Customization features shall include ability to adjust:

1. Cooling mode superheat setting (on a per IDU basis).

2. Sub-cooling setting (on a per IDU basis).

3. Compressor low pressure target.

4. Compressor high pressure target.

4.14 FIELD SUPPLIED REFRIGERANT PIPING SYSTEM

A. VRF System Refrigerant Pipe System: Attributes, Capabilities, & Limitations

B. VRF systems with a design combination ratio greater than 130% are not acceptable

C. Longest equivalent pipe length (ELF) between water source unit and farthest indoor unit shall not exceed 738 equivalent length feet.

D. Longest pipe length between the water source unit and farthest indoor unit shall not exceed 656 physical feet.

E. Maximum pipe length between the first Y-branch (closest to the water source unit) and the farthest indoor unit shall not exceed 295 physical feet.

F. Maximum distance between a Y-Branch, Header Fitting, or Heat recovery unit and an indoor unit is 131 physical feet.

G. The maximum elevation an IDU may be mounted above the water source unit: 164 physical feet

H. The maximum elevation an IDU may be mounted below the water source unit: 164 physical feet.

I. The maximum elevation change between any two recovery units piped in parallel: 49 physical feet.

J. The maximum elevation change between any recovery units piped in series: 16 physical feet.

K. The maximum elevation between the highest and lowest indoor units in a system shall be 131 physical feet.

4.15 VRF REFRIGERANT PIPE SYSTEM: COMPUTER AIDED DESIGN

A. Basis of design is LG's Air Conditioning Technical Software (LATS) or equal.

B. The VRF refrigerant system pipe design shall originate utilizing the most recent version of the proposed VRF Manufacturer's computerized Engineered Refrigerant Pipe Design tool.

C. The software brand, model, and version number shall be generated by the program and noted on the VRF Refrigerant Piping Output Tree Diagrams.

D. Piping systems designed using a BETA software version (or other test version) is not acceptable.

4.16 VRF REFRIGERANT PIPE SYSTEM: FIELD DRAWINGS/REFRIGERANT PIPING TREE DIAGRAMS

A. Shall indicate the pipe sizes and lengths of each pipe using IP unit of measure. SI units are not acceptable.

B. Shall display the Indoor Unit model number and associate the IDU with a field defined room and floor tag.

C. The *corrected* (NET) sensible, total, and heating PEAK capacity of each indoor unit at project design conditions. Tree diagrams that display "nominal" capacity or block capacity based on the capacity of the water source unit) are not acceptable.

D. The Outdoor Unit model number, the frame count and the individual frame model numbers.

E. The *corrected* (NET) cooling and heating capacity of the outdoor unit at project design conditions.

F. Shall display the VRF System's Combination Ratio.

G. A printed list of the manufacturer's pipe design rules compared with the current design.

H. The tree diagram shall graphically associate the building load(s) as listed in the mechanical schedule with the IDU serving the room(s).

I. The tree diagram shall calculate and display on a % of room load the corrected NET capacity of the indoor unit.

4.17 VRF SYSTEM: FIELD WIRING: POWER AND COMMUNICATION WIRING DIAGRAMS

A. Shall indicate the pipe sizes and lengths of each pipe using IP unit of measure. SI units are not acceptable.

4.18 VRF SYSTEM REFRIGERANT PIPE SYSTEM: FIELD CHANGE APP0ROVAL PROCESS

A. The Applied representative shall keep the installer informed of any and all critical pipe lengths that need to be closely adhered to during the pipe installation process.

B. Any proposed field modification to the Engineered Refrigerant Pipe Design shall be proposed to the VRF Applied representative dedicated to support the installation of VRF Systems.

C. The Applied Representative shall validate the installing contractor's proposed change(s) using the VRF manufacturer's pipe design tool to validate the proposed change does not violate any of the rules and limitations set-forth in the specification.

D. Communication via email, text, fax, or other written documentation validating the proposed change(s) shall be required.

E. Any of the following proposed modifications to the installation of the VRF system shall require pre-approval from the VRF equipment's Applied Representative prior to proceeding:

1. Modification of any pipe diameter.

2. Length of a segment of pipe.

3. A change in the mounting elevation of a pipe.

4. A change in the mounting elevation of one or more VRF manufacturer supplied refrigerant containing devices, the addition or deletion of an Indoor unit.

5. The installation of a VRF Indoor Unit with a model number different than the IDU specified on the VRF Engineered Refrigerant Pipe System Tree-Diagram. **4.19**

4.19 VRF SYSTEM REFRIGERANT PIPE SYSTEM: FIELD PROVIDED PIPE SYSTEM MATERIALS A.
The refrigerant distribution piping system shall be constructed using field provided copper pipe, couplings and fittings rated for use with refrigerant R-410A.

B. The VRF manufacturer shall provide all Y branch and/or Header Fittings at any junction in the pipe system that joins 3 or more pipe segments. Third party fittings are not acceptable.

4.20 VRF REFRIGERANT PIPE SYSTEM INSTALLATION

A. The quality and method of coupling pipe segments to create the pipe system shall be the sole responsibility of the installer.

B. All pipe components in the VRF system shall be installed per manufacturer's published instructions.

C. The pipe system shall be installed to allow for expansion and contraction. Pipe hangers, supports, insulation shall not impede the free movement of any pipe segment.

D. Expansion loops, offsets or other expansion absorbing configurations shall be field designed, supplied and installed based on proper evaluation of the proposed piping design. The design of expansion absorbing pipe segments shall meet or exceed the intent of specification details provided by the design Engineer of Record and the VRF equipment manufacturer's published guidelines.

E. Each refrigerant pipe shall be independently insulated. All insulation joints shall be glued and sealed with no air gaps per insulation manufactures instructions and/or best practices to create an air tight assembly.

4.21 OIL MANAGEMENT

A. Each compressor shall discharge superheated compressed refrigerant vapor directly into a centrifugal type oil separator that shall have no moving parts. The oil separator shall be a minimum of 97% effective at removing oil from the oil/refrigerant gas stream and return the extracted oil via gear pump directly to the compressor oil sump without the use of pressure regulating intermediary control devices such as injectors, hot gas-bypass valves, electronic or pressure dependent expansion valves.

B. Systems designed to return oil to the sump via the low pressure vapor pipe or alternately bypass high pressure vapor from the compressor discharge back to the suction pipe, or mix captured refrigerant oil with low pressure vapor entering the compression chamber are not acceptable.

C. The compressor shall be equipped with an oil level sensor designed with no moving parts. The sensor shall electronically notify the water source unit controller when the oil level in the compressor sump is low. The water source unit shall be factory programmed to initiate an oil return cycle only upon receiving a signal from the oil level sensor. Systems designed with oil return cycles that occur on a timed basis are not acceptable.

4.22 CABINET

A. Water source unit cabinet shall be made of 20 gauge galvanized steel and finished with a baked enamel finish.

B. Water, refrigerant and condensate drain pipe connections shall be from the front side of the water source unit. Front panel of unit shall be removable without first removing field connected piping or wiring.

C. All major maintenance and routine service activity shall be from front side of the unit. Unit designs that require service access or pipe connections through either side, top or back panels will not be acceptable.

D. A separate microprocessor service access panel, not larger than 4”x 8”, tethered to the unit case to prevent misplacement, shall be provided to access the following:

1. Service diagnostic tool access port.

2. Error code diagnostics.

3. DIP switches

E. Unit base pan shall be designed to contain, collect, and drain100% of the internal condensate that may form during heating operation and drain it via factory provided condensate drain nipple at the base of the unit.

4.23 COMPRESSOR(S)

A. Compressor shall be a hermetic, high-side shell (HSS), commercial grade, *compliant* scroll direct-drive design.

B. Compressor shall be designed and assembled by the VRF manufacturer specifically for use in the VRF product line. Third party manufactured ,branded, or designed to the VRF system's OEM specifications by a third party manufacturer shall not be acceptable.

C. The fixed and oscillating compressor scroll components shall be made of high grade (GC25) or denser steel material. All scrolls shall be heat treated and tempered.

D. The oscillating scroll shall be finely machined and polished. PVE refrigerant oil shall be used as the sole liquid used to maintain a seal between the high and low sides of the compression chamber. Compressors that requires the use of any type of mechanical or wearable sealant material between the moving surfaces of the compression chamber is NOT ACCEPTABLE.

E. Bearing surfaces shall be coated with Teflon® equal. Bearings shall be lubricated using a constant flow of PVE refrigerant oil to the bearing surfaces The film of oil separating the crankshaft journals and bearing surfaces shall be consistent at all times the crankshaft is in motion and shall be maintained irrelevant of crankshaft rotational speed.

F. An internal, integrated, mechanically driven gear pump shall draw oil from the compressor sump reservoir, pressurize the oil and inject the oil directly to the crankshaft journals maintaining a consistent film of oil between all moving parts. Auxiliary, indirect, or electronically driven pumps are not acceptable.

G. The viscosity property of the PVE oil in the compressor sump shall be maintained irrelevant or compressor operation and the surrounding ambient temperature.

1. The compressor shall be equipped with an external thermally protected electric crankcase heater that is automatically activated only when the ambient temperature is below freezing and the compressor is not running to maintain the temperature of the oil in the sump above the refrigerant boiling point.

2. During stable operation, irrelevant of ambient air temperature outside the water source unit, the temperature of refrigerant vapor in contact with the surface of the oil in the compressor sump shall be maintained above 140°F to prevent foaming and to eliminate refrigerant from mixing with the oil degrading the viscosity of the oil in the sump.

3. The compressor motor shall be designed to operate at high temperatures.

4. The motor winding insulation shall be designed to operate continuously at a minimum temperature of 180°F without deterioration.

5. The motor cooling system shall be designed to maintain acceptable operational temperature at all times and in all conditions using high pressure, hot refrigerant vapor as motor coolant.

4.24 INVERTER COMPRESSOR CONTROLLER(S)

A. Each compressor shall be equipped with a dedicated inverter compressor drive. The control of multiple compressors using a single drive is not acceptable.

B. The inverter drive shall vary the speed of the compressor crankshaft between zero (0) Hz and 140 Hz in one (1) Hz increments.

C. The inverter driver controller shall be matched with the physical properties of the compressor. The drive shall be manufactured by the VRF water source unit manufacturer. The inverter drive and matching compressor shall have been thoroughly tested as a matched pair. The inverter drive shall be programmed to avoid operating the compressor at any speed that results in harmonic vibration, nuisance noise, or mechanical damage to either the driver or the compressor with power provided that is within the tolerance specification.

D. The compressor inverter drive assembly and software must be designed, manufactured, and supplied by the VRF product manufacturer. Third party branded inverter driver hardware and/or driver software or inverter driver hardware and/or software provided by a third party manufacturer to meet OEM specifications of the VRF water source manufacturer will not acceptable.

E. All inverter drive hardware or software manufactured in, is a product of, or sourced from China, or using a broker or third party provider as an intermediary that obtains the product from CHINA shall not be acceptable.

4.25 OPERATIONAL SOUND LEVELS

A. The compressor(s) shall be wrapped with heat resistant foil faced, sound deadening blanket that covers all exposed surfaces of the compressor. Sound deadening blankets shall be secured in place by use of a Velcro™ tool-less joint sealing system with a minimum of ½" of overlap along all seams. The sound deadening compressor blanket shall be engineered to leave no direct sound path between the outer surface of the body of the compressor and the surrounding environment.

B. The compressor(s) shall be mounted on rubber isolation grommets. Compressor shall ship with removable clamps that secure the compressor in place while transported. The installing contractor shall remove and discard (or optionally adjust the clamps to allow the isolator to properly function) the clamps prior to commissioning the water source unit.

C. Unit shall be mounted on field provided combination rubber and cork (or equal) isolation pads provided by the installing contractor. Provide a minimum of (1) pad per mounting point described in the VRF manufacturer's installation manual.

D. Each water source unit frame shall be rated with a sound level not to exceed 62 dB(A)

1. Test data shall be collected in an anechoic chamber using procedures publish under ISO Standard 3745.

2. Microphone shall be placed in front of the unit on the center line of the front panel at distance of 3.3 feet away and at an elevation of 3.3 feet above the finished floor.

4.26 SENSORS:

A. Water source unit shall be provided with these sensors to monitor and control refrigerant cycle operation.

1. Compressor inlet temperature thermistor

2. Compressor discharge temperature thermistor

3. Liquid pipe temperature sensor

4. High Pressure switch
5. High Pressure sensor
6. Low Pressure sensor
7. Leaving water temperature thermistor
8. Ambient air temperature thermistor

4.27 INVERTER DRIVE/COMPRESSOR ASSEMBLY PROTECTION

A. Multiple sensors shall be provided that actively guard against the following potential conditions and when one or more occurs, the unit microprocessor control shall adjust cycle operation when possible to protect the inverter drive/compressor assembly from:

1. Over-current /under current
2. Phase loss, reversal and imbalance
3. Excessive refrigerant charge and high pressure.
4 Low refrigerant charge/ overheating

4.28 SEISMIC INSTALLIATIONS

A. Provide with submittal: 1) OSHPD Special Seismic Certification Preapproval (OSP) documents for certified product list of VRF equipment to be installed in high seismic risk areas. 2) Equipment installation documents in conformance with CBC 2013, 2016 and 2019 California Building Code and IBC 2012, 2015 and 2018 International Building Code.

PART 5- WARRANTY

5.1 LIMITED WARRANTY PERIOD

A. STANDARD ONE-YEAR PARTS WARRANTY FOR A QUALIFIED SYSTEM - The Part(s) of a qualified System, including the compressor, are warranted for a period (the “Standard Parts Warranty Period”) ending on the earlier to occur of one (1) year after the date of original installation, or eighteen (18) months from the date of manufacture.

B. ADDITIONAL SIX (6) YEAR COMPRESSOR PART WARRANTY - The Compressor is warranted for an additional six (6) year period after the end of the applicable Standard Part Warranty Period (the “Compressor Warranty Period”).

5.2 Extended Warranty

A. The Standard Warranty Period and the Compressor Warranty Period are extended to a total of ten (10) years (the “Extended Warranty Period”) for qualified Systems that have been (a) commissioned by a party that has completed the current Training Requirements, (b) such commissioning is pursuant to LG’s current published instructions, and (c) the System commissioning results and supporting documents are entered correctly into LG’s online commissioning system. Commissioning of a System requires one (1) hour of LG Monitoring View (LGMV) data. Commissioning results must be entered into LG’s online commissioning system within sixty (60) days of System startup.

PART 6- PRODUCT(S)

6.1. Heat Recovery Units (Heat Recovery Systems Only).
<PRHR023A><PRHR033A><PRHR043A><PRHR063A><PRHR083A>

A. General

1, Heat recovery unit shall be designed and manufactured by the same manufacturer of VRF indoor unit(s) and outdoor unit(s).

2. Heat recovery unit casing shall be constructed with galvanized steel.

3. Heat recovery unit shall require 208-230V/1-phase/60Hz power supply.

4. Heat recovery Unit shall be an intermediate refrigerant control device between the air source outdoor unit and the indoor units to control the systems cooling and heating operation.

5. Heat recovery unit shall be engineered to work with a three pipe VRF system comprising of:

A. High Pressure Vapor Pipe

B. Low Pressure Vapor Pipe

C. Liquid Pipe

6 Heat recovery units' main 3 pipe connections shall be capable of series or parallel pipe configuration.

7 The quantity of heat recovery units that can be piped in series shall be limited to 16.

8 Heat recovery units shall be engineered for installation in a semi-conditioned space where temperature and humidity is maintained between -22Deg F to 130Deg F. Heat recovery unit's case and internal components where surface temperatures may operate below dew point shall be factory insulated. Heat recovery units that condense and require condensate drain shall not be acceptable.

9. A single string of series piped heat recovery units shall be capable of serving any combination of styles of VRF indoor units with a combined nominal capacity of up to 230 MBh.

10. Heat recovery unit shall have 2, 3, 4, 6 or 8 ports, each port supporting one or more indoor units with a maximum connected capacity of 60 MBH.

11. Each port shall be capable of operating in cooling or heating independently regardless of the operating mode of any other port on the heat recovery unit or in the system.

12. Each port shall be capable of connecting from 1 to 8 indoor units.

13. Connection to indoor units totaling greater than 60MBh nominal capacity shall be twinned to two adjacent ports of the heat recovery unit using a reverse Y-branch connector supplied by manufacture.

14. Heat recovery unit shall be internally piped, wired, assembled and run tested at the factory.

15. Heat recovery unit shall be designed for installation in a conditioned environment per specifications.

16. Heat recovery unit shall employ a liquid bypass valve.

17. Heat recovery unit shall have (2) electronic expansion refrigerant valves per port.

18. Heat recovery unit shall have a balancing valve to control the pressure between the high pressure and low pressure pipe during mode switching to minimize any change-over pressure related sounds.

19. Heat recovery unit shall employ an electronic expansion valve to ensure proper sub cooling of the refrigerant.

20. Heat recovery unit shall contain one double spiral sub-cooling heat exchanger per port.

21. Heat recovery unit shall not require a condensate drain or connection.

22. Heat recovery unit shall be internally factory insulated.

23. All field refrigerant lines between outdoor unit and heat recovery unit and from heat recovery unit to indoor unit shall be field ACR tubing, insulated per building or energy code and as instructed by the manufacture.

24. The heat recovery unit shall not exceed a net weight of 68 lbs.

25. Heat recovery units, for line length and pressure drop calculations, shall not exceed a maximum equivalent pipe length value of 8.2 feet.

26. The VRF manufacturer shall provide published documentation that specifically allows the installation of field provided isolation valves on all pipes connected to the Heat recovery unit to allow the servicing of heat recovery units, refrigerant circuit or the replacement of heat recovery unit without evacuating the balance of the piping system.

6.2 CONTROLS

1. Heat recovery unit(s) shall have factory installed unit mounted control boards and integral microprocessor to communicate with other devices in the VRF system.

2. Heat recovery unit shall communicate with the indoor units via a 2-conductor stranded communications cable terminated using a daisy chain configuration.

3. The contractor is instructed to review the Electrical and ATC drawings and specifications for other items or tasks which this contractor is or may be responsible to provide materials and or labor under this contract. Failure to do so will not relieve this contractor of their responsibility to provide such materials and or labor and in no case shall this contractor be further compensated as a result.

6.3 SEISMIC INTALLATIONS

A. Provide with submittal: 1) OSHPD Special Seismic Certification Preapproval (OSP) documents for certified product list of VRF equipment to be installed in high seismic risk areas. 2) Equipment installation documents in conformance with CBC 2013, 2016 and 2019 California Building Code and IBC 2012, 2015 and 2018 International Building Code.

6.4 WARRANTY

A. Please refer to the respective outdoor unit for applicable warranty.

END OF SECTION 23 81 29

SECTION 23 84 16

MECHANICAL DEHUMIDIFICATION UNITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 QUALITY ASSURANCES

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

1.3 SCOPE

A. Furnish and install, where indicated, a factory-assembled, fully-enclosed, packaged environmental control system with energy recovery features designed for swimming environment control.

B. Features shall include:

1. Dehumidification by means of a direct expansion evaporator coil
2. Space heating by means of an integral indirect-fired natural gas duct furnace module
3. Cooling mode with heat rejection to an integral outdoor air-cooled condenser
4. Packaged minimum exhaust fan
5. Integral minimum outdoor air connection
6. Heat recovery by means of a glycol run-around loop between the minimum exhaust and minimum outdoor air streams

1.5. Quality and Safety Assurance

A. The complete unit shall be listed by an industry recognized, third-party, safety code agency under the title of "Special Purpose Air Conditioners" and carry the appropriate label.

B. The system shall be ETL listed

C. The system shall be completely assembled, wired, piped, and test-run at the factory prior to shipping. All controls shall be factory adjusted to satisfy the design conditions.

D. Manufacturer shall have a minimum of ten-plus years prior experience making similar equipment as described in this specification.

E. Wherever possible, the system shall have a mechanical vestibule where the electrical panel, compressor, receiver and most of the refrigeration controls are out of the process air stream

F. Warranty: The entire system shall have a 24-month limited parts warranty from the factory ship date
1. A 1-year labor warranty shall be provided by installing contractor.

2. The compressor shall have a 5-year warranty from the factory ship date
3. The internal airside heat exchanger coils shall have a 5-year warranty from the factory ship date
4. The drive line shall have a 5-year warranty from the factory ship date

1.6 Intent

A. It is the intent of this section of the specifications to provide a complete, operable, adjusted natatorium dehumidification system as shown and scheduled on the plans.

1.7 Basis of Design

A. Base Bid/Alternate

B. Unit shall be base bid with Dectron DS Series. An Add or Deduct Alternate may be provided as indicated on the bid form subject to the following conditions:

1. Alternate bid shall include revised layout including details on supply/return air connections, piping connections, ventilation/exhaust connections, power/control wiring connections.
2. 10 day prior: Alternate Bid shall include Full Compliance Disclosure (by paragraph and schedule) to be submitted to the engineer ten days prior to the bid and approved by the engineer in writing prior to the bid. Full Disclosure shall clearly list and define any exceptions or deviations to the specified equipment and specified performance, and any items, which exceed the specifications. Alternate Bid Manufacturer shall include a full disclosure of the unit's energy recovery features including unit's reheat capabilities, pool water heating capabilities and recovery of pool water evaporation energy.
3. Where the intent of the specification is met but with different construction materials or methods, the difference shall be completely defined by paragraph in the Full Disclosure. The Full Disclosure shall include complete documented data.
4. Manufacturer shall submit the following bidder's checklist with his proposal to the mechanical contractor. It shall be the mechanical contractor's responsibility to provide any modifications to the equipment to make the unit conform to the specification.

1.8 Unit To Include the Following**.**

A. Service Vestibule with compressors out of the air stream
B. Refrigerant pressure transducers used for active control of the refrigeration system and no manifold gauges needed to service the equipment
C. Fully dipped airside coils for corrosion protection
D. Fully modulating reheat coil for stable space temperature control from the DX system. Coil sized for rejecting 100% of all compressors heat.
E. All fans direct drive with VFD or ECM
F. Each evaporator coil provided with a baked powder painted IAQ Aluminum drain pan
G. Two speed fluid cooler or outdoor condenser fans
H. Cabinet 2" double walled with fully painted inner metal liner
I. Heat recovery from the minimum exhaust air stream used to directly preheat the incoming minimum outdoor air stream
J. Unit controller holds memory of basic refrigerant system info for 2 years of hourly data and 5 days of one-minute interval data
K. Standard fully dipped coating on all air side coils: corrosion resistance and hydrophilic (decreasing water carryover and increasing
L. Indirect fired gas heater packaged inside the unit

Part 2 - PRODUCT

2.1 The natatorium control system shall include:

A. Mechanical process dehumidification
B. Outdoor cabinet configuration
C. Packaged outdoor air-cooled condenser for AC heat rejection
D. A packaged indirect-fired natural gas duct furnace module installed downstream of the blower, sized as specified by the design engineer to meet the skin losses and outdoor air heating loads

E. Potable water rated coaxial condensing heat exchanger(s) with double wall vented construction for pool water heating using reclaimed compressor waste heat
B. Air filtration via MERV-8 2-inch pleated panel filters for return and outdoor air
C. Minimum exhaust fan(s)
D. Heat recovery between the minimum exhaust air and outdoor air streams and via a glycol run around loop
E. A service vestibule where the compressor, refrigeration specialties, control valves and all electronics are outside of process air stream

2.2 Sequence of Operation

A. The system shall be designed and sized to maintain the specified space conditions

B. System Startup
1. Power is turned on or the system is restarted
2. After a short initial delay to allow the sensors to stabilize, the blower starts and operates continuously
3. Based on sensor feedback, the system shall begin or resume operation based on the sequence below

B. . Airside Configuration
1. The system continuously delivers the specified supply air volume to the natatorium
2. The minimum exhaust air volume is set to meet the engineer's schedule.
3. The minimum outdoor air volume is set to meet the engineer's schedule.

C. Dehumidification Mode
1. The return air relative humidity is above the humidity setpoint
2. Return air dewpoint is above dewpoint setpoint.
3. The compressor enters the Compressor Start sequence

4. Initially, 100% of compressor hot gas discharge will be diverted to condense at the air reheat coil. The supply air temperature will be higher than the return air temperature

D. Air Conditioning Mode
1. The return air temperature is above the room temperature setpoint
2. The compressor starts, if not already operating in Dehumidification Mode

3. Excess compressor hot gas is diverted to the outdoor air-cooled condenser for up to 100% heat rejection at summer design ambient conditions

E. Space Heating Mode
1. The return air temperature is below the room temperature setpoint
2. The microprocessor space heating output signal (0-10 volts) is sent to the heating coil controller. The signal output will regulate based on the return air temperature

F.. Exhaust Air Heat Recovery Mode

G. The minimum outdoor air damper and minimum exhaust fan(s) are tied to the system's occupancy schedule and will operate as programmed . Once the outdoor air temperature falls below the heat recovery setpoint (65 °F by default; field-adjustable) the glycol pump shall circulate a glycol mixture between the exhaust air and the outdoor air heat recovery coils, recovering heat from the space condition exhaust air and using it to preheat the incoming outside air

. Freeze Protection
1. The supply air temperature falls below the freezestat setpoint or the optional freezestat sensor indicates a freezestat condition
2. Exhaust fan(s) are stopped and outdoor air damper(s) are fully closed
3. When the freezestat alarm is tripped, it must be manually cleared by the operator

2.3 Cabinet

A. The cabinet shall be designed and configured for outdoor installation with a 2" double walled cabinet including painted inner liner
1. Infill panels and doors shall be constructed with 18 gauge G90 galvanized steel exterior and 18 gauge mil aluminum finish interior suitable for chlorine and pool chemical resistance.
2. The structural base frame shall be 3/16" steel channel base with 12-gauge steel cross bracing.

B. Cabinet Construction: All cabinet 16, 20 and 24 gauge sheet metal shall be galvanized G90 steel or GalvalumeTM alloy with mill-applied zinc phosphate primer followed by an exterior grade white silicone modified polyester top coat. The sheet metal is engineered to form a cabinet with maximum strength and rigidity. All seams shall be caulked with silicone to prevent air and water leakage or infiltration
1. The cabinet floor shall be of 2-inch double-wall construction using 20-gauge pre-painted steel engineered with structural bends for maximum rigidity, mechanically fastened to the base frame
2. The cabinets shall be mechanically assembled with stainless steel 5/32" sealed blind rivets. Where bolts are required bright zinc plated bolts shall be used
3. The unit shall have non-corroding protective mesh screens on all air intake openings

C. Outdoor Air Intake:

D. Insulation: The unit shall be insulated per the following standards:
1. Fire resistant rating to conform to NFPA Standard 90A and 90B

E. Cabinet configuration shall include:
1. A filter rack with separate access doors shall be provided for the return air and minimum outdoor air streams
2. Mechanical vestibule: The unit shall have the compressor, receiver, solenoid valves and the electrical panel in a separate compartment out of the processed

air stream. All components shall be serviceable while the unit is in operation without disturbing the airflow

3. Electrical panel: The unit shall have a built-in electrical control panel in a separate compartment in order not to disturb the airflow within the dehumidifier during electrical servicing. All electrical components shall be mounted on a 16 gauge galvanized sub-panel

2.4 Filters

A. Wherever possible, air filters shall be standard sized, replaceable, off-the-shelf filters including:

B. Return Air: 2-Inch MERV 8, 30% pleated filters with rust-free non-metallic structure on a slide in rack

C. Exhaust Air: 2-Inch MERV 8, 30% pleated filters with rust-free non-metallic structure

D. Outside Air: 2-Inch MERV 8, 30% pleated filters with rust-free non-metallic structure

2.5 Coils

A. Evaporator/dehumidifier coils shall be designed for maximum moisture removal capacity
   1. Coils shall be fully dipped and coated with a polyester/enamel coating for maximum corrosion protection. Coating shall comply with ASTM B117/D1654 and ASTM D2126 for corrosion resistance against common acids, salt and gases
   2. Coil shall have galvanized casing and end plates
   3. Aluminum fin and copper tubes mechanically bonded to assure high heat transfer.

B. Air reheat condenser coils shall be sized for variable heat transfer into the air with a capacity of 100% of the compressors total required heat of rejection
   1. Coils shall be fully dipped and coated with a polyester/enamel coating for maximum corrosion protection. Coating shall comply with ASTM B117/D1654 and ASTM D2126 for corrosion resistance against common acids, salt and gases
   2. Coil shall have galvanized casing and end plates
   3. Aluminum fin and copper tube joints mechanically bonded to assure high heat transfer

C. Coils shall have a 3-year warranty extension for a total of 5 years coverage

D. Heat Recovery Coils
   1. The unit shall have heat recovery between the minimum exhaust and outdoor air streams per specifications
      A. The heat recovery coils shall be sized for heat transfer between the two air streams
      B. The heat recovery fluid circulating between coils shall be glycol. The module shall be a complete package and independent circuit that includes a circulating pump, fill valves and expansion tank
   2. Coils shall be fully dipped and coated with a polyester/enamel coating for maximum corrosion protection. Coating shall comply with ASTM

B117/D1654 and ASTM D2126 for corrosion resistance against common acids, salt and gases

3. Aluminum fin and copper tube joints mechanically bonded to assure high heat transfer

2.6 Drain Pans

A. Each evaporator coil shall be provided with a positive draining, compound-sloped, baked powder paint coated aluminum drain pan with fully-welded corners to ensure zero water retention

2.7 Blowers and Blower Motors

A. Supply blowers:
1. Each supply blower shall be an impeller plenum fan complete with backward curved, three-dimensional, profiled blades made of a high-performance composite material directly driven via a direct current (DC) electronic commuted (EC) motor. The blower and motor shall be completely corrosion resistant and be maintenance free. The EC-Motor shall be of zero-slippage design with continuously variable speed control when connected to the system's controller.
2. Each EC motor shall have maintenance-free electronic circuitry, a rotor with permanent magnets, and an integral controller to provide the windings with electrical current so that, the motor rotates continuously and quietly.
3. Each fan shall be statically and dynamically balanced on precision electronic balancers.

B. Exhaust blowers:

1. The packaged exhaust blower (EF1) shall be sized to maintain the negative pressure requirement in the space during normal operation and its operation tied to the system's occupancy scheduler
2. The blower shall be impeller plenum fan complete with backward curved, three-dimensional, profiled blades made of high performance composite material. The blower shall be completely corrosion resistant and be maintenance free a direct drive via a direct current (DC) electronic commuted (EC) motor. The EC-Motor shall have zero slippage design and have continuously variable speed control when connected to the unit's controller
3. The fan assembly shall be balanced in Class G 6.3 acc DIN ISO 1940, dynamic on two levels
4. The fan assembly shall be suitable for ambient temperatures of -40°C to max. +70°C
5. Thermal contacts installed in the windings compliant with THCL 155
6. Drive motor in external rotor principle, sealed in protection class IP54 with moisture protection impregnation of the windings, topical protection
7. High corrosion resistance design with high quality and reliability
8. The exhaust fan shall be controlled from an end switch on the power open of the exhaust air damper. The exhaust dampers shall be protected by louvers to divert rain from the face of the dampers
9. Shall be packaged with the heat recovery module

2.8 Dampers

A. Internal dampers shall be made from extruded anodized aluminum with a parallel blade configuration and neoprene double-seal tips to minimize leakage. Damper blades

shall be mounted on steel rods which rotate on nylon bushings. All damper hardware shall be corrosion resistant

B. The system shall be provided with normally closed outside air and exhaust air dampers equipped with spring-return actuators The dampers adjust between 0% to 100% open position.

C. The outdoor air and exhaust air dampers shall be of opposed blade configuration. Dampers shall have 0.750-inch insulated blades made from extruded anodized aluminum with neoprene double-seal tips to minimize leakage. Damper leakage shall be less than 1% of maximum flow at 4-inch water column differential. Damper blades shall be mounted on steel rods which rotate on nylon bushings. All damper hardware shall be corrosion resistant

2.9 Compressors

A. Hermetic, scroll action compressor, suction gas cooled, suitable for refrigerant R-410A
B. The compressor(s) shall be equipped with an internal solid-state thermal protection sensor
C. Access: Service access valves for convenient servicing.
D. The compressor(s) shall be mounted on rubber-in-shear isolators to limit the transmission of noise and vibration
E. The compressor(s) shall be equipped with removable crankcase heater(s) for liquid migration protection
F. The compressor(s) shall be located outside the conditioned air stream in the system's service vestibule
G. Compressors shall have a 3-year warranty extension for a total of 5 years coverage
H. The compressor manufacturer must have a wholesale outlet for replacement parts in the nearest major city

2.10 Refrigeration Circuit

A. The system shall consist of one factory-sealed refrigeration circuit for dehumidification and sensible cooling. No site refrigeration work shall be required
B. Each refrigeration circuit shall have pressure transducers monitoring the refrigerant discharge (high) and suction (low) pressures. The refrigeration circuit shall be accessible for diagnostics, adjustment and servicing without the need for service manifold gauges
C. All refrigeration circuits shall have solenoid control valves, check valves, a liquid line filter-drier, liquid and moisture indicator, thermostatic expansion valve and a pump down solenoid valve
D. The system shall have an externally adjustable balanced port design mechanical thermostatic expansion valve. The valve shall have a removable power head
E. Tamper proof, hermetically sealed non-adjustable high and low pressure switches and refrigeration service valves shall be installed using Schrader type valves. Refrigeration service valves shall be located outside of the airstream
F. The receiver shall have two refrigerant level (maximum and minimum) indicating sight glasses
G. The suction line shall be fully insulated with 0.500-inch closed cell insulation

2.11 Control Panel

A. The electrical contractor shall be responsible for external power wiring and disconnect switch fusing. Power block terminals shall be provided
B. The system shall include a factory-installed non-fused disconnect

C. Main control panel shall be mounted inside the service vestibule outside of the process air stream
D. Blower motors shall be protected with thermal trip overloads
E. The system shall have a voltage monitor with phase protection
F. Available dry contacts shall include:
    1. Alarm
    2. Blower interlock
    3. Stage 1 & 2 heating
    4. Outdoor air damper control
    5. Remote exhaust fan #1
    6. Remote exhaust fan #2
    7. Outdoor-air cooled equipment
    8. System on
    9. Auxiliary pool heater 1
    10. Heat recovery
G. Terminals shall be provided to send 24-volt power to the outdoor air-cooled condenser or fluid cooler fan contactor
H. All wiring shall be installed in accordance with UL or CSA safety electrical code regulations and shall be in accordance with the NFPA All components used in the system shall be UL or CSA listed
I. Wiring diagrams shall be located near the electrical panel(s) on the system. These diagrams shall provide color-coding and wire numbering for easy troubleshooting. All wires shall be contained in a wire duct.
J. The compressor(s) shall have a time delay on start to prevent short cycling
K. An airflow switch and a dry contact for alarm(s) shall be provided

2.12 Air Heating

A. The packaged indirect-fired natural gas duct furnace module shall be sized to meet the scheduled heating capacity and have the following characteristics: Modulating (0-10V) auxiliary air heat control
B. The duct furnace module shall be a natural gas indirect-fired type using spark ignition with a heating capacity as shown in this submittal and is installed in a 'blow through' configuration downstream from the blower. The heat exchanger tubes are constructed of formed and welded 16-gauge series 409 stainless steel suitable for installation downstream of the cooling coil and satisfactory for air inlet temperatures below 40 °F. The burner is the power firing type and incorporates a primary combustion air blower and spark ignition transformer
C. Standard controls shall include a modulating gas valve, intermittent spark ignition, overheat control, rollout flame supervision, combustion air flow proving switch, positive burner safety switch, pilot cock, main gas cock with 100% shut off, adjustable main and pilot pressure regulators
D. The natural gas duct furnace module shall be an ETL recognized component. The gas train shall be complete with all controls factory mounted to comply with requirements of ETL. The gas train is complete with a modulating main gas valve and is ready for connection to a natural gas supply with pressure between 7 in and 14 in WC
E. The complete system shall be test-fired and preliminary adjustments made prior to leaving the factory

2.13 Air Conditioning

A. Air-cooled air conditioning integral outdoor condenser
B. The system shall be equipped with an air conditioning mode where excess compressor heat is rejected to a factory-packaged, integral outdoor air-cooled condenser. The outdoor air-cooled condenser shall be capable of rejecting 100% of the compressor heat rejection with an air-on temperature at summer design conditions. The outdoor

condenser shall be equipped with a 24VAC controls, including a contactor for the fan motor

C. The system shall be provided with a dry contact rated for 5A at 24VAC to operate the integral outdoor condenser controls
D. Each refrigeration circuit shall include refrigerant valves, a receiver with pressure relief valve set to 650 psig, a pressure control valve and a pressure differential valve, and two manual shutoff valves to isolate the outdoor condenser
E. Coils shall be tested at 600 PSIG and mounted vertically for complete surface utilization. Coils shall be counter flow with a minimum of 10 degrees of liquid sub-cooling and have adequate capacity to dissipate the total heat rejection of the system at design conditions. Condensers shall have guards to protect the coils from vandalism and weather-related damage
F. The fan(s) shall be direct driven axial fan(s) made of aluminum in which the motor and controller are integrated. The fan includes an EC commutated direct-current external rotor motor to provide maximum efficiency and the quietest performance. The EC motor shall have maintenance-free electronic circuitry, a rotor with permanent magnets and an integral controller to provide the windings with electrical current so that the motor rotates continuously and quietly. The fan has an aerodynamically-optimized, sickle-blade profile, patterned with serrated trailing edge and winglets on the blade outer edge for energy and noise-optimized operation
    1. The fan assembly shall be balanced in Class G 6.3 acc DIN ISO 1940, dynamic on two levels
    2. The fan assembly shall be suitable for ambient temperatures of -40°C to max. +70°C
    3. Thermal contacts installed in the windings compliant with THCL 155
    4. Drive motor in external rotor principle, sealed in protection class IP54 with moisture protection impregnation of the windings, topical protection
    5. High corrosion resistance design with high quality and reliability

2.14 Roof Curb

A. The roof curb shall be a prefabricated, perimeter type curb made of 12-gauge galvanized steel with stiffeners, 2.000 in x 2.000 in treated wood nailer strip and not less than 1.500 in of rigid acoustical and thermal fiberglass insulation, knocked-down for shipment. 1.000 in x 0.250 in adhesive gasketing and all necessary hardware shall be provided for field assembly of the curb on the roof decking prior to system shipment

2.15 Factory Performance Testing

A. The system shall be thoroughly tested under factory test conditions.

Part 3 - Execution

3.1 Product Delivery, Acceptance, Storage and Handling

A. Perform a thorough physical inspection of the system upon delivery from the shipment carrier
B. Identify and immediately report any physical damage to manufacturer
C. If the system is to be stored prior to installation, store in a clean, dry place protected from weather, dirt, fumes, water, construction and physical damage
D. Handle the system carefully during installation to prevent damage
E. Damaged systems or components shall not be installed. Contact the manufacturer for RMA instructions
F. Comply with the manufacturer's rigging and installation instructions for unloading the system and moving it into position

3.2 Connections

A. Where installing piping adjacent to the system, allow space for service and maintenance
B. Duct connections: drawings indicate the general arrangements of the ducts. Connect the system to ducts with flexible duct connectors. Comply with code requirements for flexible duct connectors
C. Electrical connections: comply with code requirements for power wiring, switches and motor controls in electrical sections

3.3 Installation

A. The agency responsible for start-up should work in accordance with the specifications and in accordance with the manufacturer's instructions and only by workers experienced in this type of work

3.4 Start Up

D. Detailed instructions for start-up as provided by the manufacturer must be followed
E. Installing contractor must contact the manufacturer prior to start up to confirm start up procedures
F. On-site manufacture technician shall provide start-up assistance to the installing contractor.

END OF SECTION 23 84 16

END OF DIVISION