DIVISION 23: HEATING, VENTILATING, AND AIR-CONDITIONING

SECTION 23 0501 – COMMON HVAC REQUIREMENTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

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

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

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

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

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.

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", and "2015 International Fire Code" as published by the International Conference of Building Officials.
4. 2015 Idaho Plumbing Code as published by the International Association of Plumbing and Mechanical Officials.
5. "National Electrical Code" as published by the National Fire Protection Association.
6. "2015 International Energy Conservation Code ".

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

1.6 INSPECTIONS AND PERMITS

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

1.7 ADDITIONAL WORK:

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

PART 2 - PRODUCTS FOR COMMON HVAC REQUIREMENTS

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

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 ONE YEAR PERIOD OF CORRECTIONS

A. Contractor shall certify work under Division 23 to be free from inherent defects for a period of one year from the date of substantial completion.

B. 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 substantial completion , provided such defect is not due to carelessness in operation or maintenance.

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 air handling units, fan coil units, or other pieces of equipment used for moving supply air without proper air filters installed properly in system.

3.14 COMMON HVAC REQUIREMENTS:

A. INSTALLATION
1. During installation, protect open ends of ducts by covering with plastic sheet tied in place to prevent entrance of debris and dirt.
2. Make necessary allowances and provisions in installation of sheet metal ducts for structural conditions of building. Revisions in layout and configuration may be allowed, with prior written approval of Architect. Maintain required airflows in suggesting revisions.

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

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

END OF SECTION 23 0501

SECTION 23 0502 - DEMOLITION AND REPAIR

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

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

1.3 DRAWINGS AND EXISTING CONDITIONS

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

PART 2 - NOT USED

PART 3 - EXECUTION

3.1 TEMPORARY CONNECTIONS

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

3.2 EXISTING TO BE ABANDONED

A. All required drilling, cutting, block-outs and demolition work required for the removal and/or installation of the mechanical system is the responsibility of this Contractor.

B. No joists, beams, girders, trusses or columns shall be cut by any Contractor without written permission from the Architect.

C. The patching, repair, and finishing to existing or new surfaces is the responsibility of this Contractor, unless specifically called for under sections of specifications covering these materials.

D. Disconnect all equipment that is to be removed or relocated. Relocate any existing equipment that obstructs new construction.

3.3 EXISTING TO REMAIN IN USE

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

3.4 MATERIALS AND EQUIPMENT REMOVED

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

END OF SECTION 23 0502

SECTION 23 0514 – VARIABLE FREQUENCY DRIVE SYSTEM

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

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

1.3 QUALITY ASSURANCE

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

1.4 SUPPLIER & VENDOR REQUIREMENTS

A. Suppliers of VFD systems must be in the primary business of supplying variable frequency drives and have a minimum of five (5) years of service in that business.

B. Vendor must have local service center with factory spare parts inventory and factory authorized service technician on call 24 hr/day. The vendor must be able to show that the recommended spare parts are available locally and any repair could take place within 24 hours for equipment supplied on this project.

1.5 TESTING

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

1.6 DRAWINGS/MANUALS

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

B. Each unit shall be supplied with two owner/maintenance manuals which shall include:
   1. Vendor information of equipment being supplied.
   2. Connection Information.
   3. Startup Procedure.
   4. Fault Reset Instruction.

5. Wiring Diagrams (power and control).
6. Parts List.
7. Test Results:
   Harmonic voltage distortion on line with unit off
   Harmonic voltage distortion with unit on line
   Telephone Influence Factor (TIF) Report
   Transformer Derate Report
   Displacement Power Factor Report

1.7 WARRANTY

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

PART 2 - PRODUCTS

2.1 MANUFACTURED UNITS

A. The vendor shall verify compatibility of the VFD System being supplied with the specified motor. The motor shall be high efficiency with a 1.15 service factor, and shall be subject to VFD vendor approval.

B. Each system shall be supplied in a NEMA 1 force ventilated filtered enclosure, either wall mounted or free standing.

C. Each system shall have screened or engraved labels on all door operator and pilot devices.

D. Each system shall bear an electrical shock warning label to warn personnel that a potential of electric shock exists.

E. Each system shall be supplied complete, wired with all components assembled in a single enclosure including, but not limited to the VFD units, contactors, door interlocked circuit breaker, differential pressure controller, and/or other items listed in this specification or shown on the plans. Units requiring mounting and interwiring of separate bypass enclosure shall not be acceptable under this specification.

F. The vendor shall supply a complete set of engineering drawings consisting of, as a minimum, general arrangements, power wiring diagram, control wiring diagram and schematic of VFD System components and options.

G. The vendor shall supply an owner's manual consisting of catalog sheets listing actual component and part numbers. Manual shall also show test certificates, warranty and service personnel responsible for warranty.

H. Vendor shall supply VFD System and start-up service. Mounting unit and connecting to power supply and mounting and wiring of remote devices shall be by mechanical contractor.

I. The VFD inverter shall be altitude compensated and sized for the elevation at which the unit will be installed. The inverter shall operate in an ambient temperature of -10 degrees C to 50 degrees C and humidity of 0% to 90% non-condensing.

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 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. ABB

D. Or Approved Equal

2.4 APPROVED SUPPLIERS

A. The following suppliers have been approved for assembling and local support of the VFDS:
1. Energy Management Corporation, Midgley-Huber.
2. 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 0514

SECTION 23 0529-HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Includes But Not Limited To:
   1. Common hanger and support requirements and procedures for HVAC systems.

B. Related Requirements:
   1. Section 07 8400: Quality of Penetration Firestop Systems to be used on Project and submittal requirements.
   2. Sections Under 09 9000 Heading: Painting of mechanical items requiring field painting.
   3. Slots and openings through floors, walls, ceilings, and roofs provided under other Divisions in their respective materials.

1.2 SUBMITTALS

A. Action Submittals:
   1. Product Data:
      a. Manufacturer's catalog data for each manufactured item.

PART 2 - PRODUCTS

2.1 ASSEMBLIES

A. Manufacturers:
   1. Class Two Quality Standard Approved Manufacturers. See Section 01 6200:
      a. Anvil International, Portsmouth, NH www.anvilintl.com.
      b. Cooper B-Line, Highland, IL www.cooperbline.com.
      c. Erico International, Solon, OH www.erico.com.
      d. Hilti Inc, Tulsa, OK www.hilti.com.
      e. Minerallac, Hampshire, IL www.minerallac.com.
      f. Thomas & Betts, Memphis, TN www.superstrut.com.
      g. Unistrut, Wayne, MI www.unistrut.com.

B. Performance:
   1. Design Criteria:
      a. Support rods for single pipe shall be in accordance with following table:

Rod Diameter	Pipe Size
3/8 inch	2 inches and smaller
1/2 inch	2-1/2 to 3-1/2 inches
5/8 inch	4 to 5 inches
3/4 inch	6 inches
7/8 inch	8 to 12 inches

      b. Support rods for multiple pipes supported on steel angle trapeze hangers shall be in accordance with following table:

Rods		Number of Pipes per Hanger for Each Pipe Size						
No.	Diameter	2 Inch	2.5 Inch	3 Inch	4 Inch	5 Inch	6 Inch	8 Inch
2	3/8 Inch	Two	0	0	0	0	0	0
2	1/2 Inch	Three	Three	Two	0	0	0	0
2	5/8 Inch	Six	Four	Three	Two	0	0	0

2	5/8 Inch	Nine	Seven	Five	Three	Two	Two	0
2	5/8 Inch	Twelve	Nine	Seven	Five	Three	Two	Two

1) Size trapeze angles so bending stress is less than 10,000 psi (69 Mpa).

C. Materials:
1. Hangers, Rods, Channels, Attachments, And Inserts:
a. Galvanized and UL approved for service intended.
b. Support horizontal piping from clevis hangers or on roller assemblies with channel supports, except where trapeze type hangers are explicitly shown on Drawings. Hangers shall have double nuts.
c. Class Two Quality Standards:
1) Support insulated pipes with clevis hanger equal to Anvil Fig 260 or roller assembly equal to Anvil Fig 171 with an insulation protection shield equal to Anvil Fig 167. Gauge and length of shield shall be in accordance with Anvil design data.
2) Except uninsulated copper pipes, support uninsulated pipes from clevis hanger equal to Anvil Fig 260. Support uninsulated copper pipe from hanger equal to Anvil Fig CT-65 copper plated hangers and otherwise fully suitable for use with copper tubing.
d. Riser Clamps For Vertical Piping:
1) Class Two Quality Standard: Anvil Figure 261.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Piping:
1. Properly support piping and make adequate provisions for expansion, contraction, slope, and anchorage.
a. Except for underground pipe, suspend piping from roof trusses or clamp to vertical walls using support channels and clamps. Do not hang pipe from other pipe, equipment, or ductwork. Laying of piping on any building element is not allowed.
b. Supports For Horizontal Piping:
1) Support metal piping at 96 inches (2 400) mm on center maximum for pipe 1-1/4 inches (32 mm) or larger and 72 inches (1 800 mm) on center maximum for pipe 1-1/8 inch (28 mm) or less.
2) Support thermoplastic pipe at 48 inches (1 200 mm) on center maximum.
3) Provide support at each elbow. Install additional support as required.
c. Supports for Vertical Piping:
1) Place riser clamps at each floor or ceiling level.
2) Securely support clamps by structural members, which in turn are supported directly from building structure.
3) Provide clamps as necessary to brace pipe to wall.
d. Insulate hangers for copper pipe from piping by means of at least two layers of Scotch 33 plastic tape.
e. Expansion of Thermoplastic Pipe:
1) Provide for expansion in every 30 feet (9 meters) of straight run.
2) Provide 12 inch (300 mm) offset below roof line in each vent line penetrating roof.

END OF SECTION 23 0529

SECTION 23 0548 – SEISMIC AND VIBRATION CONTROL

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Furnish and install engineering, labor, material, and equipment necessary for a complete anchorage and seismic restraint system and vibration isolation system as described in Contract Documents.
   1. The system design and installation shall be based on Seismic Zone D or above of the International Building Code and other standards listed below.
   2. The work shall include all mechanical isolated and non- isolated equipment, ducts and piping systems which shall include:
      a. Expansion tanks
      b. Pumps.
      c. Variable frequency drives.
      d. All piping 2-1/2" and larger.

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:
   a. At all drops to equipment and at flexible connections.
   b. At all 45° or greater changes in direction of pipe.
   c. At horizontal runs of pipe, not to exceed 30 feet O.C. spacing.
   d. Piping shall be restrained by a cable restraining system using a minimum of two cables at all restraint points.
   e. Shop drawings shall be submitted with the locations of all restraints shown on a floor plan and noting the size and type of restraint to be used.
   f. Gas piping shall have additional restraints as scheduled.

D. Non Isolated Equipment:

1. The restraint systems for all non isolated equipment shall be designed according to Table 23J, sec. 2312 of the Uniform Building Code with an importance factor of 1.5, a site factor Z = 0.75 and a Cp = 0.3. Horizontal force factor for elements of structures. In addition, the vertical forces restraint requirement shall be computed as 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.

3.2 VIBRATION ISOLATION REQUIREMENTS

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

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

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

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

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

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

END OF SECTION 23 0548

SECTION 23 0553 - IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

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

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

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

PART 2 - PRODUCTS

2.1 PAINT

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

B. Use appropriate primer.

2.2 LABELS

A. Black Formica with white reveal on engraving.

2.3 CODED BANDS

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

B. Approved Manufacturers:
   1. Seton
   2. Craftmark

2.4 PIPE IDENTIFICATION

A. In addition to the colored bands, stencil with black paint in 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. Hot Water & 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
HWS	Hot Water Supply	Green
HWR	Hot Water Return	Green

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

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

END OF SECTION 23 0553

SECTION 23 0714 – PREREMOLDED ONE PIECE PVC FITTINGS INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

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

1.3 QUALITY ASSURANCE

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

PART 2 - PRODUCTS

2.1 MANUFACTURED UNITS

A. Approved Manufacturers:
   1. Zeston

PART 3 - EXECUTION

3.1 INSTALLATION

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

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

END OF SECTION 23 0714

SECTION 23 0715 - MECHANICAL INSULATION AND FIRE STOPPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Furnish and install mechanical insulation and fire stopping as described in Contract Documents including but not limited to the following:
   1. Hot Water Pipe insulation
   2. 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 0715

SECTION 23 0801 – FIRE STOPPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

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

1.3 QUALITY ASSURANCE

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

PART 2 - PRODUCTS

2.1 MANUFACTURED UNITS

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

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

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

PART 3 - EXECUTION

3.1 INSTALLATION

A. Follow manufacturer's installation instructions explicitly.

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

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

END OF SECTION 23 0801

SECTION 23 0900 – TEMPERATURE CONTROLS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SCOPE

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

PART 2 - PERFORMANCE

2.1 PERFORMANCE

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

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

C. Qualified Contractors: Johnson Controls, Inc., to match existing.

D. Clarification: Johnson Controls shall provide a Network Control Engine with BACnet communication trunk to control and interface with the new air cooled chiller and chilled water system. BYUI will provide a Local Area Network (LAN) drop to the new control panel located in the new mechanical room. Johnson Controls shall coordinate with BYUI's Information Systems group as required for the system to interface with the existing Metasys system. Control of the VFD's on the new chilled water pumps will modulate between minimum flow of 288 GPM to full flow based on Differential Pressure Transducer (DPT) signal measured between the chilled water supply and return. The minimum differential pressure setpoint for flow shall be provided by the Test & Balance Contractor. The mechanical contractor shall install the ports for the DPT in the CHW piping where shown on the prints or as directed by the Controls Contractor.

PART 3 - EXECUTION

3.1 SUBMITTAL

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

3.2 INSPECTION OF CONDITIONS

A. Examine related work and surface before starting work of this section. Report to Mechanical

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

3.3 WIRING

A. Electric wiring and wiring connections required for the installation of the temperature control system as herein specified shall be provided by the Temperature Control Contractor unless specifically shown on the drawings or called for in the specifications to be by the Electrical Contractor. All conduit and wiring shall comply with the requirements of local and national electrical codes. Plenum rated cable shall be allowed in return air openings. All connections to vibrating equipment such as fans, pumps, chillers, etc. shall be by flexible conduit. Plenum rated cable shall be permitted without EMT, in accessible ceiling spaces, being used as a supply or return air duct. All conduit and wire for thermostats shall be by the control contractor.

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

C. All power wiring (120 VAC) to each local ATC panel location shall be furnished and installed by Electrical Contractor in accordance with Division 26.

3.4 INSTRUCTION AND ADJUSTMENT

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

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

3.5 EQUIPMENT

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

B. Facility Management System:
   1. The Facility Management System shall be capable of integrating multiple building functions including equipment supervision and control, alarm management, energy management, and historical data collection, including 24 hour continuous Point History of all points, and archiving.
   2. The facility management system shall consist of the following:
      a. Standalone Network Control Units (NCUs)
      b. Standalone application specific controllers (ASCs) with HVAC System sequence pre-configured software applications programs. (This application software

program shall be demonstrated to the Mechanical Engineer prior to bid). HVAC pre-configured software shall be included in bid as specified herein.

c. Direct connection and communication capability to Standalone Intelligent Lighting, Fire and Security Controller on the same HVAC ASC communications trunk without use of a separate communication trunk to the Central Processing Unit.

d. The system shall be modular in nature, and shall permit expansion of both capacity and functionality through the addition of sensors, actuators, standalone NCU panels, and Standalone Application Specification Controller (i.e., HVAC, Lighting, Fire, Security).

3. System architectural design shall eliminate dependence upon any single device for alarm reporting and control execution. Each NCU panel shall operate independently by performing its own specified control, alarm management, operator I/O, and historical data collection. The failure of any single component or network connection shall not interrupt the execution of control strategies at other operational devices.

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

3.6 NETWORKING/COMMUNICATIONS (LOCAL AREA NETWORK)

A. Workstation/NCU Panel Support:

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

B. Dynamic Data Access:

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

3.7 STANDALONE NCU PANELS

A. General:

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

B. Capability:

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

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

D. Continuous 24 Hour Point Histories:
1. Each NCU panel without software programming by the operator shall store Point History Files for every analog and binary input and output points. The Point History routine shall continuously and automatically sample the value of all analog inputs at half hour intervals. Samples for all points shall be stored for the past 24 hours to allow the user to immediately analyze equipment performance and all problem-related events for the past day. Point History Files for binary input or output points and analog output points shall include a continuous record of the last ten status changes of commands for each point.

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

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

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

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

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

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

K. Powerfail Restart:

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

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

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

3.8 NCU SOFTWARE FEATURES

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

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

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

D. Alarm Management:

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

E. Historical Data and Trend Analysis:
1. A variety of Historical data collection utilities shall be provided to automatically sample, store, and display system data in all of the following ways.
   a. Continuous Point Histories: Standalone NCU panels shall store Point History Files for all analog and binary inputs and outputs. The Point History routine shall continuously and automatically sample the value of all analog inputs at half hour intervals. Samples for all points shall be stored for the past 24 hours to allow the user to immediately analyze equipment performance and all problem-related events for the past day. Point History Files for binary input or output points and analog output points shall include a continuous record of the last ten status changes or commands for each point.
   b. Control Loop Performance Trends: Standalone NCU panels shall also provide high resolution sampling capability with an operator-adjustable resolution of 10-300 seconds in one-second increments for verification of control loop performance.
   c. Extended Sample Period Trends: Measured and calculated analog and binary data shall also be assignable to user-definable trends for the purpose of collecting operator-specified performance data over extended periods of time. Sample intervals of 1 minute to 2 hours, in one-minute intervals, shall be provided. Each standalone NCU panel shall have a dedicated buffer for trend data, and shall be capable of storing a minimum of 5000 data samples.
   d. Data Storage and Archiving: Trend data shall be stored at the Standalone NCU panels, and uploaded to hard disk storage when archival is desired. Upload shall occur based upon either user-defined interval, manual command, or when the trend buffers become full. All trend data shall be available in disk file form for use in 3rd Party personal computer applications.

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

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

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

3.9 APPLICATION SPECIFIC CONTROLLERS - HVAC APPLICATIONS

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

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

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

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

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

3.10 INPUT/OUTPUT HARDWARE

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

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

3.11 CENTRAL OPERATOR WORKSTATION (OWS)

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

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

3.12 CENTRAL OPERATOR WORKSTATION SOFTWARE (OWSS) (EXISTING)

A. Basic Interface Description:

1. Command Entry/Menu Selection Process:
   a. Operator Workstation interface software shall minimize operator training through the use of English language prompting, English language point identification, and industry standard PC application software. For ease of operator's use, the entire facility being monitored and controlled shall be laid out in a network map similar to a "family tree". The operator interface shall minimize the use of a typewriter style keyboard through the use of a mouse or similar pointing device, and "point and click" approach to menu selection. Users shall be able to start and stop equipment or change setpoints from graphical displays through the use of a mouse or similar pointing device.
2. Graphical and Text-Based Displays:
   a. At the option of the user, Operator work stations shall provide consistent graphical or text-based displays of all system point and application data described in this specification. Point identification, engineering units, status indication, and application naming conventions shall be the same at all work stations.
3. Multiple, Concurrent Displays:
   a. The Operator Interface shall provide the ability to simultaneously view several different types of system displays in overlapping windows to speed building analysis. For example, the interface shall provide the ability to simultaneously display a graphic depicting an air handling unit, while displaying the trend graph of several associated space temperatures to allow the user to analyze system performance. If the interface is unable to display several different types of displays at the same time, the FMS contractor shall provide at least two operator stations.
4. Password Protection: Multiple-level password access protection shall be provided to allow the user/manager to limit workstation control, display and data base manipulation capabilities as he deems appropriate for each user, based upon an assigned password.
   a. Passwords shall be exactly the same for all operator devices, including portable or panel-mounted network terminals. Any additions or changes made to password definition shall automatically cause passwords at all NCU panels on a network to be updated and downloaded to minimize the task of maintaining system security. Users shall not be required to update passwords for NCU panels individually.
   b. A minimum of five levels of access shall be supported:
      1) Level 1 = Data Access and Display
      2) Level 2 = Level 1 + Operator Overrides
      3) Level 3 = Level 2 + Database Modification
      4) Level 4 = Level 3 + Database Generation
      5) Level 5 = Level 4 + Password Add/Modification
   c. A minimum of 50 passwords shall be supported at each NCU panel.
   d. Operators will be able to perform only those commands available for their respective passwords. Menu selections displayed at any operator device, including portable or panel mounted devices, shall be limited to only those items defined for the access level of the password used to log-on.
   e. User-definable, automatic log-off timers of from 1 to 60 minutes shall be provided to prevent operators from inadvertently leaving devices on-line.
5. Operator Commands: The operator interface shall allow the operator to perform commands including, but not limited to, the following:
   a. Start-up or shutdown selected equipment
   b. Adjust setpoints
   c. Add/Modify/Delete time programming
   d. Enable/Disable process execution
   e. Lock/Unlock alarm reporting for each point
   f. Enable/Disable Totalization for each point
   g. Enable/Disable Trending for each point
   h. Override PID Loop setpoints
   i. Enter temporary override schedules
   j. Define Holiday Schedules
   k. Change time/date
   l. Enter/Modify analog alarm limits
   m. Enter/Modify analog warning limits

n. View limits
o. Enable/Disable Demand Limiting for each meter
p. Enable/Disable Duty Cycle for each load.

6. Logs and Summaries: Reports shall be generated automatically or manually, and directed to either CRT displays, printers, or disk files. Summaries shall be provided for specific points, for a logical point group, for a user-selected group of groups, or for the entire facility without restriction due to the hardware configuration of the facility management system. Under no conditions shall the operator need to specify the address of hardware controller to obtain system information. As a minimum, the system shall allow the user to easily obtain the following types of reports:
   a. A general listing of all points in the network
   b. List all points currently in alarm
   c. List of all off-line points
   d. List all points currently in override status
   e. List of all disabled points
   f. List all points currently locked out
   g. List of all items defined in a "Follow-Up" file
   h. List all Weekly Schedules
   i. List all Holiday Programming
   j. List of Limits and Dead bands

B. Dynamic Color Graphic Displays: Color graphic floor plan displays, and system schematics for each piece of mechanical equipment, including air handling units, chilled water systems, and hot water boiler systems, shall be provided.
   1. System Selection/Penetration: The operator interface shall allow users to access the various system schematics and floor plans via a graphical penetration scheme, menu selection, or text-based commands.
   2. Dynamic Data Displays: Dynamic temperature values, humidity values, flow values, and status indication shall be shown in their actual respective locations, and shall automatically update to represent current conditions without operator intervention.
   3. Windowing: The windowing environment of the PC Operator Workstation shall allow the user to simultaneously view several graphics at the same time to analyze total building operation, or to allow the display of a graphic associated with an alarm to be viewed without interrupting work in progress.
   4. Graphics Definition Package: Graphic generation software shall be provided to allow the user to add, modify, or delete system graphic displays.
      a. The FMS contractor shall provide libraries of pre-engineered screens and symbols depicting standard air handling unit components (e.g. fans, cooling coils, filters, dampers, etc.), complete mechanical systems (e.g. constant volume-terminal reheat, VAV, etc.) and electrical symbols.
      b. The graphic development package shall use a mouse or similar pointing device in conjunction with a drawing program.
   5. The works station software shall have a separate graph showing current and past 24 hour Point History with all attributes listed below the graph about the selected point being viewed. With a drag bar, the operator can pinpoint exact time and temperature a variance occurred during the 24 hour period.

C. System Configuration and Definition: All temperature and equipment control strategies and energy management routines shall be definable by the operator. System definition and modification procedures shall not interfere with normal system operation and control.
   1. The system shall be provided complete with all equipment and documentation necessary to allow an operator to independently perform the following functions:
      a. Add/Delete/Modify Standalone NCU Panels
      b. Add/Delete/Modify Operator Work stations
      c. Add/Delete Application Specific Controllers
      d. Add/Delete/Modify points of any type, and all associated point parameters, and tuning constants
      e. Add/Delete/Modify alarm reporting definition for each point
      f. Add/Delete/Modify energy management applications

g. Add/Delete/Modify time- and calendar-based programming
h. Add/Delete/Modify Totalization for every point
i. Add/Delete/Modify Historical Data Trending for every point
j. Add/Delete/Modify any and all graphic displays, symbols, and cross-references to point data
k. Add/Delete/Modify dial-up telecommunication definition
l. Add/Delete/Modify all operator passwords
m. Add/Delete/Modify Alarm Messages

D. While still monitoring the network, the operator shall be capable of running concurrent DOS based programs without interruption of the Facility Management system reporting at the operator's workstation. While operator is using concurrent software and an alarm is generated, the operator will have the option to look at alarm later, now, or discard. Separate alarm printers used for printing alarms while operator is using concurrent software will not be allowed.
1. Database Save/Restore/Back-Up: Back-up copies of all standalone NCU panel databases shall be stored in at least one personal computer operator workstation. Continuous supervision of the integrity of all NCU panel data bases shall be provided. In the event that any NCU panel on the network experiences a loss of its data base for any reason, the system shall automatically download a new copy of the respective data base to restore proper operation. Data base back-up/Download shall occur over the local area network without operator intervention. Users shall also have the ability to manually execute downloads of any or all portions of a NCU panels data base.
2. Graphics Programming Language (GPL):
a. With Operator's Workstation Software, ATC contractor shall provide GPL software, to enable owner to modify or add sequences through utilization of graphics as discussed herein.
b. Programming Description: Definition of operator device characteristics, DDC panels, individual points, applications and control sequences shall be performed through fill-in-the-blank templates and graphical programming approach.
c. Graphical programming shall allow the user to define the software configuration of DDC control logic for HVAC system control sequences, fan interlocks, pump interlocks, PID control loops, and other control relationships through the creation of graphical logic flow diagrams.
d. Graphical Programming: Control sequences are created by using a mouse input device to draw interconnecting lines between symbols depicting inputs, operators (comparisons and mathematical calculations), and outputs of a control sequence. As a minimum, graphic symbols shall be used to represent:
1) Process Inputs, such as temperature, humidity, or pressure values, status, time, date, or any other measured or calculated system data.
2) Mathematical Process Operators, such as addition, subtraction, multiplication, or greater than, equal to, less than, etc.
3) Logical Process Operators such as AND, OR, Exclusive OR, NOT, etc.
4) Time Delays
5) Process Control Outputs such start/stop control points, analog adjust points, etc.
6) Process Calculation Outputs
7) Text file Outputs and Advisories
e. Network-Wide Strategy Development: Inputs and outputs for any process shall not be restricted to a single DDC panel, but shall be able to include data from any and all other DDC panels to allow the development of network-wide control strategies. Processes shall also allow the operator to use the results of one process as the input to any number of other processes (cascading).
f. Sequence Testing and Simulation: A software tool shall be provided, which allows a user to simulate control sequence execution to test strategies before they are actually applied to mechanical systems. Users shall be able to enter hypothetical input data, and verify desired control response and calculation results via graphical displays and hard copy printouts.
3. System Definition/Control Sequence Documentation: All portions of system definition shall be self-documenting to provide hard copy printouts of all configuration and

application data. Control process and DDC control loop documentation shall be provided in logical, graphical flow diagram format to allow control sequences to be easily interpreted and modified at any time in the future.

3.13 WARRANTY

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

3.14 SEQUENCE OF OPERATION

A. This DDC system is a replacement/add-on to the existing Medisys N_2 Buss System.

END OF SECTION 23 0900

SECTION 23 09 50 – ANIMAL ROOM AIR FLOW CONTROL SYSTEM

PART 1 - GENERAL

1.1 SECTION INSCLUDES

A. Animal Room Airflow Control System

1.2 REFERENCE STANDARDS

A. All referenced standards in this section pertain to the most recent publication thereof, including all addenda and errata.

- AHRI 410 - Standard for Forced-Circulation Air-Cooling and Air-Heating Coils.
- ASHRAE Standard 130 - Methods of Testing for Rating Ducted Air Terminal Units.
- ISO 9001 - Quality Management Systems – Requirements.
- ISO/IEC 17025 - General Requirements for the Competence of Testing and Calibration Laboratories
- NEC - National Electric Code.
- NIST – National Institute of Standards and Technology.

1.3 ADMINISTRATIVE REQUIREMENTS

A. Pre-installation Meeting: The contractor shall conduct a pre-installation meeting prior to the start of the work of this section, and require attendance by all affected installers.

1.4 SUBMITTALS.

A. Product Data shall be provided with data indicating configuration, general assembly, and materials used in fabrication, including catalog performance ratings that indicate airflow, static pressure, NC designation, electrical characteristics, and connection requirements.

- Shop Drawings shall indicate configuration, general assembly, and materials used in fabrication, and electrical characteristics and connection requirements.
- Certificates shall be issued to certify that the air coil capacities, pressure drops, and selection procedures meet or exceed specified requirements or coils are tested and rated in accordance with AHRI 410.
- Manufacturer's Installation Instructions shall indicate support and hanging details, installation instructions, recommendations, and service clearances required.
- Project Record Documents shall record actual locations of units and controls components and locations of access doors.
- Operation and Maintenance Data shall include manufacturer's descriptive literature, operating instructions, maintenance and repair data, and parts lists. Include directions for resetting constant-volume regulators.
- Manufacturer’s warranty shall be submitted and ensure forms have been completed in Owner's name and registered with manufacturer.

B. Maintenance Materials shall be furnished for the Owner's use in maintenance of the project.

1.5 Warranty

A. Provide 60 month manufacturer warranty from date of shipment for air terminal units, integral sound attenuators, integral heating coils, and integral controls.

PART 2 – PRODUCTS

2.1 MANUFACTURER

A. Basis of Design: Price Industries, Inc.

1. Isolation Room Air Control System

B. ACCEPTABLE MANUFACTURERES:

1. The plans and specifications for the Isolation Room Airflow Control System (IRACS) are based on systems and equipment manufactured by Price Industries Limited.
2. The isolation room airflow system provider shall be an entity that designs, develops, manufactures and sells products and services to control the environment and airflow of critical spaces using a Quality Management System registered to ISO 9001.
3. In strict accordance with this specification, alternative isolation room airflow control systems and equipment shall only be considered for approval provided that the equipment is equal in every respect to the operational characteristics, capacities and intent of control sequences specified herein. Approval to bid does not relieve the isolation room airflow control system supplier from complying with the minimum requirements or intent of this specification.
4. The manufacturer shall possess a certification of accreditation by the National Voluntary Laboratory Accreditation Program (NVLAP) for calibration laboratories, in accordance with ISO/IEC 17025.
5. Manufacturers submitting as alternate suppliers shall be in compliance with the Proposed Alternate Equipment described in Section 2.01 C.
6. Other acceptable manufacturers can be submitted provided they meet the specifications.
7. The engineer and owner shall be the sole judges of quality and equivalence of equipment, materials, methods and life cycle cost.
8. Only those systems specifically named in this specification or by addendum shall be considered for approval. Other systems submitted after the bid opening shall be returned without review.

C. PROPOSED ALTERNATE EQUIPMENT
   1. Equipment:
      a. The isolation room airflow control system supplier shall provide a detailed proposal describing all elements of the isolation room control system. A schematic layout shall be provided, showing relations of these elements and a description of how they interact.
      b. Technical specification data sheets shall be provided for all proposed system components and devices.
      c. All proposed airflow control devices shall include discharge, exhaust and radiated sound power level performance obtained from testing in accordance with ASHRAE 130.
   2. Performance Verification:
      a. The isolation room airflow control system supplier shall demonstrate a typical isolation space that includes a general exhaust and a supply airflow control device for the purpose of verifying the isolation room airflow control system’s ability to meet the performance requirements indicated in this specification.
      b. All travel and lodging costs to witness the performance verification shall be the responsibility of the isolation room airflow control system supplier.

D. Compliance Schedule:
   1. Any alternate isolation room airflow control system supplier shall provide a separate compliance schedule, which shall include the section, paragraph and subparagraph of these specifications, and a direct statement to indicate compliance or noncompliance with the requirements. For all areas of noncompliance, the supplier shall describe what specific and alternative approach has been taken and document the impact this will have on the sizing of the air delivery systems, the required cooling and heating capacities, energy costs and maintenance of the building.
   2. The alternate isolation room airflow control system supplier shall furnish a letter of compliance to the engineer, signed by a corporate officer of the isolation room system manufacturer, certifying the compliance and noncompliance items as stated above 10 days prior to the bid.

2.2 ISOLATION ROOM AIR CONTROL SYSTEM

A. General:
   1. The Isolation Room Airflow Control System (IRACS) shall be pressure independent, and be furnished and installed to control the isolation room environment.

B. Performance Requirements:
    1. While occupied, the isolation room airflow control system shall hold constant the volume of supply air into the room to operate the room at the lowest possible airflow rates necessary to maintain temperature control, achieve minimum ventilation rates, and maintain isolation room pressurization in relation to adjacent spaces.
    2. The IRACS system shall be direct digital control (DDC) type.
    3. The IRACS shall be furnished and operated as a standalone system, and as a system integrated with the Building Management System (BMS) directly through BACnet without the use of field servers or gateway devices.
    4. The system shall not use or rely on information from controllers in other isolation rooms or from outside spaces to control functions within its isolation room.
    5. All airflow control valves provided by the ORACS manufacturer shall be factory calibrated in an NVLAP certified laboratory.
    6. The calibration laboratory shall measure volumetric flow rate with the following calibration accuracy, in accordance with the scope of accreditation to ISO/IEC 17025:
    a. 30 standard cubic feet per minute to 100 standard cubic feet per minute shall have 4.0 percent expanded uncertainty.
    b. 100 standard cubic feet per minute to 250 standard cubic feet per minute shall have 2.5 percent expanded uncertainty.
    c. 250 standard cubic feet per minute to 4200 standard cubic feet per minute shall have 1.4 percent expanded uncertainty.

C. Airflow Control Device – General:
    1. See specification section 23 3115 and 23 3116

D. Room ventilation, pressurization, supply and general exhaust control: Pressure Control
    1. The IRACS shall control the supply and exhaust/return airflow in order to maintain a user defined pressure differential with adjacent spaces.
    2. The IRACS shall use an electronic device utilizing a thermal MEMS style sensor, designed to measure the differential room pressure between adjacent spaces and display the information on a digital interface mounted outside the isolation room.
    3. The isolation room control system operate the space at the lowest possible airflow rates necessary to maintain temperature control, achieve minimum ventilation rates, and maintain isolation room pressurization in relation to adjacent spaces.
    4. The IRACS shall continuously measure the isolation room differential pressure in relation to an adjacent space. The general exhaust valve shall modulate to maintain the room pressure setpoint.

E. Room temperature control:
    1. The IRACS shall maintain the room temperature at set point by varying the supply airflow (if applicable) and supply air temperature. Supply air temperature shall be varied by modulating a reheat valve.
    2. While in heating mode, the make-up/supply air volume shall target the minimum airflow allowed by the room air change rate. The reheat valve shall modulate to maintain the heating air temperature target.
    3. While in cooling mode, the make-up/supply air volume shall increase toward the maximum cooling airflow target (if larger than the minimum air change rate) to bring the room air temperature down to the room temperature setpoint. The reheat valve shall close.
    4. While in deadband mode, the make-up/supply air volume shall target the minimum airflow allowed by the room air change rate. The reheat valve shall modulate to maintain the deadband air temperature target.

F. Occupancy Control:
   1. The isolation room control system shall have the ability to change the minimum ventilation and temperature control set points, based on the occupied state, in order to reduce energy consumption when the space is not occupied.
   2. The occupancy state may be set by either the BMS as a scheduled event or through the use of a local occupancy sensor.
   3. The local occupancy sensor shall be given priority over a BMS command allowing the user to override the occupancy mode and set the space to “Occupied” for a predetermined interval.
   4. While in unoccupied mode and the room temperature is between the unoccupied heating and cooling room temperature setpoints, the make-up/supply air volume shall be reduced to the minimum unoccupied target. The reheat valve shall be closed.
   5. If the room temperature increases above the unoccupied cooling setpoint or decreases below the unoccupied heating setpoint, the make-up/supply air volume shall increase to the occupied heating/cooling targets and the reheat valve modulated as required. Once the room temperature is brought back to within the unoccupied heating/cooling setpoints, the supply air volume is once again reduced to the minimum unoccupied target and the reheat valve closed.

G. Integration into building management system:
   1. The IRACS shall be native BACnet for integration into the building management system.
   2. No protocol conversion gateway devices are acceptable for interfacing with a BACnet building-level network.
   3. The IRACS shall employ a room-level network to ensure that loss of BMS communication does not affect the room airflow control or result in a loss of room pressure.
   4. A native BACnet MS/TP connection is to be provided for each space.

H. Humidity monitoring:
   1. The IRACS thermostat shall be provided with an embedded humidity sensor. The humidity reading shall be made available to the BMS system for monitoring and/or air handler humidity control.

I. Room Pressure Monitoring
   1. The IRACS shall be provided with a room pressure sensor.
   2. The room pressure shall be monitored at all times with reference to the adjacent space.
   3. The room pressure reading shall be available to the BMS system.
   4. See specification section 23 0960 – Room Pressure Monitor

J. Multi-Variable Monitor
   1. See specification section 23 0965 Multi-Variable Monitor
   2.

PART 3 – EXECUTION

3.1 EXAMINATION

C. Verify that conditions are suitable for installation.

- Verify that field measurements are as shown on the drawings.

3.2 INSTALLATION

A. All temperature control wiring required for a complete and operating system, as herein specified, shall be furnished and installed by the temperature control contractor unless specifically shown on the electrical drawings.

B. The term “wiring” shall be construed to include the use of conduit, wire, miscellaneous materials and labor, as required for installation and connection of the electrical control devices furnished as part of the control system or furnished by equipment suppliers.
C. This wiring shall include all electrical connections required as specified in the sequence of operation. All devices and wiring required for interlocking HVAC equipment as specified in the sequence of operation shall be furnished by the temperature control contractor.
D. All line and low voltage wiring materials and installation covered by this Section shall be in accordance with the latest revision of the National Electric Code and applicable local codes and shall carry the UL label where applicable.
E. The ATC contractor shall install all routers and repeaters in an accessible location in or around the designated isolation room.
F. The ATC contractor shall install appropriately sized and fused 24 VAC transformers suitable for NEC Class II wiring.
G. All cables shall be furnished and installed by the ATC contractor. The ATC contractor shall terminate and connect all cables as required. The ATC contractor shall utilize cables specifically recommended by the isolation room airflow controls supplier.
H. The mechanical contractor shall install all airflow control devices in the ductwork.
I. The mechanical contractor shall provide and install all reheat coils and transitions that are not integral to the venturi valve.
J. The mechanical contractor shall provide and install insulation as required.
K. Each pressurization zone shall have either a dedicated, single-phase primary circuit or a secondary circuit disconnect.

3.3 SYSTEM START-UP AND TRAINING

A. System start-up shall be provided by a factory trained and authorized representative of the IRACS manufacturer. Start-up shall also provide electronic verification of airflow (supply, make-up, general exhaust or return), system programming and integration to BMS (when applicable).
B. The balancing contractor shall be responsible for final verification and reporting of all airflows. The factory trained and authorized representative of the IRACS manufacturer shall be on hand to assist the balancing contractor in adjusting any airflow or velocity readings as required.
C. The IRACS supplier shall furnish a minimum of four hours of owner training by factory trained and certified personnel. The training shall provide an overview of the job specific airflow control components, general procedures for verifying airflows of air valves and general troubleshooting procedures.
D. Operation and maintenance manuals, including as-built wiring diagrams and component lists, shall be provided for each trainee.

END OF SECTION 23 0950

SECTION 23 0960 – ROOM PRESSURE MONITOR

PART 1 - GENERAL

1.1 SECTION INCLUDES

B. Touchscreen Room Pressure Monitor

1.2 REFERENCE STANDARDS

A. All referenced standards in this section pertain to the most recent publication thereof, including all addenda and errata.
B. BTL – BACnet Testing Laboratories.
C. ISO 9001 - Quality Management Systems – Requirements.
D. ISO/IEC 17025 - General Requirements for the Competence of Testing and Calibration Laboratories
E. NEC - National Electric Code.
F. NIST – National Institute of Standards and Technology.
G. UL 916 - Standard for Energy Management Equipment.

1.3 ADMINISTRATIVE REQUIREMENTS

B. Pre-installation Meeting: The contractor shall conduct a pre-installation meeting prior to the start of the work of this section, and require attendance by all affected installers.

1.4 SUBMITTALS

A. Product Data shall be provided with data indicating configuration, materials used in fabrication, overall dimensions, electrical characteristics and connection requirements.
B. Documentation shall be issued displaying the BTL mark to certify that the monitoring device has completed BTL approved conformance testing.
C. Manufacturer's Installation Instructions shall indicate support and hanging details, installation instructions, recommendations, and service clearances required.
D. Project Record Documents shall record actual locations of units and controls components and locations of access doors.
E. Operation and Maintenance Data shall include manufacturer's descriptive literature, operating instructions, maintenance and repair data, and parts lists.
F. Manufacturer’s warranty shall be submitted and ensure forms have been completed in the Owner's name and registered with manufacturer.
G. Maintenance Materials shall be furnished for the Owner's use in maintenance of the project.

1.5 WARRANTY

B. Provide 60 month manufacturer warranty from date of shipment.

PART 2 – PRODUCTS

2.1 MANUFACTURER

E. Basis of Design: Price Industries, Inc.
   2. Touchscreen Room Pressure Monitor: PMT

F. Acceptable Manufacturers:
   9. The plans and specifications for the pressure monitors are based on systems and equipment manufactured by Price Industries Limited.
   10. The pressure monitor provider shall be an entity that designs, develops, manufactures and sells products and services to control and monitor the environment, airflow, and pressure of critical spaces using a Quality Management System registered to ISO 9001.
   11. In strict accordance with this specification, alternative pressure monitors and equipment shall only be considered for approval provided that the equipment is equal in every respect to the operational characteristics, capacities and intent of control sequences specified herein. Approval to bid does not relieve the pressure monitor supplier from complying with the minimum requirements or intent of this specification.
   12. Manufacturers submitting as alternate suppliers shall be in compliance with the Proposed Alternate Equipment described in Section 2.01 C.
   13. Other acceptable manufacturers can be submitted provided they meet the specifications.
   14. The engineer and owner shall be the sole judges of quality and equivalence of equipment, materials, methods and life cycle cost.
   15. Only those systems specifically named in this specification or by addendum shall be considered for approval. Other systems submitted after the bid opening shall be returned without review.

G. Proposed Alternate Equipment:
   3. Equipment:
      d. The pressure monitor supplier shall provide a detailed proposal describing all elements of the pressure monitors. A schematic layout shall be provided, showing relations of the elements therein, and a description of how they interact.
      e. Technical specification data sheets shall be provided for all proposed system components and devices.

H. Compliance Schedule:
   3. Any alternate pressure monitor supplier shall provide a separate compliance schedule, which shall include the section, paragraph and subparagraph of these specifications, and a direct statement to indicate compliance or noncompliance with the requirements. For all areas of noncompliance, the supplier shall describe what specific and alternative approach has been taken and document the impact this will have on the maintenance of the building.

I. Factory Supplied Documentation:
   1. The manufacturer shall provide documentation for each device to address typical wiring, sequence of operation, physical dimensions of components, and installation procedures and requirements.

J. Warranty:
   1. The warranty shall begin upon the date of shipment and continue for a period of five years. The warranty shall cover all products from manufacturer defect and include any replacement parts only during the coverage period.
   2. The manufacturer shall not include the cost of labor to replace or recalibrate, if necessary, any components found to be defective.

3. The warranty shall not cover any product failure which results from, either directly or indirectly, any damage which occurs to the device by improper installation or from failure to comply with the preventative maintenance required per the manufacturer's instructions, or by codes set by local or facility authorities.

2.2 TOUCHSCREEN ROOM PRESSURE MONITOR

A. Description:
   1. Furnish and install Price model PMT Touchscreen Room Pressure monitor in the quantities and configurations as indicated on the plans.
   2. The Touchscreen Room Pressure Monitor shall be an electronic device utilizing a flow-through style sensor, furnished and installed to measure differential room pressure between adjacent spaces and display the information on a digital interface mounted outside the critical space.

B. Construction:
   1. Digital Display Unit:
      a. The device shall be wall mounted in close proximity immediately outside the space being monitored.
      b. Each monitor shall have a 4.3 inch thin-film-transistor (TFT), dimmable, full-color touch-screen display with a 480 x 800 resolution.
      c. The display shall include additional light emitting diode (LED) status indication light bars on the sides of the device to ensure room status conditions are visible across a 180 degree viewing angle. Room status indication lights that are only visible from the face or across viewing angles of less than 180 degrees shall not be acceptable.
      d. The device must utilize a password-protected menu format to permit access for programming or set-point changes. Different levels of secure access shall be available using different passwords.

   2. Room Pressure Sensor:
      a. The device shall be mounted above the door separating the spaces for which differential room pressure is being measured.
      b. The sensor shall include stainless steel cover plates on both sides of the wall for protection from drafts and/or cleaning solvents. The sensor cover plate shall be secured with security fasteners to prevent tampering.
      c. The sensor shall maintain an accuracy of plus or minus three percent of reading. Sensors with accuracy rated as a percentage of full scale shall not be acceptable.
      d. The sensor shall be capable of monitoring pressure from -0.1 to +0.1 inches water gauge.
      e. The device must utilize digital sensor technology. Flutter strips, ball-in-tube monitors or similar approaches that do not display actual quantitative differential room pressure information are not acceptable.
      f. Sensor drift shall be less than 0.0004 inches water gage (0.1 Pascal) per year. Sensors with yearly drift specified as a percentage of their full scale range shall not be acceptable.
      g. The sensor element shall be constructed in such a way that it is protected from the effects of dust or lint. Sensors with elements exposed to the airstream are not acceptable.

   3. Alarm:

a. The monitor shall include the ability for both audible and visual alarming during a user defined event, including low pressure, high pressure, emergency condition, and door status.
b. The alarm shall incorporate a user defined delay between time when the alarm set-point is met and when the alarm initiates.
c. The monitor shall include a mute button which, when depressed during an alarm event, shall disable the audio alarm for a user defined length of time.

4. Door Switches [Optional]:
   a. Magnetic door switches shall be utilized to prevent nuisance alarms during room cleaning, patient transfer, or other situations requiring door(s) to be kept open for extended periods of time.
   b. The door switches shall be wired directly to the room pressure monitor, and the alarm delay duration shall be field adjustable through the service menu on the monitor display interface.

C. Building Management System Interface:

1. The room pressure monitor shall interface with the building management system (BMS) to allow remote monitoring of room parameters or permit settings adjustments over the building network.
2. The BMS shall use either analog inputs, digital inputs, or utilize BACnet network protocol to view points or status of the room being measured. The use of BACnet protocol shall be native to the device and shall not require the use of an external gateway.
3. The monitor shall include the ability to change MAC address, device instance, and baud rate (9600, 19200, 38400, 76800) for proper interfacing to BACnet network.
4. The manufacturer shall be a member of BACnet international and the monitor shall be BTL listed.

PART 3 – EXECUTION

3.1 EXAMINATION

A. Verify that conditions are suitable for installation.
B. Verify that field measurements are as shown on the drawings.

3.2 INSTALLATION

L. The mechanical contractor, controls contractor, or factory authorized commissioning contractor shall install and wire the components of the room pressure monitor. This includes the display unit, the control board (if applicable), transformer, room pressure sensor(s), nylon tubing for sensor(s), all options and accessories including door switches, nurse station monitors, airflow control devices and network wires.
M. Cable/wire Requirements:
   1. All other cables/wires shall be provided by the installing contractor and shall meet the requirements set by the manufacturer.

3.3 START-UP AND COMMISIONING

E. Start-up shall include verifying proper installation, testing and calibrating pressure sensor(s), setting all parameters and alarm set points, configuring and testing remote station (if applicable) and verifying network communication (if applicable).
F. The Test and Balance (TAB) contractor shall be responsible for final verification of room pressure measurement.

3.4 CLOSEOUT ACTIVITIES

A. The manufacturer or the manufacturer's representative shall provide a minimum of two hours of owner training to facilities personnel or other parties as required
B. See Section 01 78 00 - Closeout Submittals for closeout submittals.
C. See Section 01 79 00 - Demonstration and Training for additional closeout requirements.

END OF SECTION 23 0960

SECTION 23 0965 – MULTI CARIABLE MONITOR

PART 1 – GENERAL

1.1 SECTION INCLUDES

A. Multi Variable Monitor

1.2 REFERENCE STANDARDS

A. All referenced standards in this section pertain to the most recent publication thereof, including all addenda and errata.
B. ISO 9001 - Quality Management Systems – Requirements.
C. ISO/IEC 17025 - General Requirements for the Competence of Testing and Calibration Laboratories
D. NEC - National Electric Code.
E. NIST – National Institute of Standards and Technology.
F. UL 916 - Standard for Energy Management Equipment.

1.3 ADMINISTRATIVE REQUIREMENTS

A. Pre-installation Meeting: The contractor shall conduct a pre-installation meeting prior to the start of the work of this section, and require attendance by all affected installers.

1.4 SUBMITTALS

A. Product Data shall be provided with data indicating configuration, materials used in fabrication, overall dimensions, electrical characteristics and connection requirements.
B. Manufacturer's Installation Instructions shall indicate support and hanging details, installation instructions, recommendations, and service clearances required.
C. Project Record Documents shall record actual locations of units and controls components and locations of access doors.
D. Operation and Maintenance Data shall include manufacturer's descriptive literature, operating instructions, maintenance and repair data, and parts lists.
E. Manufacturer’s warranty shall be submitted and ensure forms have been completed in the Owner's name and registered with manufacturer.
F. Maintenance Materials shall be furnished for the Owner's use in maintenance of the project.
    1. See Section 01 60 00 - Product Requirements, for additional provisions.

1.5 WARRANTY

A. Provide 60 month manufacturer warranty from date of shipment.

PART 2 – PRODUCTS

2.1 WARRANTY

A. Basis of Design: Price Industries, Inc.
    1. Multi Variable Monitor - MVM

B. Acceptable Manufacturers:

1. The plans and specifications for the monitor are based on systems and equipment provided by Price Industries Limited.
2. The monitor provider shall be an entity that designs, develops, manufactures and sells products and services to control and monitor the environment, airflow, and pressure of critical spaces using a Quality Management System registered to ISO 9001.
3. In strict accordance with this specification, alternative monitors and equipment shall only be considered for approval provided that the equipment is equal in every respect to the operational characteristics, capacities and intent of control sequences specified herein. Approval to bid does not relieve the monitor supplier from complying with the minimum requirements or intent of this specification.
4. Manufacturers submitting as alternate suppliers shall be in compliance with the Proposed Alternate Equipment described in Section 2.01 C.
5. Other acceptable manufacturers can be submitted provided they meet the specifications.
6. The engineer and owner shall be the sole judges of quality and equivalence of equipment, materials, methods and life cycle cost.
7. Only those systems specifically named in this specification or by addendum shall be considered for approval. Other systems submitted after the bid opening shall be returned without review.

C. Proposed Alternate Equipment:
   1. Equipment:
      a. The monitor supplier shall provide a detailed proposal describing all elements of the monitors. A schematic layout shall be provided, showing relations of the elements therein, and a description of how they interact.
      b. Technical specification data sheets shall be provided for all proposed system components and devices.

D. Compliance Schedule:
   1. Any alternate monitor supplier shall provide a separate compliance schedule, which shall include the section, paragraph and subparagraph of these specifications, and a direct statement to indicate compliance or noncompliance with the requirements. For all areas of noncompliance, the supplier shall describe what specific and alternative approach has been taken and document the impact this will have on the maintenance of the building.

E. Factory Supplied Documentation:
   1. The manufacturer shall provide documentation for each device to address typical wiring, sequence of operation, physical dimensions of components, and installation procedures and requirements.

F. Warranty:
   1. The warranty shall begin upon the date of shipment and continue for a period of five years. The warranty shall cover all products from manufacturer defect and include any replacement parts only during the coverage period.
   2. The manufacturer shall not include the cost of labor to replace or recalibrate, if necessary, any components found to be defective.
   3. The warranty shall not cover any product failure which results from, either directly or indirectly, any damage which occurs to the device by improper installation or from failure to comply with the preventative maintenance required per the manufacturer’s instructions, or by codes set by local or facility authorities.

2.2 TOUCHSCREEN ROOM PRESSURE MONITOR

A. Description:
1. Furnish and install Price model MVM Multi Variable Monitor in the quantities and configurations as indicated on the plans.
2. The Multi Variable Monitor shall be an electronic, touchscreen device capable of displaying a customized graphical user interface.

B. Construction:
1. Digital Display Unit:
a. Each monitor shall have a 15 inch thin-film-transistor (TFT), dimmable, full-color touch-screen display with a (800 x 480)/(1024 x 768) resolution.
b. The device shall have an IP54 rating for cleaning of the display surface.
c. The device shall be able to display information for up to 8 rooms on a single screen
d. The device shall support the ability to swipe between multiple display screens.
e. The device must utilize a password-protected menu format to permit access for programming or set-point changes. Different levels of secure access shall be available using different passwords.
f. The device shall support up to 512 BACnet server points.
g. The device shall support the following graphic file formats: GIF, JPEG, BMP, TIFF, PNG, MNG, ICO

2. Multi Variable Monitor:
a. The device shall support both BACnet MS/TP and BACnet IP network types.
b. The device shall be capable of displaying any available BACnet point. At minimum this includes alarm status, room temperature and humidity, room pressure, air change rate and occupancy.
c. The Multi Variable Monitor shall support fully customizable user interfaces. The user interface shall be able to display up to 8 rooms simultaneously.

3. Alarm:
a. The monitor shall include the ability for both audible and visual alarming during a user defined event.
b. The alarm shall incorporate a user defined delay between time when the alarm set-point is met and when the alarm initiates.
c. The monitor shall include a mute button which, when depressed during an alarm event, shall disable the audio alarm for a user defined length of time.

C. Building Management System Interface:
5. The BMS shall use BACnet network protocol to view points or status of the room being measured. The use of BACnet protocol shall be native to the device and shall not require the use of an external gateway.
6. The monitor shall include the ability to change MAC address, device instance, and baud rate (9600, 19200, 38400, 76800) for proper interfacing to BACnet network.

PART 3 – EXECUTION

3.1 EXAMINATION

A. Verify that conditions are suitable for installation.
B. Verify that field measurements are as shown on the drawings.

3.2 INSTALLATION

A. The mechanical contractor, controls contractor, or factory authorized commissioning contractor shall install and wire the components of the room pressure monitor. This includes the display unit, the control board (if applicable), transformer, room pressure sensor(s), nylon tubing for sensor(s), all options and accessories including door switches, nurse station monitors, airflow control devices and network wires.
B. Cable/wire Requirements:
   1. All other cables/wires shall be provided by the installing contractor and shall meet the requirements set by the manufacturer.

3.3 START-UP AND COMMISIONING

A. Start-up shall include verifying proper installation, testing and calibrating pressure sensor(s), setting all parameters and alarm set points, configuring and testing remote station (if applicable) and verifying network communication (if applicable).
B. The Test and Balance (TAB) contractor shall be responsible for final verification of room pressure measurement.

3.4 CLOSEOUT ACTIVITES

A. The manufacturer or the manufacturer’s representative shall provide a minimum of two hours of owner training to facilities personnel or other parties as required

END OF SECTION 23 0965

SECTION 23 0970 – SEQUENCE OF OPERATION

PART 1 – GENERAL

1.1 - Pressure Control:

A. Supply and General Exhaust, Negative Room: The Airflow Control System (ACS) will measure the differential pressure between the room and the reference space and will modulate the supply air device to meet the required room pressure target. With no thermal demand, the supply will be maintained at the minimum scheduled value. As airflow demand increases (see section: Temperature Control) the supply and general exhaust will be increased simultaneously to maintain the scheduled pressure.

1.2 - Temperature Control:

A. The controller will measure the space temperature from a *exhaust air duct* mounted room temperature sensor.
B. If the space temperature falls below the adjustable room temperature setpoint, the airflow will initially be maintained at the minimum scheduled heating airflow and the reheat coil output will be increased. Once the discharge temperature reaches the adjustable maximum value, the reheat output will be maintained. If the room temperature does not rise to the room temperature setpoint, the airflow will then be increased (if scheduled) towards the maximum scheduled heating airflow, allowing the reheat output to increase while maintaining the maximum discharge temperature.
C. If the space temperature rises above the adjustable room temperature setpoint, the reheat output will be decreased. Once the discharge temperature reaches the adjustable minimum value, the reheat output will be maintained. The airflow will initially be maintained at the minimum scheduled cooling airflow (or value dictated by other demands), If the room temperature does not decrease to the room temperature setpoint, the airflow will be increased towards the maximum scheduled cooling airflow.

1.3 - Modes of Operation:

A. Occupied Mode:
B. Occupied mode may be activated by a contact input or command by building management system.
C. A local occupancy sensor shall be given priority over a building management system command allowing the user to override the occupancy mode and set the space to “Occupied” for a predetermined interval.
D. While in occupied mode the controller will target the scheduled occupied airflows.
E. Unoccupied Mode:
F. Unoccupied mode may be activated by a contact input or command by building management system.
G. While in unoccupied mode the controller will target the scheduled unoccupied airflow.
H. Emergency Purge Mode:
I. The emergency purge mode may be activated by a contact input or command by building management system.
J. While in the emergency purge mode, the room air change rate will be increased to the scheduled ‘purge’ value. Room volumetric offset will be maintained.

1.4 - Pressure Monitoring:

A. A room pressure sensor will measure the differential pressure between the room and adjoining space. The differential pressure is displayed on the wall mounted interface.
B. Low and high room pressure alarms and cautions can be enabled for local visual and audible alert.

C. Room differential pressure and alarms are available to the building management system**.**

1.5 - Humidity Monitoring:

A. A humidity sensor will measure the room relative humidity.
B. A humidity level can be displayed locally and integrated to the building management system.

1.6 - Display:

A. The display unit allows monitoring and control of system variables to be displayed on the user interface.
B. The display unit will provide local audible and visual alerts for systems variables.
C. The display unit will communicate directly with room level controllers and to display necessary system variables. It can be integrated with the building management system.

1.7 - Local/Room Level Communication:

A. All valves and controllers as part of the Airflow Control System (ACS) within the room will communicate via an independent high-speed room level network. The ACS will route all room level data to a single connection for interface to the building level network. All room level control is self-contained with no communication or data required from sources outside of the room ACS.

1.8 - Building Network Communication

A. The Airflow Control System (ACS) will communicate over a native BACnet MS/TP trunk to the building automation network. All points are available to the BMS with no network gateway required.

END OF SECTION 23 0970

SECTION 23 1123 – NATURAL GAS SYSTEMS

PART 1 - SGENERAL

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 gas piping and fittings within building including connection to meter.

1.3 QUALITY ASSURANCE

A. Qualifications:
1. Welders shall be certified and bear evidence of certification 30 days prior to commencing work on project. If there is doubt as to proficiency of welder, Owner's Representative may require welder to take another test. This shall be done at no cost to Owner. Certification shall be by Pittsburgh Testing Laboratories or other approved authority.

PART 2 - PRODUCTS

2.1 PIPE

A. Meet requirements of ASTM A 53-89a, "Specification for Pipe, Steel, Black & Hot-Dipped Zinc-Coated Welded & Seamless".

B. Carbon steel, butt welded, Schedule 40 black steel pipe.

2.2 FITTINGS

A. Black Pipe:
1. Welded forged steel fittings meeting requirements of ASTM A 234-89a, "Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and Elevated Temperatures", or standard weight malleable iron screwed.

2.3 VALVES

A. 125 psi bronze body ball valve, UL listed

B. Approved Manufacturers & Models:
1. ConBraCo - "Apollo" series 80-100
2. Jenkins - FIG-30-A
3. Jomar - Model T-204
4. McDonald - 3410
5. PGL Corp - "Red Cap" gas ball valve
6. Watts - Model B-6000-UL

2.4 PRESSURE REDUCING REGULATORS

A. Corrosion Resistant Brass Body.

B. 1/2" to 4" Threaded NPT

C. 2" and Above Flanged.

D. Max Inlet Pressure 10 psi.

E. Max Outlet Pressure 0.5 psi.

F. Temperature Capabilities - ~20 to 180° F.

G. Approved Manufactures and Models.
1. Emerson Process Management.
2. Maxitrol 3UP33
3. Or approved equal.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Pipe installed underground, through air plenums, in walls, and pipes 2-1/2 inches and larger shall have welded fittings and joints. Other pipe may have screwed or welded fittings.

B. Wrap and lay underground pipe in accordance with local gas utility company regulations and specifications.

C. Install gas cocks on lines serving boilers, furnaces, duct heaters, and water heaters adjacent to boiler, furnace, or heater on outside of boiler, furnace, or heater cabinet and easily accessible.

D. Do not use flexible pipe connections to boilers, furnaces, duct heaters, or hot water heaters.

E. Install dirt leg with pipe cap, 6 inches long minimum, on each vertical gas drop to heating equipment.

F. Use fittings for changes of direction in pipe and for branch runouts.

G. Paint exterior exposed gas piping with grey paint to match gas meter.

END OF SECTION 23 1123

SECTION 23 2113 - HYDRONIC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

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

1.3 SUBMITTALS

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

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

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

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

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

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

1.4 QUALITY ASSURANCE

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

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

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

1.5 COORDINATION

A. Coordinate layout and installation of hydronic piping and suspension system components with other construction, including light fixtures, HVAC equipment, fire-suppression-system components, and partition assemblies.

B. Coordinate pipe sleeve installations for foundation wall penetrations.

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

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

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

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

1.6 EXTRA MATERIALS

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

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

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

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

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

2.2 PIPING MATERIALS

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

2.3 COPPER TUBE AND FITTINGS

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

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

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

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

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

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

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

2.4 STEEL PIPE AND FITTINGS

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

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

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

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

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

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

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

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

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

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

1. Material Group: 1.1.
2. End Connections: Butt welding.
3. Facings: Raised face.

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

L. **Standard Mechanical Couplings, 2 inch through 12 inch**: Manufactured in two segments of cast ductile iron, conforming to ASTM A-536, Grade 65-45-12. Gaskets shall be pressure-responsive synthetic rubber, grade to suit the intended service, conforming to ASTM D-2000. (Gaskets used for potable water applications shall be UL classified in accordance with ANSI/NSF-61 for potable water service.) Mechanical Coupling bolts shall be zinc plated (ASTM B-633) heat treated carbon steel track head conforming to ASTM A-449 and ASTM A-183, minimum tensile strength 110,000 psi (758450 kPa).

1. **Rigid Type**: Coupling housings with offsetting, angle-pattern bolt pads shall be used to provide system rigidity and support and hanging in accordance with ANSI B31.1, B31.9, and NFPA 13.
   a. 2 inch through 12 inch: Installation ready rigid coupling for direct stab installation without field disassembly. Gasket shall be Grade EPDM compound designed for operating temperatures from -30 deg F to +250 deg F. Gasket temperature rating shall be met without the use of special lubricants.
2. **Flexible Type**: Use in locations where vibration attenuation and stress relief are required. Flexible couplings may be used in lieu of flexible connectors at equipment connections. Three couplings, for each connector, shall be placed in close proximity to the vibration source.
   a. 2” through 8”: Installation-ready flexible coupling for direct stab installation without field disassembly. Gasket shall be grade EPDM compound designed for operating temperatures from -30 deg F to +250 deg F. Gasket temperature rating shall be met without the use of special lubricants.
   b. 10” through 12”: Standard flexible couplings. Gasket shall be Grade “E” EPDM compound designed for operating temperatures from -30 deg F to +230 deg F.

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

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

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

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

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

2.5 VALVES

A. Grooved-End Butterfly Valves
1. 2" through 12" Sizes: 300 psi CWP suitable for bidirectional and dead-end service at full rated pressure. Body shall be grooved end black enamel coated ductile iron conforming to ASTM A536. Disc shall be electroless nickel plated ductile iron with blowout proof 416

stainless steel stem. Disc shall be offset from the stem centerline to allow full 360 degree circumferential seating. Seat shall be pressure responsive EPDM. Valve bearings shall be TFE lined fiberglass, and stem seals shall be of the same grade elastomer as the valve seat. Valve shall be complete with ISO flange for actuation mounting. Valve operators shall be lever handle or gear operator, available with memory stop feature, locking device, chainwheel, or supplied bare. (Valve with EPDM seat is UL classified in accordance with ANSI/NSF-61.)

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

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

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

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

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

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

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

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

2.6 HYDRONIC SPECIALTIES

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

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

C. Expansion Tanks: Welded carbon steel, rated for 125-psig working pressure and 375 deg F maximum operating temperature, with taps in bottom of tank for tank fitting and taps in end of tank for gage glass. Tanks shall be factory tested with taps fabricated and labeled according to the ASME Boiler and Pressure Vessel Code, Section VIII, Division 1. Include the following fittings and accessories:
   1. Air-Control Tank Fitting: Cast-iron body, copper-plated tube, brass vent tube plug, and stainless-steel ball check, 100-gal. unit only; sized for compression-tank diameter. Design tank fittings for 125-psig working pressure and 250 deg F maximum operating temperature.
   2. Tank Drain Fitting: Brass body, nonferrous internal parts; 125-psig working pressure and 240 deg F maximum operating temperature; designed to admit air to compression tank, drain water, and close off system.
   3. Gage Glass: Full height with dual manual shutoff valves, 3/4-inch- diameter gage glass, and slotted-metal glass guard.

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

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

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

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

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

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

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

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

strainer sizes. Strainer basket shall be accessed by removal of mechanical coupling.

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

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

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

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

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

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

PART 3 - EXECUTION

3.1 VALVE APPLICATIONS

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

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

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

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

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

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

3.2 PIPING INSTALLATIONS

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

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

C. Install drains, consisting of a tee fitting, NPS 3/4 ball valve, and short NPS 3/4 threaded nipple with cap, at low points in piping system mains and elsewhere as required for system drainage.

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

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

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

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

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

3.3 HANGERS AND SUPPORTS

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

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

3.4 PIPE JOINT CONSTRUCTION

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

3.5 HYDRONIC SPECIALTIES INSTALLATION

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

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

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

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

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

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

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

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

3.6 TERMINAL EQUIPMENT CONNECTIONS

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

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

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

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

3.7 CHEMICAL TREATMENT

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

B. Fill system and perform initial chemical treatment.

3.8 FIELD QUALITY CONTROL

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

3.9 GROOVED PIPING TRAINING

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

PART 4 - Testing

A. Perform the following tests on hydronic piping:

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

4.2 ADJUSTING

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

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

4.3 CLEANING

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

END OF SECTION 23 2113

SECTION 23 2115 – HOT WATER HEATING SYSTEM

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

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

PART 2 - NOT USED

PART 3 - EXECUTION

3.1 INSTALLATION

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

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

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

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

3.2 PIPING GRADE

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

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

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

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

3.3 CLEANING SYSTEM

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

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

3.4 FIELD QUALITY CONTROL

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

END OF SECTION 23 2115

SECTION 23 2116 – HOT WATER HEATING SYSTEM SPECIALTIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

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

PART 2 - PRODUCTS

2.1 MANUAL AIR VALVES

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

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

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

2.2 AUTOMATIC AIR ELIMINATORS

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

2.3 BALANCING FITTINGS

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

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

2.4 COMPRESSION TANKS

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

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

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

D. Approved Manufacturers
   1. B&G

2.5 AIR SEPARATORS

A. Furnish and install as shown on plans, air separator with tangential nozzles. The air separator shall be fitted with an NPT vent connection to facilitate installation of piping to connect a compression tank.

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

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

D. Air separators shall be fabricated steel with flanged connections, designed and constricted for 165 psig @ 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 2116

SECTION 23 2118 – BACKFLOW PREVENTER VALVE

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

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

PART 2 - PRODUCTS

2.1 MANUFACTURED UNITS

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

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

PART 3 - EXECUTION

3.1 INSTALLATION

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

END OF SECTION 23 2118

SECTION 23 2123 – CIRCULATING PUMPS AND ACCESSORIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

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

PART 2 - PRODUCTS

2.1 GRUNDFOS MAGNA3 (D) MATERIAL OF CONSTRUCTION:

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

2.2 VERTICAL IN-LINE CENTRIFUGAL

A. Provide Vertical In-Line pumps, single stage, single suction type, with pump characteristics which provide rising heads to shut off. Refer to pump schedule for pump flows, heads, motor speed, enclosure, efficiency and power requirements.

B. Pumps shall be Armstrong Series 4300 split coupled type, with rigid spacer type coupling or approved equal.

C. Pump Construction.

1. Pump Casing - Cast Iron for working pressure below 175 psig at 150°F (125 psig ANSI flange rating) and Ductile Iron for working pressures to 375 psig at 150°F (250 psig ANSI flange rating). Suction and discharge connections shall be flanged and the same size and shall be drilled and tapped for seal flush and gauge connections.
2. Impeller - Bronze, fully enclosed type. Dynamically balanced.
3. Shaft - Provide Stainless Steel pump shaft.
4. Coupling - Rigid spacer type of high tensile aluminum alloy couplings shall be split to allow removal from pump and motor shafts, leaving space between the shafts sufficient to replace all mechanical seal components without disturbing the pump or motor.
5. Mechanical Seals - Shall be Stainless Steel outside multi-spring balanced type with Viton secondary seal. Provide bronze gland plate with Stainless Steel hardware. Provide factory installed flush line with manual vent.
6. All split coupled pumps shall be provided with a lower seal chamber throttle bushing.
7. Motor Horsepower - shown on the schedule are minimum and have been sized for continuous operation without exceeding full load nameplate rating over the entire pump curve, exclusive of service factor.

2.3 SUSPENDED WET PIT PUMPS

A. The pump casing shall have an integrally cast discharge flange. The suction strainer shall be fabricated 304 stainless steel with iron bottom plate.

B. The impeller shall be semi-open and capable of passing 1 3/8" solids. The impeller shall contain a balancing ring and be cast in iron and be secured to shaft by taper fit, with Woodruff key, castellated nut, washer and cotter pin.

C. All shafting shall be 316 stainless steel and shall be a minimum of 1 1/4" diameter between the coupling and the impeller. Column pipe shall be steel with welded flanges machined for registered fit.

D. The pump bearing, located directly above impeller, shall be of bronze. Bearing housing shall be of 316 stainless steel.

E. An intermediate bearing of the same materials as the pump bearing must be provided on pumps in excess of 6'-0" in length. On intermediate bearing for each additional 5'-0" pump length shall be furnished.

F. Pump and intermediate bearings shall be water lubricated through separate lubrication lines terminating at the cover plate.

G. The motor support shall be of cast iron, machined to assure positive alignment of motor and pump shaft, fitted with a high thrust angular contact bearing with moisture-proof enclosure and grease seals. External impeller and shaft axial adjustment shall be provided.

H. Water make-up operation shall be controlled by a float operated switch. Float rod shall be fiberglass. Float shall be 304 stainless steel. Float stops shall be 304 stainless steel.

I. The flexible coupling between the motor and pump shafts shall be Woods Sure-Flex spacer type coupling.

J. Pumps shall be driven by a standard “C” face vertical electric motor.

2.4 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

2.5 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

2.6 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

2.7 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

2.8 IN-LINE CIRCULATORS

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

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

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

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install equipment in accordance with manufacturers instructions.

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

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

END OF SECTION 23 2123

SECTION 23 2125 - CLEANING AND FLUSHING WATER CIRCULATING SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

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

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

1.3 QUALITY ASSURANCE

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

PART 2 - 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.

END OF SECTION 23 2125

SECTION 23 2600- CONDENSATE DRAIN PIPING

PART 1 - GENERAL

1.1 SUMMARY

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

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

1.2 REFERENCES

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

PART 2 - PRODUCTS

2.1 SYSTEMS

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

PART 3 - EXECUTION

3.1 INSTALLATION

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

END OF SECTION 23 2600

SECTION 23 3114 - LOW-PRESSURE STEEL DUCTWORK

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

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

PART 2 - PRODUCTS

2.1 DUCTS

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

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

2.2 DUCT JOINTS

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

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

2.3 ACCESS DOORS IN DUCTS

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

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

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

D. Approved Manufacturers:

1. AirBalance - Fire/Seal #FSA 100
2. Air Control Products - HAD-10
3. Cesco-Advanced Air - HAD-10
4. Elgen - Model 85 A
5. Kees Inc - ADH-D.
6. Louvers & Dampers - #SMD-G-F
7. Nailor-Hart Industries Inc - Series 0831
8. National Controlled Air Inc - Model AD-FL-1

2.4 FLEXIBLE EQUIPMENT CONNECTIONS

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

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

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

2.5 CONCEALED CEILING DAMPER REGULATORS

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

2.6 VOLUME DAMPERS

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

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

g. Safe Air
h. Young - 820-AC

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

2.7 MOTORIZED OUTSIDE AIR DAMPERS

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

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

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

2.8 BACKDRAFT DAMPER

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

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

C. Frame shall be galvanized steel or extruded aluminum alloy.

D. Approved Models & Manufacturers:
1. Air Control Products - FBD
2. American Warming - BD-15
3. CESCO - FBD 101
4. Ruskin - NMS2
5. Safe Air

2.9 DUCT HANGERS

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

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

2.10 DUCT SEALER

A. Cain - Duct Butter or Butter Tak

B. Design Polymerics - DP 1010

C. DSC - Stretch Coat

D. Duro Dyne - S2

E. Hardcast - #601 Iron-Grip or Peel-N-Seal Tape
1. Kingco - 15-325
2. Mon-Eco - 44-41
3. Trans-Continental Equipment Co - Multipurpose Duct Sealant
4. United - Sheet Metal duct-sealer

PART 3 - EXECUTION

3.1 INSTALLATION

A. Ducts:
1. Straight and smooth on inside with joints neatly finished unless otherwise directed.
2. Duct panels through 48 inch dimension having acoustic duct liner need not be crossbroken or beaded.
3. Crossbreak unlined ducts and duct panels larger than 48 inch or bead 12 inches on center.
4. Securely anchor ducts to building structure with specified duct hangers attached with screws. Do not hang more than one duct from a duct hanger.
5. Brace and install ducts so they shall be free of vibration under all conditions of operation.
6. Ducts shall not bear on top of structural members.
7. Make duct take-offs to branches, registers, grilles, and diffusers as detailed on Drawings.
8. Ducts shall be large enough to accommodate inside acoustic duct liner. Dimensions shown on Drawings are net clear inside dimensions after duct liner has been installed.
9. Properly flash where ducts protrude above roof.
10. Install internal ends of slip joints in direction of flow. Make joints air tight using specified duct sealer.
11. Cover horizontal and longitudinal joints on exterior ducts with two layers of Hardcast tape installed with Hardcast HC-20 adhesive according to Manufacturer's recommendations.
12. Paint ductwork visible through registers, grilles, and diffusers flat black.

B. Install flexible inlet and outlet duct connections to each furnace, fan, fan coil unit, and air handling unit.

C. Install concealed ceiling damper regulators.
1. Paint cover plates to match ceiling tile.
2. Damper regulators will not be required for dampers located directly above removable ceilings or in Mechanical Rooms.

D. Provide each take-off with an adjustable volume damper to balance that branch.
1. Anchor dampers securely to duct.
2. Install dampers in main ducts within insulation.
3. Dampers in branch ducts shall fit against sheet metal walls, bottom and top of duct, and be securely fastened. Cut duct liner to allow damper to fit against sheet metal.
4. Where concealed ceiling damper regulators are installed, provide a cover plate.

E. Install grilles, registers, and diffusers. Level floor registers and anchor securely into floor.

F. Air Turns:
1. Permanently installed, consisting of single thickness curved metal blades with one inch straight trailing edge to permit air to make abrupt turn without appreciable turbulence, in 90 degree elbows of above ground supply and return ductwork.
2. 4-1/2 inch wide minimum vane rail. Do not use junior vane rails.
3. Double thickness vanes not acceptable.
4. Quiet and free from vibration when system is in operation. See SMACNA Manual

G. Install motorized dampers

END OF SECTION 23 3114

SECTION 23 3115 – VARIABLE AIR VOLUME BOXES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Furnish and install variable air volume boxes as described in Contract Documents.

PART 2 - PRODUCTS

2.1 MANUFACTURED UNITS

A. Units shall consist of primary air damper, attenuator section, radiated noise shroud, primary air damper actuator and primary air controller.

B. Box Casing:
1. Fabricated of heavy gauge (min. 22 ga.f) zinc-coated sheet steel.
2. Lined with 1" glass fiber which conforms to NFPA-90A.
3. Each box shall be provided with a bottom removal access door of sufficient size to provide access to interior of box.
4. Primary air volume controller and actuator shall be furnished and installed by box manufacturer.

C. Controls shall be pneumatic or electronic as specified in control section of this specification and shall be enclosed by a zinc-coated sheet steel cover.
1. Primary air volume controller shall be pressure independent and shall control air volume within plus and minus 5% of design air volume regardless of change in system static pressure. Primary air controller shall reset air volume, as required by thermostat, with the same accuracy.
2. Reset primary air volume shall not be affected by changes in system static pressure.
3. Boxes using cfm limiters are not acceptable.
4. Each box shall be factory set for maximum and minimum cfm.

D. Cfm sensing tubes of the automatic averaging type shall be included in each box inlet. The same sensing tube shall also be used as balancing taps for field adjustment of the maximum (and minimum) primary cfm. The balancing taps shall be used in conjunction with a flow chart of each VF box to permit readjustment of maximum (and minimum) primary air volume if job conditions so dictate. Field readjustment shall be by means of adjustment screws. A schematic drawing shall be affixed to each VF box indicating proper hookups for controls.

E. Approved Manufacturers:
1. Enviro-tec

END OF SECTION 23 3115

SECTION 23 3116 – VENTURI FX AIRFLOW CONTROL VALVE

PART 1 – GENERAL

1.1 SECTION INCLUDES

A. Venturi FX Airflow Control Valve – Price Model VFX

1.2 REFERENCE STANDARDS

B. All referenced standards in this section pertain to the most recent publication thereof, including all addenda and errata.
C. AHRI 410 - Standard for Forced-Circulation Air-Cooling and Air-Heating Coils.
D. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials.
E. ISO 9001 - Quality Management Systems – Requirements.
F. ISO/IEC 17025 - General Requirements for the Competence of Testing and Calibration Laboratories
G. NEC - National Electric Code.
H. NIST – National Institute of Standards and Technology.
I. UL 916 - Standard for Energy Management Equipment.
J. UL 1995 - Standard for Heating and Cooling Equipment.

1.3 ADMINISTRATIVE REQUIREMENTS

A. Pre-installation Meeting: The contractor shall conduct a pre-installation meeting prior to the start of the work of this section, and require attendance by all affected installers.

1.4 SUBMITTALS

A. Product Data shall be provided with data indicating configuration, general assembly, and materials used in fabrication, including catalog performance ratings that indicate air flow, static pressure, NC designation, electrical characteristics, and connection requirements.
B. Shop Drawings shall indicate configuration, general assembly, and materials used in fabrication, and electrical characteristics and connection requirements.
C. Certificates shall be issued to certify that the air coil capacities, pressure drops, and selection procedures meet or exceed specified requirements or coils are tested and rated in accordance with AHRI 410.
D. Manufacturer's Installation Instructions shall indicate support and hanging details, installation instructions, recommendations, and service clearances required.
E. Project Record Documents shall record actual locations of units and controls components and locations of access doors.
F. Operation and Maintenance Data shall include manufacturer's descriptive literature, operating instructions, maintenance and repair data, and parts lists. Include directions for resetting constant-volume regulators.
G. Manufacturer’s warranty shall be submitted and ensure forms have been completed in Owner's name and registered with manufacturer.
H. Maintenance Materials shall be furnished for the Owner's use in maintenance of the project.

1.5 WARRANTY

A. Provide 60 month manufacturer warranty from date of shipment for air terminal units, integral sound attenuators, integral heating coils, and integral controls.

PART 2 – PRODUCTS

2.1 MANUFACTURER

A. Basis of Design: Price Industries, Inc.
   3. Venturi VFX Air Control Valve

B. Acceptable Manufacturers:
   1. The plans and specifications for the airflow control system are based on systems and equipment manufactured by Price Industries Limited.
   2. The venturi air control valve provider shall be an entity that designs, develops, manufactures and sells products and services to control the environment and airflow of critical spaces using a Quality Management System registered to ISO 9001.
   3. In strict accordance with this specification, alternative venturi valves and equipment shall only be considered for approval provided that the equipment is equal in every respect to the operational characteristics, capacities and intent of control sequences specified herein. Approval to bid does not relieve the laboratory airflow control system supplier from complying with the minimum requirements or intent of this specification.
   4. The manufacturer shall possess a certification of accreditation by the National Voluntary Laboratory Accreditation Program (NVLAP) for calibration laboratories, in accordance with ISO/IEC 17025.
   5. Manufacturers submitting as alternate suppliers shall be in compliance with the Proposed Alternate Equipment described in Section 2.01 C.
   6. Other acceptable manufacturers can be submitted provided they meet the specifications.
   7. The engineer and owner shall be the sole judges of quality and equivalence of equipment, materials, methods and life cycle cost.
   8. Only those systems specifically named in this specification or by addendum shall be considered for approval. Other systems submitted after the bid opening shall be returned without review.

C. Proposed Alternate Equipment
   1. Equipment:
      a. The venturi air control valve supplier shall provide a detailed proposal describing all elements of the venturi air control system. A schematic layout shall be provided, showing relations of these elements and a description of how they interact.
      b. Technical specification data sheets shall be provided for all proposed system components and devices.
      c. All proposed venturi air control devices shall include discharge, exhaust and radiated sound power level performance obtained from testing in accordance with ASHRAE 130.
   2. Performance Verification:
      c. The venturi air control valve supplier shall demonstrate a typical laboratory space that includes a general exhaust and a supply airflow control device for the purpose of verifying the venturi air control valve system’s ability to meet the performance requirements indicated in this specification.

D. Compliance Schedule:
   1. Any alternate venturi air control valve supplier shall provide a separate compliance schedule, which shall include the section, paragraph and subparagraph of these

specifications, and a direct statement to indicate compliance or noncompliance with the requirements. For all areas of noncompliance, the supplier shall describe what specific and alternative approach has been taken and document the impact this will have on the sizing of the air delivery systems, the required cooling and heating capacities, energy costs and maintenance of the building.

2. The alternate venturi air control valve supplier shall furnish a letter of compliance to the engineer, signed by a corporate officer of the venturi valve manufacturer, certifying the compliance and noncompliance items as stated above 10 days prior to the bid.

2.2 VENTURI FX AIR CONTROL VALVES

K. General:
   2. The airflow control device shall be a venturi shaped anemometer using differential pressure to measure airflow equal to the Price model VFX venturi valve.

L. Performance Requirements:
   1. The pressure independent assembly shall respond and maintain specific airflow within one second of a change in duct static pressure irrespective of the magnitude of pressure and/or flow change or quantity of airflow controllers on a manifold system.
   2. The airflow control device shall maintain a controlled accuracy within plus or minus five percent of signal over an airflow turndown range of no less than ten to one.
   3. One duct diameter entrance shall be required to ensure accuracy.

M. Construction:
   2. The airflow control device shall be constructed of using 14 gauge aluminum with continuously welded seams.
   3. The damper shall be constructed with 16 gauge galvanized steel and mounted on a zinc plated steel shaft with composite Teflon bearings.
   4. Valves using invasive airflow sensing technology, including cross-flow sensors and vortex shedding sensors, shall not be acceptable.

N. Actuation:
   1. For electrically actuated VAV operation for tracking pairs, two-position or constant volume, a low-speed electric actuator shall be used to modulate the airflow over the range of the specific valve size. The maximum time to modulate from minimum to maximum flow shall be less than 90 seconds. A UL or CSA listed electronic actuator shall be factory mounted to the valve. The actuator shall have sufficient torque to modulate the airflow against the maximum duct static pressure (within product specifications). Loss of main power shall cause the valve to position itself in an appropriate failsafe state.

   2. This position shall be maintained constantly without external influence, regardless of the external conditions on the valve, within product specifications, until power is restored.

PART 3 – EXECUTION

3.1 EXAMINATION

A. Verify that conditions are suitable for installation.
B. Verify that field measurements are as shown on the drawings.

3.2 INSTALLATION

A. All temperature control wiring required for a complete and operating system, as herein specified, shall be furnished and installed by the temperature control contractor unless specifically shown on the electrical drawings.
B. The term “wiring” shall be construed to include the use of conduit, wire, miscellaneous materials and labor, as required for installation and connection of the electrical control devices furnished as part of the control system or furnished by equipment suppliers.
C. This wiring shall include all electrical connections required as specified in the sequence of operation. All devices and wiring required for interlocking HVAC equipment as specified in the sequence of operation shall be furnished by the temperature control contractor.
D. All line and low voltage wiring materials and installation covered by this Section shall be in accordance with the latest revision of the National Electric Code and applicable local codes and shall carry the UL label where applicable.
E. The ATC contractor shall install appropriately sized and fused 24 VAC transformers suitable for NEC Class II wiring.
F. All cables shall be furnished and installed by the ATC contractor. The ATC contractor shall terminate and connect all cables as required. The ATC contractor shall utilize cables specifically recommended by the laboratory airflow controls supplier.
G. The mechanical contractor shall install all airflow control devices in the ductwork.
H. The mechanical contractor shall provide and install all reheat coils and transitions that are not integral to the venturi valve.
I. The mechanical contractor shall provide and install insulation as required.
J. Each pressurization zone shall have either a dedicated, single-phase primary circuit or a secondary circuit disconnect.

3.3 SYSTEM START-UP AND TRAINING

A. System start-up shall be provided by a factory trained and authorized representative of the venturi valve manufacturer. Start-up shall include calibrating the fume hood monitor and any combination sash position/sidewall sensing equipment, as required. Start-up shall also provide electronic verification of airflow (fume hood exhaust, supply, general exhaust or return), system programming and integration to BMS (when applicable).
B. The balancing contractor shall be responsible for final verification and reporting of all airflows. The factory trained and authorized representative of the venturi valve manufacturer shall be on hand to assist the balancing contractor in adjusting any airflow or velocity readings as required.
C. The venturi valve supplier shall furnish a minimum of four hours of owner training by factory trained and certified personnel. The training shall provide an overview of the job specific airflow control components, verification of initial fume hood monitor calibration, general procedures for verifying airflows of air valves and general troubleshooting procedures.
D. Operation and maintenance manuals, including as-built wiring diagrams and component lists, shall be provided for each trainee.

3.4 FIELD QUALITY CONTROL

A. See Section 01 40 00 - Quality Requirements, for additional quality requirements.

END OF SECTION 23 3116

SECTION 23 3346 - FLEX DUCT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

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

PART 2 - PRODUCTS

2.1 DUCTS

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

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

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

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

2.2 APPROVED MANUFACTURERS

A. ANCO-FLEX - 4625

B. Flex-Aire - PF/UPC #090

C. Hart & Cooley - F114

D. Thermaflex - G-KM

PART 3 - EXECUTION

3.1 INSTALLATION

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

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

END OF SECTION 23 3346

SECTION 23 3400 - EXHAUST FANS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

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

1.3 QUALITY ASSURANCES

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

PART 2 - PRODUCTS

2.1 ROOF MOUNTED EXHAUST FANS

A. Direct drive or have adjustable pitch V-belt as noted on Drawings.

B. Wheels shall be backward curved and housing shall be removable or hinged aluminum.

C. Isolate motor with vibration dampeners.

D. Provide quiet type back-draft dampers.

E. Insulated, pre-fabricated metal roof curb shall be for flat or sloped roof as shown on Drawings.

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

2.2 UTILITY BLOWERS

A. Forward curve belt drive.

B. Blowers shall be completely factory assembled and tested as a unit with electric motor, adjustable motor base, adjustable V-belt drive beyond bearings and drive cover.

C. Housing shall be heavy gauge steel completely arc-welded for airtight construction. Housings shall be convertible to any one of 8 positions in 45 1/2 increments.

D. Inlet shall be unobstructed with streamlined contour.

E. Blower shall bear the AMCA certified rating seal.

2.3 FUME EXHAUST FANS

A. Forward curve direct drive utility type fans.

B. Fans shall be acid resistant cast iron or heavy steel with Kem-FP acid resisting coating.

C. Blowers shall be completely factory assembled and tested as a unit, with electric motor.

D. Fans shall be AMCA rated and tested.

E. Motor base and outside housing shall be baked chemical resistant finish.

F. Verify fan rotation and discharge to suit actual conditions.

G. Housings shall be changeable in the field.

H. Provide manual damper in discharge duct.

I. Approved Manufacturers:
1. Kewanee
2. Champion
3. Chicago Blower
4. Twin City

PART 3 - EXECUTION

3.1 INSTALLATION

A. Anchor fan units securely to structure or curb.

END OF SECTION 23 3400

SECTION 23 3713 - AIR OUTLETS & INLETS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

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

PART 2 - PRODUCTS

2.1 GRILLES & REGISTERS

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

2.2 SPIN-IN FITTINGS

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

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

2.3 LOUVERS

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

B. Frames shall have mitered corners.

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

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

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:
   a. Model TRE extruded aluminum ventilator by Loren Cook Company, Springfield Missouri
2. Louvered Penthouse
   a. Penn “Penhouse”
   b. Model WRH by Greenheck Fan Corporation, Schofield, WI
   c. Model MPH by Jenn-Air Industries Inc., Indianapolis, IN

PART 3 - EXECUTION

3.1 INSTALLATION

A. Anchor securely into openings.

B. Install with screws to match color and finish of grilles and registers.

C. Touch-up any scratched finish surfaces.

D. Install in accordance with manufacturer's instructions.

E. Check location of outlets and inlets and make necessary adjustments in position to conform with architectural features, symmetry, and lighting arrangement.

F. Install diffusers to ductwork with air tight connection.

G. Provide balancing dampers on duct take-off to diffusers, and grilles and registers, despite whether dampers are specified as part of the diffuser, or grille and register assembly.

H. Paint ductwork visible behind air outlets and inlets matte black. Refer to Section 09 9000.

END OF SECTION 23 3713

SECTION 23 5413 - STEAM INJECTION HUMIDIFIERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
1) DRI-STEEM Corporation, steam injection type humidifiers
2) Or approved equal

1.2 SUBMITTALS

A. Comply with Submittal Procedures and Execution and Closeout Requirements in General Requirements.

Submit product data (manufacturer's specifications, and technical data including performance, construction and fabrication) for each manufactured component.

1.3 warranty

A. Product shall be warranted to be free from defects in materials and fabrication for a period of two years after installation or 27 months from ship date.

PART 2 - PRODUCTS

2.1 STEAM INJECTION HUMIDIFICATION SYSTEM

A. Steam injection device, which directly injects pressurized boiler steam into ducted or free air for humidification, available in the following configurations:
1) Single-tube, factory-assembled multiple tubes, or site-assembled multiple tubes:
a) Dispersion tube(s) shall be constructed of stainless steel with Heli-arc welded seams. Design of the dispersion tube(s) shall provide steam jacketing for the full length of an internal tube, which is fitted with high temperature resin tubelets.
b) Each internal tube shall have two rows of high temperature resin tubelets, arranged to discharge the steam in a V-pattern. Each tubelet shall extend through and into the approximate center of the dispersion tube and incorporate a properly sized calibrated orifice.
c) Dispersion tube(s) shall extend the width of the duct. A two-piece escutcheon plate for sealing the duct opening around the dispersion tube shall be provided. Note: Field-installed tubes shall discharge steam **against** airflow.
d) Tube assembly options:
i. Multiple-tube humidifier with Maxi-bank® option: A Multiple-tube steam injection humidifier which consists of a stainless steel water/steam separator and steam jacketed dispersion tubes. Dispersion tubes shall extend the width of the duct. The Maxi-bank option shall incorporate a stainless steel header, be preassembled unless either dimension is 98 inches (2490 mm) or more, and include interconnecting piping.

B. Separator:
1) The humidifier shall have a 304 stainless steel water/steam separator with Heli-arc welded seams. The separator shall be a centrifugal type design with internal drying tube for condensate removal.

C. Steam valve and actuator:
1) Valve shall be a normally closed modulating type with modified linear flow. Valve trim shall be stainless steel, and sized to meet humidification requirements. Actuator shall be a pneumatic type to modulate the steam valve in response to a variable pneumatic signal demand and be direct acting.

D. Steam trap(s):
1) Multiple-tube humidifiers shall have one or more float and thermostatic (F&T) trap(s) for applications equal to or below 15 psi steam, or one or more inverted bucket steam trap(s) for applications above 15 psi steam or when lifting condensate. See drawings for trap location(s).

2.2 HUMIDIFIER Options

A. Stainless steel steam components:
1) Multiple-tube (including Maxi-bank option) Steam Injection humidifier models shall be available

with stainless steel components for projects and applications requiring stainless steel. Unit shall consist of a stainless steel water/steam separator, stainless steel steam jacketed dispersion tube(s) fitted with two rows of high-temperature resin tubelets, a stainless steel inlet strainer, and a stainless steel steam trap. Dispersion tube(s) shall extend the width of the duct. Entire valve shall be stainless steel. A stainless steel escutcheon plate for sealing the duct opening around the dispersion tube(s) shall be provided.

B. Valve:

1) Modulating electronic control valve: Normally closed modulating type with an electronic actuator. Actuator shall respond to a variable electronic signal. Available signal inputs: 4 mA to 20 mA, 2 VDC to 10 VDC.

C. Temperature switch:

2) Temperature switch, electric: Electric temperature switch shall be field installed to work in conjunction with an electric or electronic operated steam valve to prevent cold start-up of humidifier. Field set at 220 °F (104 °C).

D. Horizontal separator:

1. The humidifier shall have a horizontally-oriented, centrifugal type water/steam separator with an internal discharge tube, which extends into the center of the separator for steam/condensation separation. Separator shall be constructed of stainless steel with Heli-arc welded seams.

2.3 humidifier CONTROL Options

Control input accessory options:

1) Humidistat, electronic, room (Note: to be supplied by ATC): Electronic humidistat shall be duct-mounted and produce a modulated DC signal output, field-selectable 0 VDC to 10 VDC or 6 VDC to 9 VDC with control action field-selectable to be direct or reverse acting. Set point range 20% to 80% RH, supply voltage 24 DC or 24 AC. Maximum ambient temperature 122 °F (50 °C).

2) Airflow proving switch, sail type: Airflow proving switch shall be a sail-operated electric switch for field installation. Switch makes at 250 fpm (1.3 m/s), and breaks at 75 fpm (0.4 m/s). Maximum operating temperature for sail: 170 °F (77 °C). Maximum operating temperature for switch: 125 °F (52 °C)

2.4 HUMIDIFIER Accessories

A. Drane-kooler™: A thermostatically controlled water valve shall meter an amount of cold water into a stainless steel mixing chamber to temper 212 °F (100 °C) water with a 6 gpm (0.38 L/s) in-flow rate to a 140 °F (60 °C) discharge temperature to sanitary system.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install per manufacturer's printed instructions and as indicated on drawings.

B. Coordinate electrical connections with work of Division 26.

END OF SECTION 23 5413

SECTION 23 6200 - AIR HANDLING UNIT

PART I – GENERAL

1.1 WORK INCLUDED

A. This specification is based on an Energy Recovery model as manufactured by Annexair Inc. Manufacturers of alternate equipment must be approved to bid via addendum, in writing by the specifying engineer, at least two weeks prior to bid time in order for their bid to be accepted by the contractor. If the equipment is not pre-approved then under no circumstances shall the contractor invest any time or money in receiving submittals or considering the equipment. Costs associated with dimensional, performance or other deviations from the specified equipment, including engineering costs to evaluate such deviations, shall be paid by the contractor

B. The unit(s) shall be installed in strict accordance with the specifications. Unit(s) shall be complete with all components and accessories as specified. All units shall be factory assembled, internally wired, and 100% run tested to check operation, fan/blower rotation and control sequence before leaving the factory. Wiring internal to the unit shall be numbered for simplified identification. Units shall be ETL listed and labeled, classified in accordance with ANSI-UL 1995 / CAN/CSA C22.2 No.236.

C. Equipment start-up and project inspection by qualified factory trained representative.

1.2 QUALITY ASSURANCE

A. All unit(s) shall be factory run tested before shipping. A proof copy of the test shall be placed in the unit electrical power & control panel.

B. Unit(s) shall bear the ETL label, tested in accordance to UL 1995. Electrical components shall be UL listed.

C. Fans shall be tested in an AMCA certified laboratory; insulation shall comply with NFPA 90A.

D. Coils shall be tested in accordance to AHRI 410.

E. Energy recovery exchangers shall be in accordance to AHRI 1060, “Rating Air-to-Air Energy Recovery Equipment” and Eurovent standards.

F. Filters shall be tested in accordance to ASHRAE 52.

G. The unit manufacturers construction shall have an independent testing agency test the air leakage, panel deflection and sound pressure levels for supply airflows of minimum 20,000 CFM. The air leakage of the unit(s) shall not exceed 1% at 8” inches H2O positive static pressure and a copy of the report must be submitted upon request. Unit shall be constructed to limit frame and panel deflection to 1/250th of the panel length at 8” inches H2O positive static pressure and a copy of the report must be submitted upon request. The unit shall also be tested in accordance with ANSI S12.34-1998 and instrumentation used must be in compliance with the requirements of AMCA 300 for sound readings. The sound tests conducted shall report overall sound power and pressure readings for supply air outlet, return air inlet and casing radiated.

H. Products shall be supported with a warranty that ensures the product will be free from defects in materials and workmanship for a period of one year after shipment.

1.3 SUBMITTALS

A. Submit product data under provisions of Section 15XXX. Include product description, model, dimensions, component sizes, rough-in requirements, service sizes, and finishes. Include

rated capacities, operating weights, furnished specialties, and accessories.

B. Submit manufacturer's installation instructions.

C. Submit operation and maintenance data.

D. Submit coordination drawings. Include unit details, plans, elevations, sections, details of components. Show support locations, type of support, weight and required clearances.

E. Submit wiring diagrams including power, signal, and control wiring.

1.4 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1.5 WARRANTY

A. Annexair warrants each product to be free from defects in material and workmanship under normal and proper use, and will within twelve (12) months from date of start up and not exceed eighteen (18) months from shipment, repair or replace any part which, when returned to our factory transportation charges prepaid, and upon inspection by Annexair, proves to be defective. This warranty does not include any labor or service charges that occur under this warranty. Minimum (5) five year compressor warranty shall be provided, parts only – labor not included
B. The installing contractor must be responsible for warranty service and maintenance after the equipment is placed into operation.
C. NOTIFICATION: Any modification to the Annexair equipment, including the controls and sequence of operation, without specific approval in writing by Annexair, will result in a violation of the equipment warranty

1.6 REFERENCES

All components selected for this project shall conform to the following Standards:
A. AFBMA 9: Load Ratings and Fatigue Life for Ball Bearings
B. AMCA Standard 99: Standards Handbook
C. AMCA /ANSI Standard 204: Balance Quality and Vibration Levels for Fans
D. AMCA Standard 210: Laboratory Methods of Testing Fans for Ratings
E. AMCA Standard 300: Reverberant Room Method for Sound Testing of Fans
F. AMCA 320; Laboratory Method for Sound Testing of Fans Using Sound Intensity
G. AMCA Standard 500:Test Methods for Louvers, Dampers and Shutters
H. AHRI Standard 1060: Air-to-Air Energy Recovery Ventilation Equipment
I. AHRI Standard 410: Forced-Circulation Air-Cooling and Air-Heating Coil
J. ASHRAE Standard 52: Gravimetric and Dust Spot Procedures for Testing Air Cleaning Devices Used in General Ventilation for Removing Particulate Matter
K. ASHRAE 52.2: Procedures for Testing Air Cleaning Devices Used for Removing Particulate Matter
L. ASHRAE 84-91: Method of Testing Air-to-Air Heat Exchangers
M. ASHRAE/ANSI Standard 111: Practices for Measurement, Testing, Adjusting and Balancing of Building Heating, Ventilation, Air-Conditioning and Refrigeration Systems
N. ASTM A-525: Specification for General Requirements for Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process
O. NEMA MG-1: National Electrical Manufacturers Association Motor Standards
P. NFPA 90A: Standard for the Installation of Air Conditioning and Ventilating Systems
Q. SMACNA: Sheet Metal and Air Conditioning Contractors National Association
R. UL Standard 1995: Heating and Cooling Equipment
S. UL Standard 900: Test Performance of Air Filter Units

1.7 COORDINATION

A. Coordinate location and installation of air-handling units. Revise locations and elevations to suit field conditions and to ensure proper operation.
B. Coordinate location and installation of air handling units with the electrical, mechanical, and plumbing contractors.

PART 2 – PRODUCTS

2.1 HOUSING

A. **THERMO-COMPOSITE PANELS**

1. The unit housing shall be no-through metal with 2'' Thermo-Composite and foam panel construction - interior and exterior or an all-aluminum 4" Foam thermal break construction - interior and exterior. Thermal break construction using a gasket to insulate two panels is not an acceptable equivalent to a no-through metal constructed casing. No-through metal construction will be inherent to all the component construction in the assembly.
2. All panels and access doors shall be double wall construction with R14 foam insulation for every 2" of construction. All foam insulation must be Greenguard certified®. Any insulation incorporating CFCs or HCFCs in its construction is strictly prohibited from this application.
3. Unit casing will have no exterior condensation at interior AHU temperatures down to 43F while unit exterior conditions are maintained at 95 F dry bulb / 85 F wet bulb. The air handling unit manufacturer general conrtuction shall be tested to demonstarate the thermal performance of the unit casing. The test shall include placing the entire test unit in a climate controlled environment and exposing the unit to the conditions mentioned previously. If the manufacturer does not have access to such equipment, an independent testing agent must be hired to transport the test unit to a qualified test facility, and perform the test at the expense of the manufacturer. Inability to provide this option to the engineer will make the manufacturer ineligible to bid on this project he unit housing shall be constructed from a frame, base and panel assembly. Unit shall be completely factory assembled and shipped in one piece as shown on drawings.
4. The panels shall be tested in accordance with SMACNA and ASHRAE 111 to have a deflection of no more than L/1150 at 10'' and withstand air pressures up to 8" w.c with less than 1% leakage. Fire resistance of the panel will be in compliance with UL 94 rated at 5VA; and a flame spread / smoke development in compliance with UL 723 ASTM E84 Class 1 rating.
5. Thermo-Composite or aluminum panels shall be provided for the entire unit construction, including but not limited to, walls, doors, floors, roof, interior partitions, and electrical compartment. Panels shall be non-load bearing type.
6. The frame shall consist of anodized extruded aluminum profiles; welded together for reinforcement and insulated for superior thermal performance.
7. Base structure shall be fully welded G-90, painted exterior, and have integral lifting lugs which can be removed once the unit is installed.
8. All roof and side wall seams shall be positively sealed to prevent water and air leakage. The OA and EA compartment shall have 1" PVC drains extended to exterior of unit
9. Access doors shall be provided to all major components to facilitate quick and easy access. Access doors will be made from the same material as the unit casing and shall incorporate thermal break construction. Fan access door(s) shall have Allegis type handles, with one handle interlinking multiple latches and threaded insert fastening handles for all remaining doors. If access doors do not open against unit operating pressure, provide safety latches that allow access doors to partially open after first handle movement and fully open after second handle movement. Removable panels provided for equipment pull out for coil(s), and air to air heat exchanger section(s) shall have key tooled threaded insert fasteners. Hinges shall be Nylon hinge type designed to open 180 degrees.
10. Unit shall have the entire exterior finished with a PVDF coating designed for UV resistance. Panels shall be painted Annexair standard color white gray RAL 9002. If custom color is required, please specify the associated RAL color code. Panels shall

pass ASTM B117 3000-hour salt fog resistance test and ASTM D4585 3000-hour moisture condensation resistance test. In addition, paint must meet AAMA 620-02 standard for color, chalking, gloss retention, and abrasion resistance.

11. The air handler unit casing shall be provided with a lifetime warranty against corrosion resistance under normal use.

B. **WEATHER HOODS**

The outdoor intake weather hood shall be completely constructed in aluminum for superior corrosion resistance. The hood shall ship loose for field installation by the installing contractor. Painted galvanized hoods shall not be acceptable due to its susceptibility to corrosion. The outdoor air hood shall be designed with a 4" extruded aluminum louver, bird screen and a plenum enclosure with drain holes. The louver blades shall be drainable type with a maximum 45 degree angle and curved with integral rain baffle. The louver design shall not allow more than 0.03 oz/ft2 water penetration when tested in accordance to AMCA 500. The pressure drop of the complete hood assembly shall not exceed 0.05"wc at a maximum 500 fpm face velocity. A Pre-filter rack system shall be installed within the weather hood enclosure to prevent outdoor air dust and debris from entering the damper and unit casing plenum. Pre-filters installed inside the unit casing plenum and downstream of the outdoor damper will not be acceptable as this will increase overall maintenance on the damper, reduce indoor air quality and promote mold and bacteria growth. Filter access in the hood shall be accomplished via the louver that is installed with a stainless steel piano hinge and spring loaded latch. No tools or ladders shall be required to access the pre-filters in the weather hood assembly be and header insulation constructed from 304 stainless steel shielding for increased energy efficiency and reduced airstream heat gain. Stainless steel shields to be isolated from distributor using plenum rated synthetic foam strips. Insulation to provide air-gap to minimize conduction and The unit housing

C. EXHAUST AIR LOUVER

The exhaust air outlet louvers shall be 2" extruded aluminum, with non- restricting blade design and bird screen.

2.2 FIXED PLATE HEAT EXCHANGERS

A. Fixed plates heat exchangers shall factory installed where indicated on drawings. The heat exchanger shall be a cross flow plate air-to-air type. The alternate layers of plate create two ducts, one for supply air and one for exhaust air. The plates shall be in coated aluminum for its characteristics of corrosion resistance, ease of manufacture, flame proof, durability and excellent heat transfer properties. Minimum plate thickness shall be .008", with positive and negative stamping for spacing and turbulence. The plates shall be sealed at air entry and exit to avoid air leakage and separate exhaust and supply air by proper seals. The plates shall be housed inside a casing composed of corner profiles and side walls. The corners of the exchanger package shall be cast and sealed into especially rigid aluminum extrusions in the casing with permanent elastic non acetic silicone. The side walls shall be manufactured from galvanized steel sheets and bolted to the aluminum extrusions. The fixed plate heat exchanger assembly shall be tested in accordance to ARI1060 and to ASHRAE 84-91. Access for all four sides of the heat exchanger shall be provided for cleaning and inspection. Stainless Steel drain pan shall be provided underneath the entire Fixed Plate with 1" PVC drains on each 4 sides of the heat exchanger. Drain connections protrude through the side of the unit. Note: Drain lines must be properly trapped and freeze protected in field. Frost control shall be accomplished by face & bypass damper where temperatures fall below freezing.

2.3 FANS

A. PLENUM FANS (ER model)

1. Fans shall be direct drive radial centrifugal fans with free running impeller. No fan belts will be acceptable for this application. Fans shall be compact, optimized and construction made of galvanized sheet steel with backward curved 7-blade high efficiency impeller, protected by an epoxy powder coating.
2. To reduce vibration, the impeller shall be balanced with hub to an admissible vibration severity of less than 2.8 mm/s in conformity with DIN ISO 14694 and proof shall be supplied for each individual impeller. Tests shall be made according to DIN ISO 1940 Part 1, quality of balancing G2.5/6.3.
3. The single inlet shall be mounted onto constant speed direct drive motor, equipped with an air flow optimized inlet cone from galvanized sheet steel.
4. Fans shall be completely certified as per ISO 5801 and in accordance to AMCA standards.
5. Fan/ fan bank will require to be operated by a Variable speed drive.
6. Optional: Plenum fan shall come equipped with guard grilles for the air intake side.

B. FAN ISOLATIONS
1. The fan housing and motor assembly shall be isolated from the unit cabinetry with a minimum 95% efficient spring isolators or high efficiency rubber isolators or seismic isolators.
2. In addition, fans shall have flexible canvas to reduce vibration transmission.

C. SOUND ATTENUATION IN FAN COMPARTEMNT (OPTIONAL)
1. The fan section shall be constructed with a perforated interior liner, same construction as the housing interior lining and shall be insulated with Permacote anti-microbial coating fiber glass. The perforated lining shall be installed on fixed panels only, with exception on the interior ceiling

2.4 FAN MOTORS

A. The fan motors shall meet NEMA standard dimensions and comply with the Energy policy Act of 1997.
B. Motors shall have premium efficiencies with low noise and vibration output. Motors shall be certified and built in accordance to ISO 9001 quality control system
C. Motors shall have ODP enclosure with Premium efficiency performance.
D. Units shall be designed for constant application. Please refer to the unit schedule for the application type.
E. Option: A shaft grounding brush kit will be provided to prevent electrical damage to motor bearings by safely channeling harmful shaft currents to ground.

2.5 VARIABLE FREQUENCY DRIVE (VFD)-ABB

A. VFDs will be used to set or regulate the fan speed and airflow for these units.
B. The VFD shall have PID function for constant flow applications
C. The VFDs will be installed with integral brake transistor, overload protection, and adjustable pulse-width modulation (PWM).
D. The VFD shall use Insulated Gate Bipolar Transistor (IGBT) technology to convert three phase input power to coded PWM output and have 4-20mA analog output terminals that are fully programmable for variable flow applications.
E. The VFD shall be equipped with a keypad with status indicators, easy access functions, and monitoring functions during motor operation.
F. In the event of a momentary power failure or fault the VFD shall read the inverter speed and direction of a coasting motor and shall automatically restart the motor smoothly.
G. Technical support will be provided by the VFD manufacturer.
H. VFDs shall be installed as shown on drawings with contactors, relays, and all specified accessories.
I. VFDs will be installed WITHOUT by-pass.

2.6 FILTERS

A. PRE-FILTERS *(HIGH CAPACITY SERIES 400 2" MERV 10)*)

1. Filters shall be factory installed upstream of the heat exchanger and coils, in both airstreams.
2. The filters shall be Filtration Group Series 400, MERV 10.
3. Each filter shall consist of 100% synthetic media, expanded metal on the downstream and enclosing with high wet-strength beverage board with diagonal support bonded on air entering and air exiting side of each pleat.
4. MERV 10 model High Capacity Serie 400 filters, UL 900 classified are rated as per ASHRAE test 52.2.2012 at 88% efficiency initial (based on Minimum Average Efficiency) at 3-10 microns.
5. The model High Capacity Serie 400 could be operated at 500 FPM, surface area 18 FT2 of media based on 24 x 24 x 2 initial static pressure at 0.24", final will be 1".
6. Filters shall be placed in a completely sealed, galvanized holding frame with quick release latches for easy replacement.

B. FINAL FILTERS (GEOPLEAT 4'' MERV 11 (60-65%))

1) Filters shall be factory installed upstream of the heat exchanger and coils. The air filters shall be MERV 11. Each filter shall consist of 100% synthetic gradient dual density media, in a 100% high impact plastic frame. Media is adhesively bonded to all four sides of the frame. Filters shall be placed in a completely sealed, galvanized holding frame with quick release latches for easy replacement.

2.7 DAMPERS

A. NON-INSULATED TAMCO SERIES *1000*

1. Dampers shall be installed where shown on the drawings.
2. Dampers shall be low leak type with rubber edges, opposed blades, and constructed from extruded aluminum.
3. Galvanized dampers will not be acceptable.
4. The exhaust air outlet shall have a standard aluminum gravity type damper, unless otherwise noted below.
5. Dampers shall be installed in the compartments (as shown on the drawings) with linkage rod for actuators
6. Actuators shall be 24V factory installed: two-position or modulating (please refer to the unit schedule).
7. All actuators shall have spring return mechanism and auxiliary switches. Dampers will be installed in the failed close positions unless otherwise noted

2.8 CONDENSING UNIT

A. AIR COOLED CONDENSING UNIT WITH VARIABLE SPEED COMPRESSORS (AEROMOD AZ)

1. Provide an integral air cooled condensing section with variable speed compressors. The condensing section shall be factory piped, wired, and charged with R-410A refrigerant. The section shall be from the same manufacturer as the air handling unit. Factory mounting and piping an air cooled condensing unit, provided by a third party is not acceptable. Furthermore, the exterior cabinet of the air cooled section shall be of the same construction and paint color as the air handling unit.
2. Compressors shall be variable speed scroll type that can modulate from 30% to 100% capacity per compressor. Variable capacity compressors which do not modulate the speed of the scrolls are not considered equal to a variable speed scroll since they consume more energy at the same capacity output. Mechanically stepped scrolls which are unloaded via a digital signal to a solenoid valve, in a timed sequence, will not be acceptable for this application. The variable speed scrolls shall be operated via a factory supplied variable speed controller per compressor, and all tandem compressors will modulate in unison. Using a single variable speed controller on the lead circuit alone is not efficient during part load conditions, therefore will not be acceptable for this application. Each compressor and controller assembly shall be equipped with the following features: PERMANENT MAGNET MOTOR, electronic expansion valve, a crankcase heater function, anti-short cycling, built-in phase loss detector, EMC filter, oil return management system, and reverse rotation protection. All refrigeration parts, including the compressor and the speed

controller will be located in a closed and vented service compartment, separate from the condenser coil airflow. Compressors located in compartments open to the outside are not acceptable. Compressors shall be mounted on rubber isolators to limit vibration transmission and shall include flexible hoses on both the suction and discharge refrigeration lines.

3. All air cooled condensing units above 23T will have a minimum of two compressors.

4. Condenser fans shall have 7 air foil type blades with external mounted asynchronous motors that are class F insulated, IP54 and 100% variable speed. Each condenser fan bank shall be provided with a variable voltage controller which modulates via refrigerant head pressure control for superior part load performance. All the condenser fans in a fan bank shall modulate in unison for each respective circuit. Staging condenser fans are not an acceptable mode of control for head pressure control. Protective guards shall be included on all condenser fans, and condenser coils. The coil protective guards shall be ideal to keep coil at maximum operating performance, protect the condenser from hail damage and allow for easy cleaning with quick release latches. The condenser coils shall be micro-channel design for maximum efficiency performance, consist of a single pass arrangement with integral receiver, and be pressure tested at 650 psig. Coil construction shall consist of aluminum alloys for the fins, tubes and manifolds. Copper tube, aluminum fin condenser coils are not acceptable as they require more refrigeration charge for the same capacity output.

5. The following components shall be included in each refrigeration circuit: Liquid line filter dryer, high and low pressure switch, high and low pressure transducers, suction and liquid lines shutoff valves and suction line accumulators. In addition, refrigeration piping must use Shrader type connections for all components, including but not limited to valves and transducers. Under no circumstances shall the units leave the factory without a complete run test and a copy of the QC report shall be provided upon request.

6. Minimum (5) five year compressor warranties shall be provided

2.9 COILS

A. DX COILS

1. Coils shall be factory installed in the unit.
2. Coils shall be designed with respective circuits to match the design requirements. All coils shall have a distributor per circuit connection. Coils shall be circuited for counter-flow heat transfer to provide maximum mean effective temperature difference for maximum heat transfer rates.
3. Primary surface shall be round seamless (3/8” O.D.) copper tube staggered in the direction of airflow. Secondary surface shall consist of rippled aluminum plate fins for higher capacity and structural strength. Fins shall have full drawn collars to provide a continuous surface cover over the entire tube for maximum heat transfer. Tubes shall be mechanically expanded into the fins to provide a continuous primary to secondary compression bond over the entire finned length for maximum heat transfer rates. Headers shall have intruded tube holes to provide a large brazing surface for maximum strength and inherent flexibility.
4. Casing shall be constructed of continuous galvanized steel.
5. The complete coil shall be tested with 315 pounds air pressure under warm water and be suitable for operation at 250 psig working pressures. Maximum finned coil height shall be 60” and shall not exceed 500 FPM face velocity.
6. Drain pan shall be provided on cooling coils. Cooling coils shall sit on stainless steel tubular support rails, which shall stand a minimum of (2) two inches above the highest point of the floor drain pan. Stacked coils shall be provided for larger airflows and intermediate drain pans shall be provided for each coil bank. Drain pans shall be stainless steel with 1.25” stainless steel drain connections on one side only. Pan shall be sloped in two planes.
7. All coils shall be rated in accordance with AHRI standard 410.

B. DX HOT GAS REHEAT

1. Coils shall be factory installed in the unit.
2. The hot gas reheat coil shall be installed at minimum 8” from the moisture producing DX cooling coil. A plexi glass between the two items shall be required to visually inspect the DX cooling coil surface area, and also have the ability to clean the coils when necessary.
3. A modulating valve shall be provided to control air leaving temperature for dehumidification.
4. Coils shall be designed with respective circuits to match the design requirements. Coils shall be circuited for counter-flow heat transfer to provide maximum mean effective temperature difference for maximum heat transfer rates.
5. Primary surface shall be round seamless (3/8” O.D.) copper tube staggered in the direction of airflow. Secondary surface shall consist of rippled aluminum plate fins for higher capacity and structural strength. Fins shall have full drawn collars to provide a continuous surface cover over the entire tube for maximum heat transfer. Tubes shall be mechanically expanded into the fins to provide a continuous primary to secondary compression bond over the entire finned length for maximum heat transfer rates. Headers shall have intruded tube holes to provide a large brazing surface for maximum strength and inherent flexibility.
6. Casing shall be constructed of continuous galvanized steel.
7. The complete coil shall be tested with 315 pounds air pressure under warm water and be suitable for operation at 250 psig working pressures.
8. All coils shall be rated in accordance with AHRI standard 410.

2.10 BURNERS

A. INDIRECT GAS FIRED FURNACE (*HM SERIES*)

1. Furnish and install where shown on plans Gas-fired Duct Furnace Heat Module(s).
2. The module shall be a Recognized Component by Intertek Testing Services (ITS / ETL). All modules will have a minimum thermal efficiency of 80%.
3. The module shall employ a tubular heat exchanger and a draft inducer assembly to provide for positive venting of flue gases. Burner assemblies shall employ in-shot type burners constructed of aluminized steel body and sintered metal flame holder with integral carryover plenum.
4. The ignition system will include a 6000 V Igniter and flame rod detection. Ceramic hot surface ignition systems are unacceptable.
5. Gas-fired duct furnace(s) provided shall employ a tubular heat exchanger constructed of 18-gauge minimum, type 409 stainless steel, and 1 ¾” to 2 ¼” diameter having a minimum wall thickness of 0.047”. Tubes and shall be produced to ASTM A249 standards for heat exchanger application. Tubes shall employ integral formed-dimple restrictors to eliminate noise associated with expansion and contraction of internal baffles during heating cycles, and to provide for unobstructed drainage of condensate that occurs in the tubes during cooling operation. Drainage shall be configured so that burners and burner surfaces are not exposed to condensate during cooling system operation.
6. Full Modulation control shall be provided. On a call for heat and subsequent safe burner light OFF, the burner modulation shall be minimum 5:1 as noted on the schedule. Stepped modulation is not acceptable. Controls shall include an ignition control with alarm capable contact and one hour auto reset on lockout, roll out switch, high limit switch and a proving switch of loss of the induced draft fan. Additionally, on modulating and 2-stage systems all timing and switching functions shall be controlled through an electronic timer relay control. Staging controller available for 0 to 10VDC or 4 to 20mA input from building management control.
7. Burners will use Natural Gas (with gas pressure min 7"-max 14"wc) unless otherwise specified. Gas train compartment shall be provided with 1” PVC drain.

2.11 ROOF CURB (Optional)

A non-insulated, pre-fabricated roof curb shall be provided and shipped knocked down. The roof curb will be made of 16-gauge galvanized steel with 4" flanges, minimum 17" high with a factory installed 2" x 3" wood nailer strip.

2.12 POWER AND SAFETY CONTROL

A. The power and control center shall be integral to the unit housing and rated equivalent to NEMA 3R.
B. Under no circumstances shall any wiring or parts be field installed. If units show up at the job site without wiring by the manufacturer, the contractor will have to send back units to the manufacturer at the contractors' expense to get them factory wired and re-tested.
C. Panels that are externally mounted to the unit shall not be accepted, regardless of the NEMA rating they may have. A separate access door shall be provided with an approved locking device.
D. All electrical components contained in the panel shall be UL/CSA certified and labeled. The unit shall be complete with VFDs, fuses, relays, phase protection for compressorized units, terminals for main ON/OFF and step-down transformer. All components shall be factory wired for single point power connection by the manufacturer of the unit. A non-fused safety disconnect switch shall be factory installed for ON/OFF servicing.
E. An electrical pipe chase for power and control feeding shall be provided next to the control panel.
F. Any power or control wiring that is field installed shall not be accepted under any circumstances. The Short Circuit Current Rating (SCCR) is 5 kA rms symmetrical, 600V Maximum or as noted on schedule.
G. GFI, lights, and switches shall be factory installed and wired to a common junction box. A separate power connection 120V/1 will be required (powered by others).

2.13 AIR TEMPERATURE CONTROL PACKAGE

A. The unit shall be delivered with factory installed control system. Under no circumstances shall control be provided by other than the manufacturer of the equipment. Field installed control package by the ATC will not be acceptable.
B. The control system shall consist of a microprocessor with LCD display, 7 day time clock, 20 day holiday schedule, occupied/unoccupied mode switch, warm up mode, cool down mode, hi-lo limit discharge control, fan status, temperature and humidity sensors when applicable, scroll buttons to change settings as required and alarm history.
C. Supply air temperature and humidity sensors shall be provided by Annexair and field mounted in the supply duct and wired by others. Optional - Space temperature and humidity wall mounted sensors shall be field wired and installed by others.
D. Refer to the Sequence of Operation and control schematic for detailed description and options.
E. Communication Interface Card: The microprocessor shall be capable of communicating with the following protocol language: Select one of the following: Bacnet MS/TP RS-485.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine ducts, and conditions for compliance with requirements for installation tolerances and other conditions affecting performance.

B. Examine roughing-in for piping systems to verify actual locations of piping connections before installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install Air Handling Unit per manufacturers' instructions.

B. Install with required clearance for service and maintenance.

3.3 TESTING

A. System verification testing is part of the commissioning process. Verification testing shall be performed by the Contractor and witnessed and documented by the Commissioning Authority. Refer to section 01810, Commissioning, for system verification tests and commissioning requirements.
B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect field-assembled components and equipment installation, including piping and electrical connections. Report results in writing.
    1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
    2. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation. Remove malfunctioning units, replace with new units, and retest.
    3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

3.4 TRAINING

A. Training of the Owner’s operation and maintenance personnel is required in cooperation with the Commissioning Authority. Provide competent, factory-authorized personnel to provide instruction to operation and maintenance personnel concerning the location, operation, and troubleshooting of the installed systems. The instruction shall be scheduled in coordination with the Commissioning Authority after submission and approval of formal training plans. Refer to System Demonstrations, section 01670, for contractor training requirements. Refer to section 01810, Commissioning, for further contractor training requirements.
B. Contact Annexair to request pricing to include factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain humidifiers.
    1. Train Owner's maintenance personnel on procedures and schedules for starting and stopping, troubleshooting, servicing, and maintaining equipment and schedules.
    2. Review data in maintenance manuals. Refer to Division 1 Section "Contract Closeout."
    3. Review data in maintenance manuals. Refer to Division 1 Section "Operation and Maintenance Data."
    4. Schedule training with Owner, through Architect, with at least seven days advance notice.

END OF SECTION 23 6200

SECTION 23 6213 - AIR COOLED CONDENSING UNIT (OPTION B)

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Provide and install condensing units as described in Contract Documents.

B. Furnish and install complete a hot gas by-pass system.

1.3 QUALITY ASSURANCE

A. Requirements of Regulator Agencies:
   1. Each unit shall be UL labeled.

1.4 WARRANTY

A. Five-year warranty on compressors.

B. Two-year warranty on condensing unit.

PART 2 - PRODUCTS

2.1 MANUFACTURED UNITS

A. Unit shall be completely factory assembled and shall be given a thorough running factory performance test at normal operating conditions.

B. Unit shall be shipped as a single package on a common base and lifting lugs shall be provided for handling.

C. Casing:
   1. Casing shall be fabricated of 12 gauge .080 inch textured aluminum sheathing and thoroughly reinforced.
   2. Structural members shall be fabricated of continuous galvanized steel or galvanized structural steel channel.

D. Compressor:
   1. Accessible hermetic type
   2. Suction and discharge service valves
   3. Crankcase heaters
   4. Oil sight glass and oil charging connection.
   5. Force feed lubrication system with reversible oil pump and operating oil charge.
   6. Compressor motors:
      a. High torque
      b. Hermetic induction type
      c. 1750 rpm with inherent thermal protection
   7. Compressors shall be mounted on vibration absorbing mounts.

E. Condenser Coil:
   1. Constructed of 1/2 inch O.D. seamless copper tubes and rippled, plate type aluminum fins.
   2. Fins shall be mechanically bonded to the tubes.

3. Fins shall have full drawn collars to completely cover the copper tube against atmospheric corrosion.
4. Provide factory coil guards.

F. Sub-cooling Coil:
1. Integral with the main condenser coil
2. Minimum of 15 degrees liquid sub-cooling for improved system performance and longer piping runs without flash gas.

G. Condenser Fans:
1. Fan section:
   a. Furnished with propeller fans arranged for vertical air discharge.
   b. Divided by full width baffles between fans.

H. Fans:
1. Statically and dynamically balanced
2. Individually driven by separate fan motors.
3. Permanently lubricated, ball bearing motors with inherent thermal overload protection.
4. Motors for direct drive fans shall not exceed 1140 rpm.
5. Motors for belt drive fans shall not exceed 1750 rpm.

I. Low Ambient Control:
1. Units shall be provided with automatic head pressure control by cycling condenser fans in response to ambient temperature.
2. Control Center:
   a. Controls shall be contained within a weatherproof cabinet with key lock.
   b. Dual compartments shall isolate safety and operating controls from starting equipment.
   c. Control panel shall have dead-front construction for operator's safety.
   d. Control center shall include:
      1) System on-off switch
      2) Compressor on-off switch
      3) Oil safety switch
      4) High and low pressure controls
      5) Pumpdown relay
      6) Fan cycling thermostat

J. Dual or tandem compressor models shall include time delay sequenced start.

K. Power and starting equipment for compressor and condenser fan motors shall include:
1. Three-leg companion trip circuit breakers and starting contactors
2. Overload protection
3. Power terminal block

L. Factory Performance Test:
1. Each unit shall be individually tested at full and partial load conditions.
2. With unit in operation, controls shall be properly calibrated and adjusted.
3. After performance testing, unit shall be thoroughly leak tested with a high sensitivity electronic leak detector.

M. Refrigerant:
1. Unit shall be shipped with holding charge of Refrigerant-410a.

N. Approved Manufacturers:
1. McQuay
2. American Air
3. Dunham-Bush

PART 3 - EXECUTION

3.1 INSTALLATION

A. Set condensing units on concrete slab.

3.2 FIELD QUALITY CONTROL

A. Manufacturer's Field Service:

3.3 Condensing units shall be started up, checked out, and adjusted by Condensing Unit Manufacturer's authorized factory trained service mechanic.

3.4 Mechanic shall use check-out sheet provided by Manufacturer, complete and sign all items on sheet, and submit to Architect.

END OF SECTION 23 6213

SECTION 23 6214 – VRF CONDENSING UNITS

PART 1 - PRODUCT(S) - Outdoor Units (Variable Refrigerant Flow Systems)

1.1 Multi V™ 5 Heat Recovery and Heat Pump System(s) – (6 to 42 tons nominal)

A. Product Design

1. LG Multi V 5 heating and cooling system shall be an air cooled system allowing user to configure in the field a heat pump or a heat recovery system consisting of one to three outdoor unit modules, conjoined to make a 6-42 ton single refrigerant circuit.

a) Heat recovery systems, employing three pipes, shall be connected to Heat recovery (heat recovery) unit(s) and indoor unit(s). Multi-port heat recovery units shall allow simultaneous heating and cooling of individual zone(s) at various capacities as required to satisfy their zone requirements.

b) Heat pump systems shall require two pipes, simultaneous heating and cooling shall not be supported. The heat recovery system shall consist of three pipes, liquid, suction and hot gas pipes. Heat recovery systems operating at 0°F that cannot deliver single phase superheated refrigerant vapor at a minimum of 162°F while operating in the heating mode shall not be acceptable.

2. All three-phase VRF heat pump and heat recovery outdoor units shall be from the same product development generation. Mixing of outdoor units from different development generations is not acceptable.

B. Operating Conditions

1. Outdoor Unit shall be capable of continuous compressor operation between the following operating ambient air conditions, operation outside of these conditions are possible and may involve non-continuous operations.

2. Operating Ambient Air Conditions:

a) Cooling: 5°F DB to 122°F DB <With optional low ambient kit from -9.9°F DB to 122°F DB>

b) Heating: -22°F WB to 61°F WB

c) Cooling Based (ODU reversing valve in cooling position) Synchronous: 14°F DB to 81°F DB (Heat Recovery Operation Only)

d) Heating Based (ODU reversing valve in heating position) Synchronous: 14°F WB to 61°F WB (Heat Recovery Operation Only)

C. Electrical

a) All air source heat pump and heat recovery frame(s) shall be designed and electrically protected to maintain stable continuous compressor operation when provided with 208-230/60/3 power with the following specifications:

i. <208-230/60/3>

1. Voltage fluctuation of ± 10%

ii. Voltage imbalance of up to two percent;

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

D. General Features

1. The air-conditioning system shall use R410A refrigerant.

2. Each system shall consist of one, two or three air source outdoor unit modules conjoined together in the field to result in the capacity specified elsewhere in these documents.
3. Dual and triple frame configurations shall be field piped together using manufacturer's designed and supplied Y-branch kits and field provided interconnecting pipe to form a common refrigerant circuit.
4. System shall have following frame configurations vs. capacity.
   a) 6 to 20 ton units shall be a single frame only.
   b) 22 to 34 ton units shall be dual frame only.
   c) 36 to 42 ton heat recovery units shall be triple frame only
5. System shall employ self-diagnostics function to identify any malfunctions and provide type and location of malfunctions via fault alarms.
6. Field Provided Refrigerant Piping:
   a) The refrigerant circuit shall be constructed using field provided ACR copper, de-hydrated, refrigerant rated copper pipe, piped together with manufacturer supplied Heat recovery unit(s) and Y- branches, as may be required, connected to multiple (ducted, non-ducted or mixed combination) indoor units to effectively and efficiently control the heat pump operation or simultaneous heating and cooling operation of the heat recovery VRF system. Other pipe materials, if used, shall perform, at a minimum, as well as that specified above, shall not have any adverse reactions, for example galvanic corrosion, to any other components or materials also in use in the system and shall be installed per manufacturer's instructions.
   b) The unit shall be shipped from the factory fully assembled including internal refrigerant piping, inverter driven compressor(s), controls, temperature sensor, humidity sensor, contacts, relay(s), fans, power and communications wiring as necessary to perform both Heat Pump and Heat recovery operations.
   c) Each outdoor unit refrigeration circuit shall include, but not limited to, the following components:
      i. Refrigerant strainer(s)
      ii. Check valve(s)
      iii. Inverter driven, medium pressure vapor injection, high pressure shell compressors
      iv. Liquid refrigerant cooled inverter PCB
      v. Oil separator(s)
      vi. Accumulator /controlled volume receiver(s)
      vii. 4-way reversing valve(s)
      viii. Vapor injection valve(s)
      ix. Variable path heat exchanger control valve(s)
      x. Oil balancing control
      xi. Oil Level sensor(s)
      xii. Electronic expansion valve(s)

xiii. Sub-cooler (s)

xiv. Vapor Injection Valve(s)

xv. High and low side Schrader valve service ports with caps

xvi. Service valves

7. Field Insulation:

   a) All refrigerant pipe, y-branches, elbows and valves shall be individually insulated with no air gaps. Insulation R-value (thickness) shall not be less than the minimum called for by the local building code, local energy code or as a minimum per manufacture installation requirements. In no case shall the insulation be allowed to be compressed at any point in the system.

      i. All joints shall be glued and sealed per insulation manufactures instructions to make an air tight assembly.

8. Microprocessor:

   a) Factory installed microprocessor controls in the outdoor unit(s), heat recovery unit(s), and indoor unit(s) shall perform functions to optimize the operation of the VRF system and communicate in a daisy chain configuration between outdoor unit and heat recovery unit(s) and indoor unit(s) via RS485 network. Controls shall also be available to control other building systems as required from the VRF control system. DIO/AIO capabilities shall be available as well as a central controller to perform operation changes, schedules and other duties as required by this specification. Addition of separate building control system shall not be required. Other control devices and sequences shall be as specified in other sections of this project specification.

9. Inverter PCB Cooling:

   a) Cooling of the inverter PCB shall be conducted by way of high pressure, sub-cooled liquid refrigerant via heat exchanger attached to the inverter PCB. The full capacity flow of refrigerant shall pass though the heat exchangers to maximize the cooling effect of the PCBs and to aid in the evaporation process and capacity of the outdoor coil during the heating mode. The recovered heat of the PCBs must be used to enhance the overall heating process, other uses or dissipation of heat to ambient shall not be permitted.

10. Compressor Control:

    a) Fuzzy control logic shall establish and maintain target evaporating temperature (Te) to be constant on cooling mode and condensing temperature (Tc) constant on heating mode by Fuzzy control logic to ensure the stable system performance.

11. Initial Test Run (ITR) (Heating or Cooling) / Fault Detection Diagnosis (FDD) Code:

    a) This control mode shall monitor and display positive or negative results of system initial startup and commissioning. Heating or Cooling ITR mode will be automatically selected. It shall monitor and provide performance metrics for the following, but not be limited to, refrigerant quantity charge, auto-charge, stable operations, connection ratios, indoor unit status, error status, and number of indoor units connected. This control mode shall not replace the system error monitoring control system.

12. BMS Integration:

a) The VRF system shall be able to integrate with Building Management Systems via BACnet™ IP gateway. This gateway converts between BACnet™ IP or Modbus TCP protocol, and RS-485 LGAP (LG Aircon protocol) allowing third party control and monitoring of the LG A/C system, or LonWorks™ gateways. See controls specification for points list.

13. Wi-Fi Communication:

a) The outdoor unit shall be Wi-Fi enabled and capable. Wi-Fi shall allow service or maintenance personal access to the complete operating system, via LGMV mobile, without need of tools other than smart phone or tablet. Active live system review, collection of all system data for a field determined duration presented in a .csv file format or collection of all operating conditions, including all indoor units, valves, sensors, compressor speeds, refrigerant pressures, etc., by snapshot of conditions and placing that snapshot into a power point slide to be reviewed at another time. Systems that require computers, hard wire only connection or other devices to collect, review or record operating conditions shall not be allowed.

14. Indoor Unit Connectivity:

a) The system shall be designed to accept connection up to 64 indoor units of various configuration and capacity, depending on the capacity of the system.

15. Power and Communication Interruption:

a) The system shall be capable of performing continuous operation when an individual or several indoor units are being serviced; communication wire cut or power to indoor unit is disconnected. Systems that alarm and/or shut down because of a lack of power to any number of indoor units shall not be acceptable.

16. Connection Ratios:

a) The maximum allowable system combination ratio for all VRF systems shall be 130% and the minimum combination ratio shall be 50%.

17. Comfort Cooling Mode:

a) Comfort cooling shall be initiated via a field setting at the outdoor unit during commissioning or anytime thereafter. Comfort cooling shall allow user to select all or some of the zones on a system to adjust automatically their evaporator temperatures, independent of other zones, based on the impending total loads of that zone determined by using the zone controller temperature sensor.

18. The outdoor unit refrigerant circuit shall employ for safety a threaded fusible plug.

19. Refrigerant Flow Control

a) An active refrigerant control and multi section accumulator-receiver that dynamically changes the volume of refrigerant circulating in the system based on operating mode and operating conditions to ensure maximum system performance and efficiency.

b) Subcooler: The VRF outdoor unit shall include a factory provided and mounted sub-cooler assembly consisting of a shell and tube-type sub-cooling heat exchanger and EEV providing refrigerant sub-cooling modulation control by fuzzy logic of EEV and by mode of operation to provide capacity and efficiency as required. Brazed plate heat exchangers shall not be allowed for this function.

c) Smart Load Control: The air source unit shall be provided with Smart Load Control (SLC) enhanced energy saving algorithm that reduces compressor lift during off peak operation.

i. The SLC algorithm shall be monitoring in real time, the rate of change of the outdoor ambient air temperature, either the outdoor ambient air relative humidity or the indoor air relative humidity [field selectable], and the rate of change of the building load.

ii. The SLC algorithm shall foresee pending changes in the building load, outdoor temperature and humidity (or indoor humidity) and proactively reset head and/or suction pressure targets in anticipation of the reduction/increase in building load.

iii. The SLC algorithm shall provide no fewer than 3 field selection options to maximize the control of the VRF system operation during morning warm-up or cool-down following night-setback reset. The selection shall be set by the commissioning agent (or at any other time thereafter). Selectable algorithm choices include:

1. Maximize energy savings

2. Balance the rate of temperature change with energy consumed.

3. Quickly cool/heat the building.

20. Refrigerant Volume Management

a) Active Refrigerant Charge

i. The VRF system shall be able to operate at any and all published conditions year round in cooling or heating mode without the need of adding or removing refrigerant from the system.

ii. The air source unit shall be provided with an isolated vessel to store spare refrigerant and actively pass refrigerant to (or from) the accumulator in real time as necessary to maintain stable refrigeration cycle operation.

iii. The air source unit microprocessor shall be provided with an algorithm that monitors the VRF system head pressure, suction pressure, subcooling, superheat, compressor speed, high and low side temperatures and the load on the system to adjust the volume of refrigerant actively circulating.

b) Manual Seasonal Refrigerant Charge Adjustments

i. Alternates: Systems that CANNOT passively and automatically modify the active refrigerant charge using the method(s) stated to maintain stable cycle operation shall clearly state so in bold capital letters in the proposal. VRF systems that cannot perform active refrigerant control may submit a proposal as an Alternate and must include as part of the equipment price the cost of to provide bi-annual refrigerant charging services for 15 years. Service shall be performed by the factory authorized agent only. Service shall include refrigerant, parts, labor, and fees necessary to analyze the current state of the system and perform the refrigerant charge adjustment. Service must occur one month before the winter season and one month before the summer season.

ii. If the VRF system requires a charge adjustment more frequently to maintain stable operation, the VRF manufacturer shall provide additional services at no additional charge.

iii. The 15 year period shall begin on the date the equipment is commissioned or the date the building occupancy permit was issued for the area(s) served by the system – whichever date is later.

iv. This service shall be underwritten, warranted, and administered by the VRF equipment manufacturer – not the local distributor or applied representative.

v. The selected service provider shall be mutually agreeable between the building owner (or owners agent) and must be licensed, insured, and trained to work on the VRF system. No third party service (subcontracted service) providers will be acceptable.

vi. If the service provider is not an employee of the VRF manufacturer, the service provider shall be reimbursed for services rendered directly from the manufacturer. Labor rate for services shall be paid at the prevailing wage rate in place at the time of service.

21. VRF Systems with Onboard Alternate Operating Mode Selection Capability

a) All VRF systems which provide field selectable Alternate Operating Modes, for example, High Heat or High Ambient Cooling, published data tables must be available to the public for all modes offered.

b) Acceptable Alternate Operating Modes must ship with all models of the VRF product offering and must be factory embedded. Custom factory or field modifications to factory provided algorithms created to meet scheduled requirements are not acceptable.

c) Provide a copy of instructions required to set the Alternate Operation Mode with the initial submittal.

d) For systems that provide field selectable Alternate Operating Modes, ALL technical data provided in the submittal data sheets showing product rated condition performance data, must also provide separate data sheets that show product performance data at each of the field selectable Alternate Operating Modes available. Capacity, power input, and acoustic performance data for each mode offered shall be reported separately. Mixing of ODU, IDU, or VRF system performance capability operating in one mode with for example the power consumption, sound power rating, or electrical requirements of the same system operating in another mode is not acceptable.

E. Field Supplied Refrigerant Piping Design Parameters

1. The outdoor unit shall be capable of operating at an elevation difference of up to 360 feet above or below the lowest or highest indoor unit respectively without the requirement of field installed subcooler or other forms of performance enhancing booster devices.

2. The outdoor unit shall be capable of operating with up to 3280 equivalent length feet of interconnecting liquid line refrigerant pipe in the network.

3. The outdoor unit shall be capable of operating with up to 656 actual feet or 738 equivalent length feet of liquid line refrigerant pipe spanning between outdoor unit and farthest indoor unit.

4. The piping system shall be designed with pipe expansion and contraction possibilities in mind. Required expansion devices shall be field designed, supplied and installed based on proper evaluation of the proposed piping design. In addition to these requirements, the piping system installation must conform to the VRF equipment manufacturer’s published guidelines.

5. The installation of pipe hangers, supports, insulation, and in general the methods chosen to attach the pipe system to the structure must allow for expansion and contraction of the piping system and shall not interfere with that movement.

6. The elevation difference between indoor units on <heat pump systems> shall be 131 feet.

7. The elevation differences for <heat recovery systems> shall be:

a) Heat recovery unit to connected indoor unit shall be 49 feet

b) Heat recovery unit to heat recovery unit shall be 98 feet

c) Indoor unit to indoor unit connected to same heat recovery unit shall be 49 feet

d) Indoor unit to indoor unit connected to separate parallel piped heat recovery units shall be 131 feet.

8. The acceptable elevation difference between two series connected heat recovery units shall be 16 feet.

F. Defrost Operations

1. The outdoor unit(s) shall be provided with a minimum of 4 independent field adjustable defrost cycle algorithms to maximize the effectiveness of the defrost cycle to the local weather conditions. Intelligent Defrost shall melt accumulated frost, snow and ice from the outdoor unit heat exchanger. The defrost cycle length and sequence shall be based on outdoor ambient temperatures, outdoor unit heat exchanger temperature, and various differential pressure variables. Intelligent Heating Mode, when outdoor unit humidistat is engaged, shall extend the normal heating sequences by adjusting the outdoor unit coil target temperature to be above the ambient dew point temperature delaying the need for defrost operations, so long as heating demand is being met.

2. Smart Heating: This feature shall be capable of eliminating several defrost actions per day based on outdoor air temperature and humidity conditions. Smart heating shall extend the heating operation cycle by delaying the frost formation on the outdoor coil by adjusting the surface temperature to keep it above the current outdoor ambient dew point. The algorithm shall delay while maintaining indoor space temperature.

3. Defrost Mode Selection: The outdoor unit shall be provided with a minimum of three field selectable defrost operation modes: Normal, Fast, or Forced.

a) Normal Defrost: Operation intended for use in areas of the country that experience adverse winter weather with periods of heavy winter precipitation and extremely low temperatures. This strategy shall maximize the systems heating performance and maintain operational efficiency. When the ambient temperature is either: a) above 32°F or b) below 32°F with the humidity level below 60% RH, Intelligent Defrost shall continue heating regardless of ice build-up on the coil until the quality of the heated air (i.e. discharge air temperature) decreases. At temperatures below 4°F, a defrost cycle shall occur every two hours to optimize system heating efficiency.

b) Fast Defrost: Operation intended for use in areas of the country with mild winter temperatures and light to moderate humidity levels. The strategy minimizes defrost cycle frequency allowing frozen precipitation to build longer in between cycles. Minimum time between defrost cycles shall be 20 minutes. Intelligent Defrost shall choose between split coil/frame and full system methods based on current weather conditions to minimize energy consumption and maximize heating cycle time.

c) Forced Defrost: Operation shall be available for the service provider to test defrost operations at any weather condition and to manually clear frozen water from the outdoor coil surfaces.

4. Defrost Method Selection: The outdoor unit shall be provided with two field selectable defrost operation methods: Split Coil/Frame and Full System. Split Coil/Frame option provides continuous heating of the occupied space during defrost operation.

a) Split Coil/Frame method shall be available when Normal Defrost mode is selected. Split Coil method shall be available on all Heat Pump and Heat recovery single-frame VRF systems. Split Frame defrost shall be available on all Heat Pump and Heat recovery multi-frame outdoor units.

b) Split Coil method shall remove ice from the bottom half of the outdoor unit coil first for a maximum time of six minutes, then the top half for a maximum of six minutes. Next the bottom coil shall be heated again for an additional three minutes to remove any frozen water that may have dripped onto the lower coil during the top coil defrost operation.

c) When Split Coil/Frame method is selected, a Full System defrost shall occur every 1-9 (field selectable) defrost cycles to assure 100% of the frozen precipitation has been removed to maintain efficient performance.

d) Full System method shall be available as a field selectable option. All outdoor units located in areas of the country where large volumes of frozen precipitation are common, the commissioning agent shall be able to select the Full System only defrost method.

5. Indoor Unit Fan Operation During Defrost

a) During partial defrost operation indoor units operating in cooling or dry mode shall continue normal operation.

b) During partial defrost operation, indoor units that are commissioned with fans set for continuous operation shall maintain normal fan speed unless the leaving air temperature drops, then the fan speed will be reduced to low speed for the remainder of the defrost cycle.

c) During full system defrost operation indoor unit fans will cycle off and remain off during the remainder of the defrost cycle.

G. Oil Management

1. The system shall utilize a high pressure oil return system to ensure a consistent film of oil on all moving compressor parts at all points of operation. Oil is returned to compressor through a separate high pressure oil injection pipe directly into the oil sump. Oil returned to the compressor via the suction port of the compressor shall not be allowed.

2. Each compressor shall be provided with a high efficiency independent centrifugal cyclone type oil separator, designed to extract oil from the oil/refrigerant gas stream leaving the compressor.

3. The system shall have an oil level sensor in the compressor to provide direct oil level sensing data to the main controller. The sensor shall provide data to main outdoor unit PCB to start oil return mode and balance oil levels between multiple compressors.

4. The system shall only initiate an oil return cycle if the sensed oil level is below oil level target values as determined by the microprocessor. The system shall display an error if the oil sensor signals low oil level for a period of 130 minutes or longer.

5. A default oil return algorithm shall automatically initiate the oil return mode if the system detects a failure of the oil sump sensor. A fault code shall be reported by the system.

6. Timed oil return operations or systems that do not directly monitor compressor oil level shall not be permitted.

7. Indoor Unit Fan Operation during Oil Return Cycle

a) During oil return cycle indoor units operating in cooling or dry mode shall continue normal operation.

b) During oil return, indoor units that are commissioned with fans set for continuous operation shall maintain normal fan speed unless the leaving air temperature drops, then the fan speed will be reduced to low speed for the remainder of the oil return cycle.

c) During oil return cycle indoor unit fans will cycle off and remain off during oil return cycle while operating in all modes.

H. Fan and Motor Assembly

1. 6 ton frames shall be equipped with one direct drive variable speed propeller fan with Brushless Digitally Controlled (BLDC) motor with a vertical air discharge.
2. 8 to 20 ton frames shall be equipped with two direct drive variable speed propeller fan(s) with BLDC motor(s) with a vertical air discharge.
3. The fan(s) blades shall be made of Acrylonitrile Butadiene Styrene (ABS) material and incorporate biomimetic technology to enhance fan performance and reduce fan generated noise.
4. The fan(s) motor shall be equipped with permanently lubricated bearings.
5. The fan motor shall be variable speed with an operating speed range of 0-1150 RPM cooling mode and 0-1150 RPM heating mode.
6. The fan shall have a guard to help prevent contact with moving parts.
7. The cabinet shall have option to redirect the discharge air direction from vertical to horizontal with the addition of optional factory provided air guides.
8. The fan controller shall have a DIP switch setting to raise external static pressure of the fan up to 0.32 inch of W.C. to accommodate ducted installations.
9. The fan control shall have a function setting to remove excess snow automatically.
10. The fan control shall have a function setting to remove access dust and light debris from the outdoor unit and coil.

I. Cabinet

1. Outdoor unit cabinet shall be made of 20 gauge galvanized steel with a weather and corrosion resistant enamel finish. Outdoor unit cabinet finish shall be tested in accordance with ASTM B-117 salt spray surface scratch test (SST) procedure for a minimum of 1000 hours.
2. Cabinet weights and foot prints shall vary between 430 lbs., 7.61 sq. ft. (1.27 sq. ft. per ton), for 6 ton cabinet to 666 lbs., 10.14 sq. ft. (.51 sq. ft. per ton), for 20 ton cabinet for single cabinet configurations. The front panels of the outdoor units shall be removable type for access to internal components.
3. A smaller service access panel, not larger than 7” x 7” and secured by a maximum of (2) screws, shall be provided to access the following:

   a) Service tool connection

   b) DIP switches

   c) Auto addressing

   d) Error codes

   e) Main microprocessor

   f) Inverter PCB

4. The cabinet shall have piping knockouts to allow refrigerant piping to be connected at the front, right side, or through the bottom of the unit.
5. The cabinet shall have a factory installed coil guard.

J. Outdoor Unit Coil

1. Outdoor unit coil shall be designed, built and provided by the VRF outdoor unit manufacturer.
2. The outdoor unit coil for each cabinet shall have lanced aluminum fins with a maximum fin spacing of no more than 17 Fins per Inch (FPI). All the outdoor unit coils shall be a 2 or 3 rows consisting of staggered tubes for efficient air flow across the heat exchanger
3. Outdoor unit coil shall be comprised of aluminum fins mechanically bonded to copper tubing with inner surfaces having a riffling treatment to expand the total surface of the tube interior
4. The aluminum fin heat transfer surfaces shall have factory applied corrosion resistant Black Fin coating. The copper tubes shall have inner riffling to expand the total surface of the tube interior.
   a) ISO 21207 Salt Spray Test Method B – 1500 hours
   b) ASTM B-117 Acid Salt Test – 900 hours
   c) The Black Fin coating shall be certified by Underwriters Laboratories and per ISO 21207. The above conditions shall establish the minimum allowable performance which all alternates must comply.
5. Variable Path Heat Exchanger: System shall have a variable flow and path outdoor heat exchanger function to vary the refrigerant flow and volume and path. Control of the variable path circuits shall be based on system operating mode and operating conditions as targeted to manage the efficiency and minimize or maximize the circulating volume of the operating fluids of the system. This feature allows MV 5 to maintain system head pressure that delivers “gas-furnace leaving air temperature” from the indoor unit at moderate and low ambient outdoor air temperatures.
6. The outdoor unit coil, all indoor units and pipe network shall be field tested to a minimum pressure of 550 psig.

K. Compressor(s)

1. Compressor shall be designed and assembled by the VRF manufacturer specifically for use in the air source 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.
2. Compressor shall be a hermetic, high-side shell (HSS), commercial grade, compliant scroll direct-drive design.
   a) Compressor Design: The compressor design shall be of the high pressure shell scroll type where the internal pressure below the suction valves of the compressor shall be at the same high pressure and high temperature. The motor shall be cooled by high pressure gas at temperatures above saturation conditions and minimize the mixing of refrigerant liquid with oil in the sump. The system shall employ a high pressure oil return method returning recovered oil from the oil separator directly into the oil sump of the compressor; oil shall not be allowed to return via the suction line. Bearing surfaces are continually coated with oil. The compressor shall employ an Aero-bearing constructed with high lubricity materials increasing operation time in case of low sump oil level. Compressor shall have a nominal operating range from 12Hz to 150 Hz.
3. 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.

4. 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.
5. Vapor Injection: System shall have a medium pressure gas vapor injection function employed in the heating and cooling modes to increase system capacity when the outdoor ambient temperatures are low and lower compressor lift when temperatures are high. The compressor vapor injection flow amount shall be controlled by the vapor injection sub-cooling algorithm reset by discharge gas temperatures of the compressor.
6. 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.
7. 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.
8. The viscosity property of the PVE oil in the compressor sump shall be maintained irrelevant or compressor operation and the surrounding ambient temperature.

    a) 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.

    b) 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.

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

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

    b) 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.

10. 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.

    c) The inverter driver controller shall be matched with the physical properties of the compressor. The drive shall be manufactured by the VRF air 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.

11. Compressor(s)

a) Each 6, 8, 10 ton frames shall be equipped with a single hermetically sealed, inverter driven, High Side Shell (HSS) scroll compressor.

b) 12, 14, 16, 18 and 20 ton frames shall be equipped with dual hermetically sealed, inverter driven, High Side Shell (HSS) scroll compressors.

c) Each inverter driven, HSS scroll compressor shall be capable of operating from 12 Hz up to 150 Hz in any and all modes (cooling, heating or simultaneous modes).

d) The compressor shall be designed for a separate port for oil to be directly returned to the compressor oil sump.

e) The compressor bearing(s) shall have Teflon™ coating and shall be an aero type design using High lubricity materials.

f) The compressor(s) shall be protected with:

i. High Pressure switch

ii. Over-current /under current protection

iii. Oil sump sensor

iv. Phase failure

v. Phase reversal

vi. Compressor shall be capable of receiving injection of medium pressure gas at a point in the compression cycle where such injection shall allow a greater mass flow of refrigerant at lower outdoor ambient and achieving a higher heating capability. The VRF outdoor unit shall have published performance data for heating mode operation down to -13°F on both heat pump and heat recovery systems.

g) Standard, non-inverter driven compressors shall not be permitted nor shall a compressor without vapor injection or direct sump oil return capabilities.

L. Operational Sound Levels

1. Each single frame outdoor unit shall be rated with an operational sound pressure level not to exceed as listed on below chart when tested in an anechoic chamber under ISO 3745 standard at the highest field selectable heating operating modes available. Such documentation shall be presented in all submittals, manufactures who elect to rate their equipment at other than tested in an anechoic chamber under ISO 3745 standard at the highest field selectable heating operating modes available and the highest field selectable conditions shall not be allowed.

2. A field setting shall be available to program the outdoor unit to reduce sound levels at night, when desired, to a selectable level while still able to meet building load requirement. This mode is available in both cooling and heating modes.

M. Sensors

1. Each outdoor unit module shall have:

   a) Suction temperature sensor

   b) Discharge temperature sensor

   c) Oil level sensor

   d) High Pressure sensor

   e) Low Pressure sensor

   f) Outdoor temperature sensor

   g) Outdoor humidity sensor

   h) Outdoor unit heat exchanger temperature sensors

N. Wind Load Installations for Outdoor Units

1. LG FL Wind load Installation Drawings meet the requirements of the 2017 Florida Building Code, 6th Edition and ASCE Standard 7-2010

O. Seismic Installations

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

P. Warranty

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”).

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 2 - PRODUCT(S) - Heat Recovery Units (Heat Recovery Systems Only)

A. General

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

4. Heat recovery unit casing shall be constructed with galvanized steel.
5. Heat recovery unit shall require 208-230V/1-phase/60Hz power supply.
6. 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.
7. 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
8. Heat recovery units' main 3 pipe connections shall be capable of series or parallel pipe configuration.
9. The quantity of heat recovery units that can be piped in series shall be limited to 16.
10. 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 240 MBh.
11. 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.
12. 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.
13. Each port shall be capable of connecting from 1 to 8 indoor units.
14. 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.
15. Heat recovery unit shall be internally piped, wired, assembled and run tested at the factory.
16. Heat recovery unit shall be designed for installation in a conditioned environment per specifications.
17. Heat recovery unit shall employ a liquid bypass valve.
18. Heat recovery unit shall have (2) electronic expansion refrigerant valves per port.
19. 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.
20. Heat recovery unit shall employ an electronic expansion valve to ensure proper sub cooling of the refrigerant.
21. Heat recovery unit shall contain one double spiral sub-cooling heat exchanger per port.
22. Heat recovery unit shall not require a condensate drain or connection.
23. Heat recovery unit shall be internally factory insulated.
24. 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.
25. The heat recovery unit shall not exceed a net weight of 70 lbs.

26. Heat recovery units, for line length and pressure drop calculations, shall not exceed a maximum equivalent pipe length value of 8.2 feet.
27. 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.

B. 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.

C. Seismic Installations

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

D. Warranty

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

END OF SECTION 23 6214

SECTION 23 6320 - COOLING COILS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 TESTING

A. All standard coils shall be leak tested at 250 psig air under water.

PART 2 - PRODUCTS

2.1 MANUFACTURED UNIT

A. Fins shall be continuous aluminum configurated plate-fin type with full fin collars for accurate spacing and maximum fin-tube contact.

B. Tubes shall be copper expanded into the fin collars for a permanent fin-tube bond and expanded into the header for a leak-tight joint at 250 psig air pressure under water.

C. Headers shall be gray cast iron hydrostatically tested to 400 psi before assembly.

D. Casings shall be constructed of 16 gauge, continuous coated galvanized steel with fins recessed into the channels to minimize air bypass. Top and bottom channels shall have 3/8" holes on 3" centers for mounting purposes.

E. Approved Manufacturers:
   1. Trane
   2. Dunham-Bush
   3. Bohn

F. Cooling Coil:
   1. Cooling coil shall consist of heavy gauge steel cabinet with baked-on enamel finish to match furnace.
      a. Coil shall have aluminum fins bonded to seamless copper or aluminum tubing.
      b. Coil shall be ARI rated. Provide drain pans with connections at one end.
      c. Use thermal expansion valve.
      d. Cooling coil for use with R410a refrigerant.

END OF SECTION 23 6320
END OF DIVISION 23