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.

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

1.3 SUBMITTALS

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

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

C. Drawings of Record: One complete sets of blue line mechanical drawings shall be provided for the purpose of showing a complete picture of the work as actually installed.

1. These drawings shall serve as work progress report sheets. Contractor shall make notations neat and legible therein daily as the work proceeds.
2. The drawings shall be kept at the job at a location designated by the Mechanical Engineer.
3. At completion of the project these "as-built" drawings shall be signed by the Contractor, dated, and returned to the Architect.

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

E. Include water balance reports.

1.4 SUBMITTALS FOR COMMON HVAC REQUIREMENTS

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

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

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

1.5 QUALITY ASSURANCE

A. Requirements of Regulatory Agencies:

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

B. Applicable Specifications: Referenced specifications, standards, and publications shall be of the issues in effect on date of Advertisement for Bid.
1. "Heating, Ventilating and Air Conditioning Guide" published by the American Society of Heating and Air Conditioning Engineers.
2. "Engineering Standards" published by the Heating, Piping, and Air Conditioning Contractors National Association.
3. "2015 International Building Code", "2015 International Mechanical Code", 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 warrant work as provided by the General Conditions of the contract, (AIA Document A201, 1997 edition). The contractor shall specifically reference paragraph 3.5 WARRANTY and Paragraph 12.2, CORRECTION OF WORK.

B. Contractor shall certify work under Division 22 to be free from inherent defects for a period of one year from the date of substantial completion.

C. 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 12 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. The VFD shall be rated for 115% continuous current equal to the motor service factor.

F. Rated overload current shall be 150% for 1 minute.

G. The VFD unit shall have an adjustable acceleration/deceleration time setting from 1 second to 120 seconds.

H. The VFD unit shall maintain a 95% or better displacement power factor over the entire speed range.

I. 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.

J. 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)

K. 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

L. 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)

M. 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.

N. 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.

O. 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.

P. Digital or Analog Ammeter.

Q. Elapsed Time meter.

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

S. 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.

T. 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.

U. 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 HARMONIC TESTING AND CORRECTION REQUIREMENTS

A. Vendor of VFD system shall supply a harmonic voltage distortion report once unit is installed. Said report shall show harmonic voltage distortion on line with VFD unit Off and with VFD unit running (at highest operating speed).

B. Vendor shall guarantee the following:
1. Harmonic voltage distortion, on line does not increase by more than 3% once VFD unit is operating on line.
2. The vendor shall provide complete field testing to measure harmonic, power factor, and voltage rise parameters, and provide a certified report.
3. The owner and/or engineer may (at their option) witness any of the tests required in this section.

C. Vendor shall correct harmonic voltage distortion by supplying reactors and/or filters, at his cost, to stay within the above limits. The contractor shall install these devices if supplied.

D. After VFD unit is installed, vendor shall take harmonic voltage and current distortion readings as described above and supply actual strip chart recordings of same with owner's manual with copy to Architect.

2.4 APPROVED MANUFACTURERS

A. Energy Management Corporation EMC M Series

B. Mitsubishi VTP Series

C. ABB

D. Or Approved Equal

2.5 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 4 - GENERAL

4.1 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.

4.2 SUBMITTALS

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

PART 5 - PRODUCTS

5.1 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 6 - EXECUTION

6.1 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. Chilled 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
CHW	Chilled Water	Blue

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

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

END OF SECTION 23 0553

SECTION 23 0593 - TESTING, ADJUSTING, AND BALANCING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY SCOPE

A. This Section includes TAB to produce design objectives for the following:
   1. Hydronic Piping Systems.
      a. Primary - Secondary Systems
      b. Chiller
      c. Pumps

1.3 SUBMITTALS

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

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

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

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

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

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

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

1.4 CERTIFICATION

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

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

1.5 PROJECT CONDITIONS

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

1.6 SEQUENCING AND SCHEDULING

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

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

PART 2 - NOT USED

PART 3 - EXECUTION

3.1 PROCEDURES FOR HYDRONIC SYSTEMS

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

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

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

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

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

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

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

3.2 MEASUREMENTS

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

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

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

D. Apply instrument as recommended by the manufacturer.

E. Use instruments with minimum scale and maximum subdivisions and with scale ranges proper

for the value being measured.

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

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

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

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

3.3 PERFORMING TESTING, ADJUSTING, AND BALANCING

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

B. Seal piping, and test for and repair leaks.

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

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

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

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

3.4 RECORD AND REPORT DATA

A. Record all data obtained during testing, adjusting, and balancing in accordance with, and on the forms recommended by the referenced standards, and as approved on the sample report forms.

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

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

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

3.5 DEMONSTRATION

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

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

END OF SECTION 23 0593

SECTION 23 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. Chilled 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 0716- CHILLED WATER SUPPLY & RETURN PIPING INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

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

PART 2 - PRODUCTS

2.1 MATERIAL

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

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

PART 3 - EXECUTION

3.1 INSTALLATION

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

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

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

1. Metal jacketing shall be 0.016" (0.4 mm) minimum aluminum or stainless steel with moisture barrier, secured in accordance with the jacket manufacturer's recommendations. Joints shall be applied so they will shed water and shall be sealed completely.

2. UV resistant PVC jacketing may be applied in lieu of metal jacketing provided jacketing manufacturer's limitations with regard to pipe size, surface temperature, and thermal expansion and contraction are followed.

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

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

END OF SECTION 23 0716

SECTION 23 0800 - COMMISSIONING OF HVAC SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

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

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

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

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

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

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

1.2 DESCRIPTION OF WORK

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

1. Chilled Water Systems

1.3 REFERENCE STANDARDS

A. ASHRAE Standard 202-2013

B. Idaho State Commissioning Guidelines

1.4 DEFINITIONS

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

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

C. Systems, Subsystems, Equipment, and Components: Where these terms are used together or separately, they shall mean "as-built" systems, subsystems, equipment, and components.

D. Commissioning Representatives: Those members of the Contractor's staff, Sub-contractor's staff, Owner's staff, Architect's staff, or Owner's independent contractor assigned to participate in the commissioning process.

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

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

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

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

1.5 INTENT

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

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

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

1.6 HVAC CONTRACTOR REQUIREMENTS

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

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

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

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

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

1.7 RESPONSIBILITIES OF THE MECHANICAL CONTRACTORS AND CXA

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

1. Provide startup for all equipment in the contracted scope
2. Assist and cooperate with the Testing and Balancing (TAB) contractor and the CxA by:
    a. Putting all equipment and systems into operation and continuing the operation during each working day of TAB and Cx as required.
    b. Providing temperature and pressure taps according to the Construction Documents for TAB and Cx testing.
    c. Assist the TAB in the location and operation of all balancing equipment
3. List and clearly identify on the as-built drawings the locations of all P/T plugs, meters, sensors and all other such measure and verification devices.
4. Prepare a preliminary schedule for all pipe system testing, flushing and cleaning, equipment start-up and TAB start and completion for use by the CxA. Update the schedule as appropriate.
5. Notify the GC when pipe system testing, flushing, cleaning, lighting panel testing, fixture testing, power distribution and startup of each piece of equipment and TAB will occur. Be responsible to notify the GC, ahead of time, when Cx activities not yet performed or not yet scheduled will delay construction. Be proactive in seeing that Cx processes are executed and that the CxA and GC both have the scheduling information needed to efficiently execute the Cx process.
6. In each purchase order or subcontract written, include requirements for submittal data, Cx documentation, O&M data and training.
7. Attend Cx scoping meetings and other meetings necessary to facilitate the Cx process.
8. Provide a copy of the O&M manuals and submittals of commissioned equipment, through normal channels, together during equipment submittals to the CxA for review and approval. See this specification section for additional information and requirements for the O&M manuals.
9. Contractors shall assist (along with the design engineers) in clarifying the operation and control of commissioned equipment in areas where the specifications, control drawings or equipment documentation is not sufficient for writing detailed testing procedures.
10. Review test procedures to ensure feasibility, safety and equipment protection and provide necessary written alarm limits to be used during the tests.

11. Develop a full start-up and initial checkout plan using manufacturer's start-up procedures and populate the PFTs from the CxA for all commissioned equipment. Submit to CxA for review and approval prior to startup.
12. During the startup and initial checkout process, execute the MEP-related portions of the PFTs for all commissioned equipment. Perform and clearly document all completed startup and system operational checkout procedures, providing a copy to the CxA.
13. Address current outstanding punch list items before functional testing. Water Pressure Testing and Water Testing and Balancing (TAB) shall be completed with discrepancies and problems remedied before functional testing of the respective air- or water-related systems. Fire protection piping pressure testing shall be completed with discrepancies and problems remedied before functional testing of the respective air- or water-related systems.
14. Complete Prefunctional Test Checklists (PFTs) provided by the CxA and return these to the CxA. After the contractors have completed the PFTs and returned them to the CxA, the CxA will back-check a percentage for accuracy. If the actual field work is not in agreement with the sheets, the contractor will be required to make corrections at their expense. After completion of corrective work, the CxA will review another section of the work and check for agreement with the checklists. The contractor(s) will be back charged for this, and all additional, checks required to verify checklists and complete the prefunctional phase of commissioning.
15. Provide access for equipment to be tested, such as removing ceiling tiles.
16. Provide skilled technicians to execute starting of equipment and to execute the functional performance tests. Ensure that they are available and present during the agreed upon schedules and for sufficient duration to complete the necessary tests, adjustments and problem solving.
17. Provide skilled technicians to assist with functional performance testing under the direction of the CxA for specified equipment outlined in the Cx Plan. Assist the CxA in interpreting the monitoring data, as necessary.
18. Correct deficiencies (differences between specified and observed performance). The CxA will provide one (1) functional retest of commissioned equipment at no additional charge to the contractor(s). If repeated failures of the equipment and/or system require retest beyond the first retest, the contractor(s) will be back charged for the time of the CxA required to complete the additional retesting.
19. Prepare O&M manuals according to the Contract Documents, including clarifying and updating the original sequences of operation to as-built conditions. Provide assistance, cooperate and provide required materials to others as directed by the GC (and CxA) in the compilation of the O&M manuals. Prepare draft versions of the O&M Manual for use as the training syllabus.
20. During construction, maintain as-built red-line drawings for all drawings and final CAD as-builts for contractor-generated coordination drawings. Update after completion of Cx (excluding deferred testing).
21. Provide Training Plan and training of the Owner's operating staff using expert qualified personnel, as specified. Use the draft O&M manual as the training manual.
22. Coordinate with equipment manufacturers to determine specific requirements to maintain the validity of the warranty.
23. Attend Cx coordination meetings and provided assistance and cooperate in the preparation of a Cx schedule with the GC and CxA.
24. Cx Tasks shall be performed by the same personnel who were involved in the installation and are familiar with the equipment.
25. During the Warranty Period execute seasonal or deferred functional performance testing, witnessed by the CxA, according to the specifications and correct deficiencies and make necessary adjustments to O&M manuals and as-built drawings for applicable issues identified in any seasonal testing.

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

1. Prior to starting TAB, submit to the GC the qualifications of the site technician for the project. The owner or CxA will approve the site technician's qualifications for this project.
2. Meet with the CxA and GC and submit the outline of the TAB plan and approach for each system and component to the CxA, GC and the controls contractor prior to starting TAB. The submitted plan will include:
    a. Certification that the TAB contractor understands the Cx requirements.
    b. An explanation of the intended use of the building control system for TAB. The controls contractor will comment on feasibility of the plan.
    c. All field checkout sheets and logs to be used that list each piece of equipment to be tested, adjusted and balanced.
    d. Discussion of what notations and markings will be made on the duct and piping drawings during the process.
    e. Final test report forms to be used.
    f. Procedures for TAB work for each system and issue: terminal flow calibration (for each terminal type), diffuser proportioning, branch / submain proportioning, total flow calculations, rechecking, diversity issues, expected problems and solutions, etc. Criteria for using air flow straighteners or relocating flow stations and sensors will be discussed. Provide the analogous explanations for the water side.
    g. Details of how *total* flow will be determined
    h. The identification and types of measurement instruments to be used and their most recent calibration date.
    i. Specific procedures that will ensure that water systems are operating at the lowest possible pressures and provide methods to verify this.
    j. Details regarding specified deferred or seasonal TAB work.
    k. Details of any specified false loading of systems to complete TAB work.
    l. Plan for hand-written field technician logs of discrepancies, deficient or uncompleted work by others, contract interpretation requests and lists of completed tests (scope and frequency).
3. Provide a draft or preliminary TAB report within two weeks of completion. A copy will be provided to the CxA. The report will contain a full explanation of the methodology, assumptions and the results in a clear format with designations of all uncommon abbreviations and column headings. The report should follow the latest and most rigorous reporting recommendations by AABC, NEBB or ASHRAE Standard 111.
4. Provide the CxA with any requested data, gathered, but not shown on the draft reports.
5. Provide a final TAB report for the CxA with details, as in the draft.

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

1. Provide the OPR documentation (if applicable) to the CxA and the Cx Team for use in developing the Cx plan; systems manual; operation and maintenance training plan; and testing plans and checklists
2. Assign operation and maintenance personnel and schedule them to participate in Cx team activities including, but not limited to, the following:
    a. Coordinate Meeting
    b. Training in operation and maintenance of systems, subsystems, and equipment.
    c. Testing meetings.
    d. Demonstration of operation of systems, subsystems, and equipment.
3. Provide utility services required for the Cx process.

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

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

1. Organize and lead the Cx team.
2. Prepare a construction-phase Cx plan. Collaborate with Contractors and with subContractors to develop test and verification procedures. Include design changes and scheduled Cx activities coordinated with overall Project schedule. Identify Cx team member responsibilities, by name, firm, and trade specialty, for performance of each Cx task.
3. Review and comment on submittals from Contractors for compliance with the OPR, BOD, Contract Documents, and construction-phase Cx plan. Review and comment on performance expectations of systems and equipment and interfaces between systems relating to the OPR and BOD.
4. Convene Cx team meetings for the purpose of coordination, communication, and conflict resolution; discuss progress of the Cx processes. Responsibilities include arranging for facilities, preparing agenda and attendance lists, and notifying participants. The CxA shall prepare and distribute minutes to Cx team members and attendees within five workdays of the Cx meeting.
5. At the beginning of the construction phase, conduct an initial construction-phase coordination meeting for the purpose of reviewing the Cx activities and establishing tentative schedules for operation and maintenance submittals; operation and maintenance training sessions; TAB Work; and Project completion.
6. Observe and verify construction and report progress and deficiencies. In addition to compliance with the OPR, BOD, and Contract Documents, verify systems and equipment installation for adequate accessibility for maintenance and component replacement or repair.
7. Prepare project-specific test and verification procedures and checklists.
8. Schedule, direct, witness, and document tests and verifications.
9. Compile test data, verification reports, and certificates and include them in the systems manual and Cx report.
10. Develop custom pre-functional testing protocol for review by interested parties.
11. Perform functional testing with assistance by appropriate contractors
12. Certify date of acceptance and startup for each item of equipment for start of warranty periods.
13. Review project record documents for accuracy. Request revisions from Contractor to achieve accuracy. Project record documents requirements are specified in Division 1.
14. Review and comment on operation and maintenance documentation and systems manual outline for compliance with the OPR, BOD, and Contract Documents. Operation and maintenance documentation requirements are specified in Division 1 Section "Operation and Maintenance Data."
15. Review operation and maintenance training program and provide assessment and feedback on the completeness of the maintenance training program requirements. Operation and maintenance training is specified in Division 1, Section 01 79 00 "Demonstration and Training".
16. Prepare Cx reports.
17. Assemble the final Cx documentation, including the Cx report and Project Record Documents.

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

1. Integration of existing DDC interface with new equipment as required to fully control new equipment per design requirements.
2. Assist in equipment startup as required by mechanical contractor.
3. Assist in TAB as required by the TAB contractor.

4. Perform point-to-point checkouts prior to scheduling any functional testing with all interested parties.
5. Support CxA as needed and provide access to final control systems in collaboration with owner representatives to ensure functional testing can be performed.
6. Control equipment as needed to simulate loads or other implement testing protocols required for functional testing.
7. Provide CxA with control based point-to-point checkout documentation.
8. Notify CxA of training dates for O&M personnel at hand-off.

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

1. HVAC System
    a. Chiller
    b. Chilled Water Piping and Insulation
    c. Local controls & Integration with existing DDC
    d. Integration with existing equipment
    e. Installation Quality
    f. Overall HVAC Functionality

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

1.8 RECORD DRAWINGS

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

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

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

1.9 COMMISSIONING APPROACH

A. General

1. The commissioning approach shall include a series of checks, tests, and operational procedures, applied in specific sequences, to each system or equipment component to be commissioned.
2. The contractor shall perform startup tests in accordance with manufacturer's requirements and pre-functional testing in accordance with Commissioning Authority supplied checklists utilizing members of the construction staff and representatives of the equipment and system manufacturer's who are fully knowledgeable of the equipment and systems installation and operation.
3. The HVAC contractor is required to fill out the pre-functional testing forms provided by the Commissioning Agent. The Commissioning agent may observe certain pre-functional tests and their discretion.
4. The specific commissioning procedures required are described in the Project Commissioning plan to be provided after contract and award. These procedures shall be performed in a specific sequence as described in the Project Commissioning Plan. The sequenced application of the procedures is intended to provide a step-wise development, proceeding from the individual component level, to the system level, and ultimately to the multiple integrated level of system operation. This sequencing approach will require certain procedures to be performed earlier in the construction process than for non-commissioned construction, and is intended to

help ensure that the installation is free of defects at the earliest opportunity, allowing increased time for correction or modification if defects or performance issues are found.

PART 2 - (Not Used)

PART 3 - EXECUTION

3.1 SUBMITTALS

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

B. Contractor shall provide populated prefunctional checklists.

3.2 PRE-COMMISSIONING work SESSION & Kickoff meeting

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

B. The work session shall be held at the Contractor's principle place of business or at the job site. The GC, CxA, appropriate subcontractors and representatives of the owner shall be scheduled for attendance as a minimum. Sub-contractor representatives of the principle trades involved in the commissioning process should also be in attendance and may be scheduled for attendance at the discretion of the CxM.

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

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

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

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

3.3 STARTUP

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

3.4 CONTROLS TESTING PREPARATION AND VERIFICATION

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

1. Sequences of Operation Submittals: The Controls Contractor shall send to the CxA complete controls submittals. Submittals of control drawings shall include complete detailed sequences of operation for each piece of equipment, regardless of the completeness and clarity of the sequences in the specifications. See Division 1 for complete details.

2. Points List: The Controls Contractor shall send to the CxA a draft points list as soon as it is available but no later than two months prior to occupancy. This shall be updated as often as required. A complete "as-built" points list shall be sent at the end of the project. See Division 1 for complete required contents of the points list.

3. Point-To-Point Checks – The Controls Contractor is required to perform their own point-to-point checks and provide verification to the CxA prior to the HVAC contractor scheduling functional testing.

4. Notification of Operation: The Controls Contractor shall notify the CxA when each piece of equipment, panel or sub-panel is under automatic control and may be viewed in operation, prior to final functional testing.

5. The Controls Contractor shall review all CxA provided functional test procedures. The receipt of the procedures by the contractor constitutes certification that the contractor has reviewed

the procedures and confirmed they are safe and will not harm any equipment or systems. Any subsequent damage incurred as a result of conducting the documented verification shall be the responsibility of the contractor.

3.5 TAB

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

3.6 PRE-FUNCTIONAL TESTING

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

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

C. Submit to the CxA all the testing logs.

D. Without limiting the following work shall be performed:

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

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

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

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

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

3.7 FUNCTIONAL TESTING

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

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

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

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

D. Procedure Acceptance

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

E. On-Site Procedure Rejection

1. The CxA shall have the authority to reject a procedure in its entirety or to cause the procedure to be stopped if in the opinion of the CxA, any of the following conditions exist:
    a. The pre-procedure review meeting is incomplete.
    b. Appropriate or sufficient contractor staff is not available or required commissioning representatives are not present.
    c. Required pre-testing or report data, such as point-to-point control verifications, alignment reports, and trend log data is not available or is incomplete.
    d. The installation is insufficient or incomplete as required for the procedure or not in compliance with the Contract Documents.
    e. Numerous checks or tests fail or cannot be accomplished.
    f. Installation and/or operation of equipment or systems beyond or in advance of the commissioning requirements.
    g. Installation, operation, or commissioning not in compliance with the sequencing requirements.
    h. Indication of improper maintenance or operation.
    i. Inadequate instrumentation
2. The CxA shall additionally reject a procedure and require the equipment operation or procedure to be stopped if in the opinion of the CxA unsafe conditions to either staff or equipment exist. Consideration of safety issues by the CxA shall not in any way relieve the Contractor from his sole responsibility for job site safety and protection of the equipment.
3. Direction to stop the procedure or halt the operation of equipment will be given verbally. Upon notification the Contractor shall immediately stop the procedure and restore the system or equipment to a safe condition.
4. At the discretion of the CxA, the Contractor may be afforded the opportunity to correct the conditions indicated by the CxA and resume the procedure.
5. If in the opinion of the CxA corrections cannot be implemented in a satisfactory manner, within the scheduled time available for the procedure and with sufficient time available to complete the

procedure, the procedure shall be stopped and rescheduled by the CxM. The CxA shall provide the CxM with written notification of procedure rejection stating the cause of the action.

6. The Contractor shall be liable for all actual costs associated with the required attendance by the CxA, the Owner's and A/E's commissioning representatives, and required outside agents, resulting from rejected procedure.

7. Actual costs shall include:

   a. Cost for the CxA and for each Owner's and A/E's commissioning representative, which are comprised of contractual billing rate as defined in the respective organization's agreement for such work, including overhead and profit. For CxA and A/E's commissioning representatives, these rates may be found in the A/E schedule for additional services.

   b. Travel-related expenses for the CxA and for each Owner's or A/E's commissioning representative, where such staff is required to be in attendance and not headquartered within the city limits, which are comprised of compensation for actual travel time, with an established minimum of 5 hours, and mileage rates, billed at the prevailing national government rate.

   c. Costs assessed for required outside agents, contractors, or specialists employed by the Owner or A/E at the actual contractual billing rates as defined in the respective organization's agreement for such work.

   d. Equipment rentals, special tools, and related material fees associated with the participation of contracted outside organizations and specialists.

8. The costs assessed will be documented by the CxA and will be deducted from the Contractor's fees or progress payments at the time of occurrence.

3.8 CHANGES TO THE WORK

A. Changes to the work shall be as directed by Change Order, Construction Change Directive, or Order for Minor Change as defined in the General Conditions of the Contract.

B. The CxA shall have authority to issue Orders for Minor Change, on behalf of the Owner and the Engineer, on-site, in conjunction with the commissioning activities. Such directions to the contractor will be provided in writing and will be signed and dated by the CxA.

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

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

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

3.9 FINAL ACCEPTANCE

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

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

C. Where specific components, equipment, or system elements are demonstrated to comply with the specified requirements and perform to the manufacturer’s published or advertised capabilities, but are demonstrated not to provide the performance as required by the Contract Documents and the

commissioning procedures, disposition of the issue and/or related modifications shall be provided as directed by the Architect. Final acceptance shall be contingent on the completion of any resulting correction work and related commissioning requirements determined as necessary in final disposition of the issue.

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

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

END OF SECTION 23 0800

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 0953 – 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.

B. Existing water cooled chiller, cooling towers, chilled water pumps, cooling tower pumps, and coil 3 way valves will be replaced. Remove any and all control devices/wiring associated with this equipment, and extend to new equipment supplied under Division 23.

C. New air cooled chiller – Chilled will be supplied with a bacNet N_2 controller, so that all chiller operating controls, and faults can be broadcast to the existing Johnson Medisys system.

D. Chilled water pumps – Chilled water pumps will operate via pressure transducer thru VFD supplied by division 23 and installed by division 26. Pumps have been sized for 30% glycol and to operate together for full load conditions.

E. Air Handler Coils – Each separate air handler coil will have a 2 way control valve. All 4 valves shall stage open to maintain cooling discharge air temperature (adjustable), Min. flow thru each valve is 288 gpm.

END OF SECTION 23 0953

SECTION 23 2113 - HYDRONIC PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes pipe and fitting materials, joining methods and specialty items for the following:

1. Chilled Water piping.
2. Make-up water piping
3. Air Vent piping
4. Air control devices – air separators / expansion tanks

1.2 RELATED SECTIONS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions, Section 23 0501 and Division 1 Specification sections apply to work of this section.

1.3 REFERENCE DOCUMENTS

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

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

C. NSF/ANSI 14 – Plastic Piping System Components and Related Materials.

1.4 DEFINITIONS

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

1.5 SUBMITTALS

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

1.6 QUALITY ASSURANCE

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

B. Material shall comply with manufacturer’s specifications.

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

1.7 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.

1.8 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 PIPE AND PIPING PRODUCTS

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

B. Pipe shall be Aquatherm® Green Pipe® MF® or Blue Pipe® MF®, available from Aquatherm, NA. Piping specifications and ordering information are available at www.aquatherm.com or Approved Equal.

2.2 FITTINGS

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

B. Fittings shall be Aquatherm® Green Pipe® or Blue Pipe® available from Aquatherm, NA. Fittings specifications and ordering information are available at www.aquatherm.com or Approved Equal.

2.3 WARRANTY

A. Manufacturer shall warrant pipe and fittings for 10 years to be free of defects in materials or manufacturing.

B. Warranty shall cover labor and material costs of repairing and/or replacing defective materials and repairing any incidental damage caused by failure of the piping system due to defects in materials or manufacturing.

C. Warranty shall be in effect only upon submission by the contractor to the manufacturer valid pressure/leak test documentation indicating that the system was tested and passed the manufacturer’s pressure/leak test.

2.4 VALVES

A. Valves shall be manufactured in accordance with the manufacturer's specifications and shall comply with the performance requirements of ASTM F 2389 or CSA B137.11. The valves shall contain no rework or recycled thermoplastic materials except that generated in the manufacturer's own plant from resin of the same specification from the same raw material.

B. Valves shall be Aquatherm® available from Aquatherm, NA. Valve specifications and ordering information are available at www.aquatherm.com.

2.5 SMOKE AND FIRE RATINGS

A. Where indicated on the drawings that a Plenum-rated Piping System is needed, the pipe shall be wrapped and/or insulated with standard pipe insulation, field installed. The pipe wrap or insulation shall meet the requirements of CAN/ULC-S102.2-03 or ASTM E84. The system shall have a Flame Spread Classification of less than 25 and Smoke Development rating of less than 50.

2.6 UV PROTECTION

A. Where indicated on the drawings that the pipe will be exposed to direct UV light for more than 30 days, it shall be provided with a Factory applied, UV-resistant coating or alternative UV protection.

2.7 THERMAL AND VAPOR BARRIER

A. Insulation materials furnished and installed hereunder should meet the minimum thickness requirements of American Society of Heating, Refrigeration, and Air Conditioning Engineers ASHRAE 90.1 (current edition), "Energy Efficient Design of New Buildings." However, if other factors such as condensation control or personnel protection are to be considered, the selection of the thickness of insulation should satisfy the controlling factor.

B. Where standard pipe insulation is indicated on the drawings or in these specifications, the contractor shall provide a thermal (radiant, conductive, and convective) and vapor barrier insulation. The insulation products shall be provided in 3 R-value and 1 ½" thickness or as indicated on the drawings or elsewhere in these specifications. The standard pipe insulation shall be UV resistant, CFC-free, non-porous, non-fibrous, and resist mold growth.

1. For indoor systems operating at temperatures from 0°F (-18°C) to 200°F (93°C):
   a. Owens CorningTM FiberglasTM Insulation for Aquatherm with SSL II® Positive Closure System, or approved equal.

2. For systems operating below ambient (32°F (0°C) to +65°F (18°C)) temperature:
   a. Owens CorningTM VaporWick® Pipe Insulation for Aquatherm, or approved equal.

2.8 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. Expansion Tanks:
   a. Amtrol, Inc.
   b. Armstrong Pumps, Inc.
   c. ITT Bell & Gossett; ITT Fluid Technology Corp.
   d. Taco, Inc.

2. Air Separators and Air Purgers:

a. Spirotherm.
b. Or Approved Equal.

2.9 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. 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.

D. 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.

E. 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.

F. 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.

G. 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.

H. 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.

I. 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.

J. 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.

K. 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.

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

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of domestic water piping. Indicated locations and arrangements are used to size pipe and calculate friction loss, expansion, and other design considerations. Install piping as indicated unless deviations to layout are approved on coordination drawings.

B. Installers shall be trained and certified to install the pipe according to the manufacturer's guidelines. Contact your local Aquatherm representative for training.

C. Install listed pipe materials and joining methods below in the following applications:
1. Underground Piping: Polypropylene (PP-R) piping in SDR 7.4, 11, or 17.6 per manufacturer's instructions and ASTM D2774.
2. Aboveground: Polypropylene (PP-R) piping in SDR 7.4, 11, or 17.6 based on the required minimum pressure rating and use temperature, in accordance with manufacturer's instructions and ASTM F2389.

D. Installation must be accomplished with the proper tools for installing Aquatherm piping following manufacturer's instructions. Installation tools are available from your local Aquatherm representative. Tools may be purchased or rented.

E. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

3.2 FUSION WELDING OF JOINTS

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

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

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

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

3.3 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 gate valves close to the main on each branch and riser serving 2 or more equipment connections and where indicated.

G. Install gate or ball valves on the inlet to each equipment item and elsewhere as indicated.

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

I. Install swing check valve on the discharge side of each pump and elsewhere as indicated.

J. Install ball valves in each hot-water circulating loop and the discharge side of each pump.

K. Fire stopping shall be provided to both be compatible with the Aquatherm Piping and meet the requirements of ASTM E 814 or ULC S115 , “Fire Tests of Through-Penetration Firestops”. Pipe insulations or fire resistive coating shall be removed where the pipe passes through a fire stop and, if required by the firestop manufacturer, for 3 inches beyond the firestop outside of the fire barrier.

L. When installed in systems with pumps in excess of 7.5 HP, piping shall be protected from excessive heat generated by operating the pump at shut-off conditions. Where the possibility exists that the pump will operate with no flow, the protection method shall be a temperature relief valve or comparable level of protection, set to a maximum temperature of 185°F.

M. If heat tracing or freeze protection is specified for the piping, it should be installed on the pipe interior or exterior. It must be suitable for use with plastic piping and be self-regulating to ensure that the surface temperature of the pipe and fittings will not exceed 70°C (158°F).

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.

C. Comply with requirements for seismic-restraint devices in Section 23 0548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."

D. Comply with requirements for pipe hanger, support products, and installation in Section 23 0529 "Hangers and Supports for Plumbing Piping and Equipment."

   1. Vertical Piping: MSS Type 8 or 42, clamps.
   2. Individual, Straight, Horizontal Piping Runs:

      a. Adjustable, steel clevis hangers.
      b. Clamps on strut trapeze.
      c. Clamps on strut attached to structure.
      d. Clamps attached directly to the structure.

   3. Base of Vertical Piping: MSS Type 52, spring hangers.

E. Support vertical piping and tubing at base and at each floor. For piping 2” (63mm) or smaller, install mid-story guides.

F. Install hangers and supports at intervals specified in the applicable Plumbing Code and/or as recommended by pipe manufacturer.

G. For hot water piping, provide clamps and supports that are felt or rubber/vinyl coated or lined.

H. For cold water piping supports and clamps may be bare metal. Ensure that the clamp or support does not have sharp edges that may scrape or gouge the piping.

I. Use care when installing riser clamps to not over tighten the clamps to cause indentation of the pipe.

3.4 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 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.

D. 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.

E. 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.

F. 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.

3.5 EXPANSION AND CONTRACTION

A. Provide expansion and contraction controls, guides and anchors to take into account the expansion and contraction of the pipe. Provide expansion loops or offsets as required and as indicated in the manufacturer's literature.

1. While Aquatherm MF (faser) piping can absorb most of their own expansion stresses, this can cause the pipe to bow or bend.
2. Install anchor points at least every 120 feet.
3. Install expansion loop or offset between each anchor point. Expansion device must be able to absorb all of the stresses between the two anchor points. Refer to manufacturer's published instructions, formulas and calculations at www.aquatherm.com.
4. Non-MF pipes used for hot applications shall have expansion controls every 30 feet of straight runs.
5. Vertical risers of MF piping shall be anchored at each floor.
6. Provide anchor poi

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.

B. 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.

3.9 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.

3.10 PRESSURE TESTING

A. While still accessible all piping shall be pressure/leak tested to the manufacturer’s standards. Tests shall be carried out using water, compressed air or a mixture of the two. The test pressure shall be as indicated in the pressure leak testing procedures required by the manufacturer. Any leaks detected shall be repaired at the contractor’s expense by removing the leaking part and replacing with new parts welded per the pipe manufacturer’s guidelines. See www.aquatherm.com for additional details and forms.

3.11 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.

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

END OF SECTION 23 2113

SECTION 23 2115 – CHILLED WATER 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 chilled water supply and return piping 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. Chilled water 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 cooling 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 cooling 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. Cooling 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 –CHILLED WATER 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 spirotherm spirotop automatic air vent.

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 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

2.5 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

2.6 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 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 2500 – CHEMICAL WATER TREATMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

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

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

1.3 SUBMITTALS

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

1.4 MAINTENANCE

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

PART 2 - PRODUCTS- NOT USED

PART 3 - EXECUTION

3.1 INSTALLATION

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

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

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

END OF SECTION 23 2500

SECTION 23 2510 – GLYCOL SYSTEM

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

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

PART 2 - PRODUCTS

2.1 MATERIALS

A. Chilled water system shall be a 40% glycol and water system. Furnish and install an automatic glycol pump and fill system and fill the chiller, coils and piping system with the solution.

B. Coils, pumps, and piping have been sized to handle the 40% solution.

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

PART 3 - EXECUTION

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

END OF SECTION 23 2510

SECTION 23 6210 - SCROLL WATER CHILLERS (AIR-COOLED)

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Chiller package.

B. Charge of refrigerant and oil.

C. Controls and control connections.

D. Chilled water connections.

E. Starters.

1.02 REFERENCES

A. ANSI/AHRI 550/590-2011 - Standard for Water Chilling Packages using the Vapor Compression Cycle.

B. AHRI 370 – Sound Rating of Large Outdoor Refrigerating and Air-Conditioning Equipment

C. ANSI/ASHRAE 15 - Safety Code for Mechanical Refrigeration.

D. ANSI/ASHRAE 90.1 - Energy Efficient Design of New Buildings.

E. ANSI/ASME Boiler and Pressure Vessel Code SEC VIII, Division 1

F. UL 1995 - Central Cooling Air Conditioners.

G. ANSI/AFBMA 9-1978 - Load Ratings and Fatigue Life for Ball Bearings.

H. California Administrative Code - Title 24

I. ASTM B117 - Standard Method of Salt Spray (Fog) Testing

J. ASTM A123 - Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products

K. ASTM A525 - Zinc (Hot-Dip Galvanized) Coatings on Sheet Steel Products

L. ASTM D1654 - Evaluation of Painted or Coated Specimens, Subjected to Corrosive Environments

1.03 SUBMITTALS

A. Submit drawings indicating components, assembly, dimensions, weights and loadings, required clearances, and location and size of field connections. Indicate accessories where required for complete system.

B. Submit product data indicating rated capacities, weights, specialties and accessories, electrical requirements and wiring diagrams.

C. Submit manufacturer's installation instructions.

1.04 OPERATION AND MAINTENANCE DATA

A. Submit operation data.

B. Include start-up instructions, maintenance data, controls, and accessories.

C. Submit maintenance data.

1.05 REGULATORY REQUIREMENTS

A. Conform to AHRI 550/590-2011 Standard for testing and certified rating of Water Chilling Packages using the Vapor Compression Cycle.

B. Conform to ANSI/UL 1995 code for construction of water chillers. In the event the unit is not UL approved, the manufacturer shall, at manufacturer expense, provide for a field inspection by an UL representative to verify conformance to UL standards. If necessary, contractor shall perform modifications to the unit to comply with UL, as directed by the UL representative.

C. Conform to ANSI/ASME Boiler and Pressure Vessel Code SEC 8 for construction and testing of water chillers.

D. Conform to ANSI/ASHRAE 15 code for construction and operation of water chillers.

E. Chiller must be built in an ISO 9001 classified facility.

1.06 VERIFICATION OF CAPACITY AND EFFICIENCY

A. Factory Functional Test: The chiller shall be pressure tested, evacuated and fully charged with R134a refrigerant and oil. In addition, a factory functional test to verify correct operation by cycling condenser fans, compressors and reading data points from temperature and pressure sensors.

B. Chiller manufacturer shall have a factory trained and supported service organization that is within a 75 mile radius of the site.

1.07 SUBMITTALS

A. Submit shop drawings and product data in accordance with the specifications.

B. Submittals shall include the following:

1. Dimensioned plan and elevation view drawings, required clearances, and location of all field connections.

2. Weights and loading document.

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

1.08 STORAGE AND HANDLING

A. Comply with manufacturer's installation instructions for rigging, unloading, and transporting units.

B. Unit controls shall be capable of withstanding 203 Deg F (95 Deg C) storage temperatures in the control compartment for an indefinite period of time.

1.09 WARRANTY

A. Provide a full parts warranty for one year from start-up or 18 months from shipment, whichever occurs first.

B. A 5-year motor/transmission/compressor warranty shall be provided.

1.10 MAINTENANCE SERVICE

A. All inspections and service of units shall be accomplished by factory trained and authorized servicing technicians.

B. OEM shall provide and report quarterly, annual, and bi-annual maintenance in compliance with or better than ASHRAE Standard 180-2008.

C. Include maintenance items as recommended in manufacturer's operating and maintenance data.

D. Submit copy of service call work orders and summary report to the Owner, including description of work performed, operating performance status and noted exceptions.

PART 2 PRODUCTS

2.01 SUMMARY

A. The contractor shall furnish and install air-cooled water chillers as shown as scheduled on the contract documents. The chillers shall be installed in accordance with this specification and perform at the specified conditions as scheduled.

APPROVED MANUFACTURERS
1. Trane Model CGAM
2. Equal by Carrier, or York.
3. Others require prior approval a minimum of 7 days prior to bid opening.

2.02 COMPRESSORS

A. Construct chiller using semi-hermetic, direct-drive, helical rotary screw compressors with capacity control via a variable speed drive and independent circuits.

B. Provide oil lubrication system with oil charging valve and oil filter to ensure adequate lubrication during starting, stopping, and normal operation.

C. Provide compressor with automatic capacity reduction equipment consisting of a capacity control variable speed drive. The controls system logic must decelerate the compressor to minimum speed for a soft start.

D. Provide direct-drive compressor motor that is suction gas cooled with robust construction and system design protection. Compressor starter shall be a variable speed drive to provide a soft start. Compressors without variable speed drive shall be provided with a wye-delta or solid state starter for reduced inrush current upon starting.

E. Provide compressor heater to evaporate refrigerant returning to compressor during shut down. Energize heater when compressor is not operating.

2.03 EVAPORATOR

A. The evaporator shall be designed, tested, and stamped in accordance with ASME code for a

refrigerant side working pressure of 200 psig. Waterside working pressure shall be 150 psig.

B. Insulate the evaporator and water boxes with a minimum of 1.25 inch (K=0.28) UV rated insulation. If the insulation is field installed, the additional money to cover material and installation costs in the field should be included in the bid.

C. Evaporator heaters shall be factory installed and shall protect unit down to -20 F. Contractor shall wire separate power to energize heat tape and protect cooler while chiller is disconnected from the main power.

D. Provide shell and tube type evaporator, seamless or welded steel construction with cast iron or fabricated steel heads, seamless internally and externally finned copper tubes, roller expanded into tube sheets.

E. Provide ability to remove evaporator tubes from either end of the heat exchanger.

F. Provide water drain connection, vent and fittings for factory installed leaving water temperature control and low temperature cutout sensors.

G. Water connections shall be grooved pipe. Evaporator shall have only one entering and one leaving connection. If manufacturer provides 2 separate evaporators, contractor shall provide manifold and pressure gauges to ensure equal flow is provided to each evaporator.

H. Proof of flow shall be provided by the equipment manufacturer, mechanically installed and electrically wired, at the factory of origin.

2.04 CONDENSER AND FANS

A. Low Sound Fans shall by dynamically and statically balanced, direct drive, corrosion resistant glass fiber reinforced composite blades molded into a low noise fan blade.

B. Chiller shall be able to start and operate in ambient conditions down to 15ºF (with water) or 0ºF (with glycol) and up to 105ºF (40.6ºC). Low ambient operation is accomplished with variable frequency drives on the condenser fans and control logic.

C. Construct condenser coils of aluminum fins mechanically bonded to internally finned aluminum tubing. The condenser coils shall have an integral subcooling circuit and shall be factory proof and leak tested at 385 psig.

D. Provide factory installed, louvered, "architecturally pleasing" guard panels. Panel louvers shall cover condenser, evaporator and compressor sections so all are hidden from sight. Wire screens or wire mesh will not be allowed.

2.05 ENCLOSURES / STARTERS

A. House components in a galvanized steel frame and mounted on a formed steel base. Hot-dip galvanized steel frame coating shall be Underwriters Laboratories Inc. (UL) recognized as G90-U, UL guide number DTHW2.

B. Unit panels, base rails and control panels shall be finished with a baked on powder paint. Control panel doors shall have door stays. Paint system shall meet the requirements for outdoor equipment of Federal Government Agencies.

C. Mount starters and Terminal Blocks in a UL 1995 rated weatherproof panel provided with full opening access doors. If a circuit breaker is chosen, it should be a lockable, through-the-door type with an operating handle and clearly visible from outside of unit indicating if power is on or off.

D. Casings fabricated from steel that do not have a Zinc coating conforming to ASTM A 123 or ASTM A525 shall be treated for the prevention of corrosion with a factory coating or paint system. The coating or paint system shall withstand 1000 hours in a salt-spray fog test in accordance with ASTM B 117. Each specimen shall have a standard scribe mark as defined in ASTM D 1654. Upon completion of exposure, the coating or paint system shall be evaluated and rated in accordance with procedures A and B of ASTM D 1654. The rating of failure at the scribe mark shall be not less than six (average creepage not greater than 1/8 inch). The rating of the unscribed area shall not be less than ten (no failure). Thickness of coating or paint system on the actual equipment shall be identical to that on the test specimens with respect to materials, conditions of application, and dry-film thickness. For each compressor provide a variable speed drive starter. Across-the-line and Delta-Delta shall be unacceptable. If a variable speed drive starter is not applicable, wye-delta or solid state starter must be provided.

E. A control power transformer shall be factory-installed and factory-wired to provide unit control power.

2.06 VARIABLE SPEED DRIVE

A. VARIABLE SPEED DRIVE (VSD), UNIT MOUNTED

1. The water chiller shall be furnished with a liquid cooled variable speed drive (VSD). The VSD shall be factory mounted on the chiller and shipped completely factory assembled, wired and tested.

2. The VSD will be specifically designed to interface with the water chiller controls and allow for the operating ranges and specific characteristics of the chiller. The VSD control logic shall optimize chiller efficiency by coordinating compressor motor speed to maintain the chilled water setpoint.

3. The VSD efficiency shall be 95% or better at full speed and full load. Fundamental displacement power factor shall be a minimum of 0.95.

4. The VSD shall be solid state, microprocessor based pulse-width modulated (PWM) design. The VSD shall be voltage and current regulated. Output power devices shall be IGBT transistors.

5. Power semi-conductor and capacitor cooling shall be from a liquid cooled heatsink.

6. The water chiller shall be furnished with a refrigerant cooled variable speed drive (VSD) to minimize maintenance and maximize cooling efficiency. If a water cooling design is used, especially an open loop condenser water design, a cleanable shell and tube heat exchanger must be supplied. Plate and frame heat exchangers are not allowed. The VSD shall be factory mounted on the chiller and shipped completely factory assembled, wired and tested.

7. The VSDs shall each be furnished in a UL 1995 rated metal enclosure having as minimum a short circuit withstand rating of 65,000 amps per UL 508. It will include three phase input lugs plus a grounding lug for electrical connections, output motor connection via factory installed bus bars and all components properly segregated and completely enclosed in a single metal enclosure.

    a. Enclosure shall include a padlockable, door-mounted circuit breaker with shunt trip and AIC rating of 65,000 amps.
    b. The entire chiller package shall be UL/CUL listed.

8. The VSD shall include the following features:

a. All control circuit voltages are physically and electrically isolated from power circuit voltage.
b. Soft start, adjustable linear acceleration, coast-to-stop.
c. Adjustable current limiting and UL approved electronic motor overload protection.
d. Insensitivity to incoming power phase sequence.
e. VSD and motor protection from the following faults: - Output line-to-line short circuit protection - Line-to-ground short circuit protection - Phase loss at AFD input - Phase reversal / Imbalance - Over-voltage - Under-voltage - Over temperature

9. The following VSD status indicators shall be available to facilitate startup and maintenance: - Output speed in hertz and rpm - Input line voltage - Input line kW - Output/load amps - Average current in percent RLA - Load power factor - Fault - VSD transistor temperature

10. Warranties

a. The variable speed drive shall be warranted by the manufacturer for a period of twelve months from the date of installation. The warranty shall include parts, labor, travel costs, and living expenses incurred by the manufacturer to provide factory-authorized on-site service.

2.07 REFRIGERANT CIRCUIT

A. All units shall have 2 refrigeration circuits to provide redundancy, each with one or two (manifolded) compressor(s) on each circuit.

B. Provide for each refrigerant circuit:

1. Liquid line shutoff valve.

2. Suction Service Valve

3. Filter (replaceable core type).

4. Liquid line sight glass.

5. Electronic expansion valve sized for maximum operating pressure.

6. Charging valve.

7. Discharge and oil line check valves.

8. High side pressure relief valve.

9. Full operating charge of HFC-134a and oil.

C. Capacity Modulation: Provide capacity modulation by a variable speed drive. Unit shall be capable or operation down to 20%.

2.08 CONTROLS

A. Chilled water temperature control shall be microprocessor-based, proportional and integral controller to show water and refrigerant temperature, refrigerant pressure, and diagnostics. This microprocessor-based controller is to be supplied with each chiller by the chiller

manufacturer. Controls shall include the following readouts and diagnostics:

1. Phase reversal/unbalance/single phasing and over/under voltage protection.

2. Low chilled water temperature protection.

3. High and low refrigerant pressure protection.

4. Load limit thermostat to limit compressor loading on high return water temperature.

5. Condenser fan sequencing to automatically cycle fans in response to load, expansion valve pressure, condenser pressure, and differential pressure to optimize unit efficiency.

6. Display diagnostics.

7. Oil pressure control based off of maintaining system differential pressure.

8. Compressors: Status (on/off), %RLA, anti-short cycle timer, and automatic compressor lead-lag.

B. On chiller, mount weatherproof control panel, containing starters, power and control wiring, factory wired with terminal block power connection. Provide primary and secondary fused control power transformer and a single 115 volt 60 Hz single phase connection for evaporator freeze protection heaters.

1. The unit controller shall utilize the following components to automatically take action to prevent unit shutdown due to abnormal operating conditions which will perform as follows:

   a. High pressure switch that is set 20 PSIG lower that factory pressure switch that will automatically unload the compressor to help prevent a high pressure condenser control trip. One switch is required for each compressor and indicating light shall also be provided.
   b. Motor surge protector that is set at 95% of compressor RLA that will automatically unload the compressor to help prevent an over current trip. One protector is required for each compressor and indicating light shall also be provided.
   c. Low pressure switch that is set at 5 PSIG above the factory low pressure switch that will automatically unload the compressor to help prevent a low evaporator temperature trip. One switch is required for each compressor and indicating light shall also be provided.

C. In the above case, the chiller will continue to run in an unloaded state, and will continue to produce some chilled water in an attempt to meet the cooling load. However, if the chiller reaches the trip-out limits, the chiller controls will take the chiller off line for protection, and a manual reset will be required. Once the "near-trip" condition is corrected, the chiller will return to normal operation and can then produce full load cooling.

D. Provide the following safety controls with indicating lights or diagnostic readouts.

1. Low chilled water temperature protection.

2. High refrigerant pressure.

3. Low oil flow protection.

4. Loss of chilled water flow.

5. Contact for remote emergency shutdown.

6. Motor current overload.

7. Phase reversal/unbalance/single phasing.

8. Over/under voltage.

9. Failure of water temperature sensor used by controller.

10. Compressor status (on or off).

E. Provide the following operating controls:

1. A variable method to control capacity in order to maintain leaving chilled water temperature based on PI algorithms. Five minute solid state anti-recycle timer to prevent compressor from short cycling. Compressor minimum stop-to-start time limit shall be 2 minutes. If a greater than 5 minute start-to-start, or greater than 2 minute stop-to-start timer is included, hot gas bypass shall be provided to insure accurate chilled water temperature control in light load applications.

2. Chilled water pump output relay that closes when the chiller is given a signal to start.

3. Load limit thermostat to limit compressor loading on high return water temperature to prevent nuisance trip outs.

4. High ambient unloader pressure controller that unloads compressors to keep head pressure under control and help prevent high pressure nuisance trip outs on days when outside ambient is above design.

5. Compressor current sensing unloader unit that unloads compressors to help prevent current overload nuisance trip outs.

6. Auto lead-lag functions that constantly even out run hours and compressor starts automatically. If contractor cannot provide this function then cycle counter and hour meter shall be provided for each compressor so owner can be instructed by the contractor on how to manually change lead-lag on compressors and even out compressor starts and running hours.

7. Low ambient lockout control with adjustable setpoint.

8. Condenser fan sequencing which adjusts the speed of all fans automatically in response to ambient, condensing pressure and expansion valve pressure differential thereby optimizing unit efficiency.

F. Provide user interface on the front of the panel. If display is on the inside of the panel, then a control display access door shall be provided to allow access to the display without removal of panels. Provide user interface with a minimum of the following features:

1. Leaving chilled water setpoint adjustment from LCD input

2. Entering and leaving chilled water temperature output

3. Percent RLA output for each compressor

4. Pressure output of condenser for circuits one and two

5. Pressure output of evaporator for circuits one and two

6. Ambient temperature output

7. Voltage output

8. Current limit setpoint adjustment from LCD input.

9. Remote leaving water temperature setpoint. [OPTIONAL]

10. Alarm indicating light and relay [OPTIONAL]

G. Digital Communications to BAS system shall consist of a BACnet MS/TP interface via a single twisted pair wiring. [OPTIONAL]

H. The chiller control panel shall provide leaving chilled water temperature reset based upon return water temperature.

I. The chiller control panel shall provide an alarm relay output that shall energize whenever a fault requiring manual reset is detected by the panel. [OPTIONAL]

J. The chiller control panel shall provide input for leaving chilled water temperature setpoint based upon a 2-10VDC or 4-20mA signal from a building automation system.

K. The chiller control panel shall provide an output for chiller Percent Capacity via a 2-10VDC or 4-20mA signal to a building automation system.

2.09 SOUND

A. Acoustic treatment consisting of insulating sound material applied to the suction and discharge lines of each refrigerant circuit. An acoustically treated compressor enclosure for each compressor and a variable speed drive for each condenser fan to reduce the fan speed shall be included to further attenuate the chiller. If chiller does not meet the scheduled sound levels, chiller manufacturer shall pay for field installed treatment to meet scheduled sound performance.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Align chiller package on steel or concrete foundations.

C. Install units on vibration isolators.

D. Connect to electrical service.

E. Connect to chilled water piping.

F. Arrange piping for easy dismantling to permit tube cleaning.

3.02 MANUFACTURER'S FIELD SERVICES

A. OEM Startup is performed by factory trained and authorized servicing technicians confirming equipment has been correctly installed and passes specification checklist prior to equipment

becoming operational and covered under OEM warranty.

1. Included in OEM Factory Startup:
   Centrifugal and Rotary Screw/Scroll Chillers

B. Applied Chiller manufacturers shall maintain service capabilities no more than 300 miles from the jobsite.

C. The manufacturer shall furnish an alternative price for:

1. Extended compressor warranty for 5 years.

D. The manufacturer shall furnish complete submittal wiring diagrams of the package unit as applicable for field maintenance and service.

END OF SECTION 23 6210

END OF DIVISION 23