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SPECIFICATIONS

SECTION 21 05 00

COMMON WORK RESULTS FOR FIRE SUPPRESSION

PART 1 – GENERAL

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PART 2 – NOT USED

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END OF SECTION

SECTION 21 08 00

COMMISSIONING OF FIRE SUPPRESSION SYSTEM

PART I – GENERAL

1.1 RELATED DOCUMENTS

A. The requirements of the General Conditions, Supplemental Conditions and Section 23 05 02 apply to all work specified in this section.

1.2 SPECIFIC REQUIREMENTS

A. All tests shall be made in the presence of the Architect or their representatives, and the local authorities having jurisdiction of the work to be tested, as may be directed. At least 72 hours notice shall be given in advance of all tests.

B. The Work of this Contractor shall include the furnishing of all testing instruments, gauges, pumps, compressors and other equipment required or necessary for tests, required by laws, rules and regulations and as specified. All tests shall be made at the expense of the Contractor.

C. Before any paint is applied, the combined sprinkler/standpipe system shall be tested hydrostatically at not less than 250 psi pressure for two (2) hours minimum. In addition to this testing, provide all other tests and certifications required by the local inspectors, Factory Mutual and all other Authorities Having Jurisdiction.

D. Systems installed in multiple phases shall be tested at the completion of each phase. Portions of systems that need to remain in service during construction shall be tested before return to service if taken off-line to complete work. Provide hydraulic calculations for each phase if systems are brought online in a state of partial completion that may impact hydraulics.

E. All appurtenances shall be operated after installation to confirm proper operation.

F. If the installation fails to meet testing requirements the Contractor shall determine, at his own expense, identify the source or sources of leakage or failure and shall repair or replace all defective materials or workmanship at no additional cost to the Owner. The completed pipe installation shall be re-tested after the defects have been corrected. No caulking on screwed joints, cracks or holes will be acceptable.

G. Tests are not permitted to be made with air except as noted.

H. All piping which is to be enclosed in partitions or hung ceilings shall be tested and made tight and tested when directed by the Construction Supervisor and in adequate time to permit the installation of partitions and ceilings. When necessary, the

Contractor shall drain the piping and/or take over such precautions as required to prevent damage by freezing.

I. The Contractor shall be responsible for the Work of other trades that may be damaged or disturbed by the tests, or the repair or replacement of his Work, and he shall, without extra charges, restore to its original condition any Work so damaged or disturbed.

PART 2 – NOT USED

PART 3 – NOT USED

END OF SECTION

SECTION 21 13 00

FIRE SUPPRESSION SPRINKLER SYSTEMS

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Provide a complete fire protection system as indicated on the Drawings and as specified herein consisting of the following but not limited thereto.

1. Complete sprinkler systems including relocations and connections to new and existing systems, sprinkler heads, valves, all required accessories, etc.
2. Sleeve, hangers and supports.
3. Apply for, obtain and pay for all permits certificates, inspections and approvals required in connection with all Fire Protection Work.
4. Shop drawings: Shop drawings shall be produced in accordance with generally accepted standards for shop drawings and coordination drawings and shall be based on the Contractor's own field measurements. When a project is "phased" the Contractor shall anticipate that multiple filings may be required to allow permitting and approval of the project in a phased manner and shall prepare shop drawings and hydraulic calculations in packages matched to the final phasing plan.
5. Color coding and stenciling of all piping systems.
6. Cutting and rough and finish patching.
7. Prime and finish painting of all pipe risers and mains.
8. Hydrant flow tests unless recent data is specifically indicated on drawings and age of test data provided is acceptable to Authority Having Jurisdiction for duration of project.
9. Provide hydraulic calculations and drawings signed and sealed by a licensed professional engineer all as required by applicable Building Code, FM Global Referenced Standards, and N.F.P.A. Code. Contractor shall replace Engineer as Engineer of Record.
10. Provide ladders to all valves more than 7'-6" above finished floor.
11. Tests for all systems provided under this Section of the Specifications.
12. Where due to Union regulations or trade agreements, any of the work shown on the Drawings or specified herein is not considered Fire Protection Contractor's Work, this Contractor shall sub-contract the work in question, but this Contractor shall be held responsible for the complete installation.
13. It is not the intention of these Specifications to describe, nor the Contract Drawings to show in detail, all the various pieces of apparatus and appurtenances and their connections. This Contractor shall, as part of the Contract, furnish and install all incidentals, such as piping, fittings, valves, etc., required to complete the installation of the equipment. This Contractor shall refer to Architectural Drawings for exact location of devices including type and quantities. This Contractor shall be responsible for providing and connecting all fixtures and equipment.

14. All work described in these Specifications and not shown on the Drawings, or vice versa, shall be installed in a manner similar to the work shown or described.
15. Sprinkler drawings shall be reviewed and approved by insurance underwriters prior to installation.
16. All drains shall discharge to sanitary. Verify capability of existing drains to accept full flow discharge. If connection to sanitary sewer is determined to be infeasible or cost prohibitive, alternatives like splash blocks to prevent erosion (during discharging water to grade) may be considered.

B. It is the intent of this Specification for the Contractor to provide complete hydraulically designed wet sprinkler systems for the areas indicated in these Specifications and shown on the Contract Drawings. This Contractor shall be the Engineer of record for the fire sprinkler system. Furnish all design, material, and labor to complete the contract within the intent of these Specifications and Contract Drawings even though each and every item necessary is not specifically mentioned or shown.

1.2 QUALITY ASSURANCE

A. Contractor Qualifications: Work shall be performed by a Contractor regularly engaged in the design and installation of fire protection systems in accordance with NFPA requirements and having at least ten years continuous experience in this type of work. Experience shall include projects of similar type, size and complexity.

B. Design Criteria: Provide fire protection systems of types, pressure, flow and densities required by regulatory agencies having jurisdiction.

1. Systems shall be calculated in a manner acceptable to regulatory agencies.
2. Contractor shall complete a hydrant test to confirm static and residual pressure for use in the hydraulic calculation. Contractor shall not assume that a prior hydrant test has been completed unless the test data is presented on the drawings. The Contractor shall complete all required hydrant tests or sub-contract this work to qualified testing parties.
3. Provide the following sprinkler head densities:

   .10 GPM/SQFT – Light Hazard
   .15 GPM/SQFT – Ordinary Hazard
4. Occupancy classification: Mixed – Light and Ordinary hazard.
5. Maximum sprinkler head spacing – based on NFPA Code: Light hazard- 225 sq.ft./sprinkler head. Ordinary hazard – 130 sq.ft./sprinkler head.
6. Calculations shall be based upon 1500 sq.ft. of the hydraulically most remote area of sprinkler operation for each system unless increased by dry systems or sloped ceiling. (30% increase for each condition).
7. Where source pressure allows, systems shall be sized for a minimum safety margin of 7 PSI. This margin is in addition to the 7 PSI code required minimum required at each head.
8. FM Global DOES NOT recognize NFPA's reduced demand area rules, and as such, they are not allowed for use in designing sprinkler systems.

C. Pipe sizes shown on drawings may be larger than minimum required. This is to accommodate additional partitioning which may occur in the future. Do not reduce sizes.

D. Requirements of Regulatory Agencies: Total system shall be acceptable upon completion and testing to the following:

1. Jurisdictional Code Enforcement Agencies
2. Jurisdictional Insurance Agency or Underwriter
3. Confirm requirements of the authority having jurisdiction and Owner's Insurance Underwriter prior to bid.

E. The Contractor shall give necessary notices, file drawings and specifications with the department having jurisdiction, obtain permits or licenses necessary to carry out this work and pay all fees therefore.

F. Certificate of Installation: Submit certificate upon completion of fire protection work, stating that the work has been completed and tested in accordance with the specified standards, that there are no defects in the system and it is operational.

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

1.3 CODES AND STANDARDS

A. In addition to those specified in Section 21 05 02, comply with local fire department regulations and with the following:

1. Local Water Department
2. Local Building Department
3. Connecticut Building Code
4. Factory Mutual Engineering Division (FM)
5. Local Health Department
6. Connecticut Department of Buildings
7. NFPA 13, 14, 24, 231C
8. Local `modifications to the Fire Codes
9. UL 218 Standard for Fire Pump Controllers
10. UL 1008 Automatic Transfer Switches
11. UL 508 Industrial Control Equipment
12. NFPA 20 Installation of Centrifugal Fire Pumps
13. NFPA 70 National Electrical Code

B. All materials and equipment used in the installation of the fire protection system shall be as approved in the Underwriters' Laboratories list of inspected fire protection equipment and materials, or the Factory Mutual Laboratories list of approved equipment and fire protection devices involving fire hazard, and shall be the latest product of the manufacturer, and shall bear their label.

1.4 SUBMITTALS

A. Submittal data shall be in accordance with Division 1 and the following shall be submitted for review to the Architect prior to the start of installation.

B. Material and equipment information shall include catalog cuts and technical data for each system component or device. This shall include, but not be limited to piping, fittings, globe and angle valves, O.S.&Y valves, butterfly valves, check valves, automatic sprinkler heads, escutcheons, hangers, flow switches, tamper switches, dry pipe valves, fire pumps, jockey pumps, pre-action valves, air maintenance device and air compressor.

C. Prepare shop drawings showing layout of fire protection system and piping. Use minimum scale of 3/8" = 1'-0" for floor plans. Drawings shall be based on the Contractors field measurements and information collected in coordination meetings, discussions and correspondence with other trade contractors and shall reckon with all building components and show routing of piping to clear same. Drawings shall be accurately dimensioned to show proposed location of all fire protection system components. Drawings shall be of sufficient detail to allow the creation of a bill of materials for off-site fabrication of at least 90% of the installed system piping. System design shall be completely coordinated with the architectural, structural, mechanical, and electrical features of the building. The drawings shall show all details required by NFPA 13. In all areas with suspended ceilings, reflected ceiling plans shall be prepared showing the location of sprinklers, lights, diffusers, grilles, etc. Drawings shall be suitable for filing with DOB, FM and FD. Contractor and Contractor's Engineer shall complete these filings with DOB and FM.

D. On some projects the Owner will insist that the Engineer provide CAD files of the Engineering drawings for the Contractor's use. When the Contractor has been provided with the Engineer's CAD files, these files shall not be used to prepare the as-built drawings and drawings similar to the Engineer's contract drawings will not be accepted as as-built drawings.

E. Submit a complete schedule of the material and equipment proposed for this installation to the Architect/Engineer for approval. Include catalog cuts, diagrams, drawings, and such other descriptive data as may be required to clearly show what is intended to be installed and how. In the event any items of material or equipment contained in the schedule fail to comply with the specifications, such items may be rejected.

F. Submit to the engineer five (5) sets of blueprints and hydraulic calculations signed and sealed by a Professional Engineer retained by the contractor. After approval by the engineer, submit three (3) copies of the drawings and hydraulic calculations of the sprinkler system to the regulatory agencies having jurisdiction, including FM Global. Update the drawings to reflect any comments and resubmit the drawings until approval is obtained. Upon receipt of approval submit the drawings and hydraulic calculations to the Architect for record. Approval of the Architect must be obtained before purchasing or installing any equipment. Submissions shall be signed and sealed by an Engineer retained by the fire protection contractor.

G. Approval of submittals will not relieve the Contractor of the responsibility for correcting any errors which may exist or for meeting requirements of the specifications. No partial submittals will be accepted.

H. A set of approved installation drawings shall be kept at the job site and marked to indicate all installation conditions which are different from the approved drawings.

I. In the event that the contractors final design deviates from the bid documents and a re-filing is required, the contractor shall prepare all documents required for the re-filing and provide adequate copies signed and sealed by an engineer retained by the contractor. Contractor shall also execute any documents required to replace Engineer as Engineer of record if Engineer has previously served as Engineer of Record.

J. Grooved joint couplings and fittings shall be shown on shop drawings and product submittals and shall be specifically identified with the applicable manufacturer style or series number.

K. Sprinklers shall be referred to on drawings, submittals and other documentation, by the sprinkler identification (SIN) or Model number as specifically published in the appropriate agency listing or approval. Trade names or other abbreviated designations shall not be allowed.

L. Manufacturer’s Data: Submit manufacturer’s product data for fire protection valves including:

1. Dimensions
2. Sizes
3. End Connections
4. Weights
5. Installation instructions
6. Instructions on repacking and repairing valves.
7. Range of flow for balancing valves and plug valves.

M. Valve Tag List: Refer to Section 22 05 53 of the Specifications.

N. The final project submittal shall be an as-built drawing signed and sealed by the contractor’s Engineer. The as-built drawing shall document the final installed condition of the fire protection system and shall meet the as-built filing requirements of the Authority Having Jurisdiction.

1.5 DESIGN REQUIREMENTS

A. Engineer’s bid documents are provided to define the scope of the sprinkler work and the general arrangement of systems. It shall be the Contractor’s responsibility to size the sprinkler system pipes in accordance with the requirements of NFPA. Contractor shall submit all calculations to the Engineer for review at time of drawing submittal. Submittal of these calculations to the Engineer will in no way relieve the Contractor of his responsibilities for complete and proper design of the fire protection system. Upon preliminary approval by the Engineer, the Contractor shall prepare a complete set of filing documents for submission to DOB and FM. Filing sets shall be developed in phases as required to allow partial filings and approvals in support of the phasing plan developed for the project. All filings shall include plan drawings suitable for DOB filing and hydraulic calculations as required to support proposed pipe and pump configuration and sizing.

B. The Contractor shall fully inform himself regarding any special characteristics and limitations of the space available for the installation of all materials under Fire Protection Work.

C. The contractor shall ascertain that all his equipment, such as valves, flow switches and such other apparatus as may be necessary to be reached from time to time for operation and maintenance is made easily accessible for operation and maintenance.

D. Existing conditions revealed during demolition may identify conflicts with the building construction. The contractor shall call the Architects attention to this fact before installing this work and shall be guided by their instructions.

E. The contractor shall prepare calculations in accordance with N.F.P.A., Chapter 13, Insurance Carrier Specifications and requirements herein indicated. Calculations shall be prepared for as many areas of application as necessary to demonstrate to the satisfaction of the Insurance Carrier, Building Department and Architect that the system meets the herein outlined criteria.

F. It shall be the Contractor’s responsibility to design the system so that no interferences exist between the fire protection system and work of other trades, equipment and systems designed and installed by others. The latest issues of all architectural, structural, mechanical and electrical drawings shall be reviewed to assist the Contractor in preparing the design so as to avoid interference.

G. This Contractor shall provide all necessary control wiring and equipment necessary for an operational system. This includes, but not limited to, key switches, releasing panels, solenoid valves, etc.

H. Any fees charged by local first responders for false alarms associated with construction activities or installation related conditions will be the responsibility of the Contractor.

I. The Drawings are diagrammatic and indicate the general arrangement and location of equipment, piping, sprinkler heads, etc. Make modifications in the layout work that may be required to suit actual job conditions without extra compensation. Provide additional heads and branch piping for a code compliant system, if necessary, at no additional cost to the Owner.

J. Drawings and Specifications are intended to be fully cooperative. Any materials, equipment, or systems related to this Section and exhibited on the Architectural and Fire Protection Drawings but not mentioned in the Specifications are to be executed to the intent and meaning thereof, as if it were both mentioned in the Specifications and set forth on the Drawings.

K. Should any discrepancy or apparent difference occur between Drawings and Specifications or should occur in the work of others affecting the work, the Contractor shall notify the Architect immediately. If the Contractor proceeds with the Work affected without instructions from the Architect, he shall make good any resultant damage or defect. All misunderstandings of Drawings and Specifications shall be clarified by the Architect.

1.6 EXAMINATION AND COORDINATION

A. The Drawings are diagrammatic and indicate the general arrangement of systems and work indicated under this Section. (Do not scale the Drawings). The Contractor shall consult the Architectural Drawings and Details for exact locations of fixtures, and equipment; where same are not definitely located, he shall obtain this information from the Architect.

B. The Contractor shall follow the Drawings in laying out work and check Drawings of other trades to verify spaces in which work will be installed and maintain maximum headroom and space conditions at all points. Where headroom or space conditions appear inadequate, the Architect shall be notified in writing. The installation shall not proceed before receiving the Architect's written instructions.

C. If directed by the Architect, the Contractor shall, without extra charge, make reasonable modifications in the layout as needed to prevent conflict with work of other trades, maintain required headroom and space conditions, and for proper execution of the work.

D. Where variances occur between the Drawings and the Specifications, or within either document itself, the item or arrangement of better quality, greater quantity, or higher cost shall be included in the Contract. Architect will decide on the item and manner in which the Work shall be installed and his decision shall be final.

E. It shall be the responsibility of the Contractor to closely schedule his work so that his work will be installed at the proper time and without delaying the completion of the entire Project.

F. Where the Fire Protection Work will be installed in close proximity to the Work of other trades, or where there is evidence that the Work of the Contractor will interfere with the Work of other trades, he shall assist in working out space conditions to make a satisfactory adjustment. The Contractor shall work with all trades to prepare composite working drawings and sections at a suitable scale not less than 3/8" = 1'-0" clearly showing how his work is to be installed in relation to the Work of other trades. If the Contractor installs his Work before coordination with other trades or so as to cause interference with Work of other trades, he shall make necessary changes in his Work to correct the condition without extra charge.

G. Study the Drawings and Specifications in order to insure completeness of the Work required under this Section. Supplementary items normal and necessary to complete the Work, though not definitely shown or specified shall be included.

H. Verify all measurements and conditions in the field before starting work.

I. Examine all surfaces to which Work under this Section is to be applied and notify the Architect in writing if any conditions exist which are detrimental to the proper and expeditious installation of Work. Starting of Work shall be understood to be acceptance of surfaces.

J. If it should be necessary to remove and relocate any material or equipment that has been installed without proper investigation and coordination with the work of other Sections, such materials or equipment shall be removed and relocated without additional cost to the Owner.

1.7 WARRANTIES

A. The entire new system shall be warranted to be free from defects for a period of one (1) year from the date of Notice of Acceptance.

1.8 PROJECT RECORD DOCUMENTS

A. Upon completion of the work, the Contractor shall revise all fire protection drawings to agree with the construction as actually accomplished and stamp "As-Built". Those drawings where no change is involved shall be likewise stamped. These "As-Built" drawings shall show the fire protection system as it existed at the completion of the contract work.

B. On some projects the Owner will insist that the Engineer provide CAD files of the Engineering drawings for the Contractor's use. When the Contractor has been provided with the Engineer's CAD files, these files shall not be used to prepare the as-built drawings and drawings similar to the Engineer's contract drawings will not be accepted as as-built drawings.

C. See Division 1 for additional requirements.

1.9 CLEANING, PROTECTION AND ADJUSTING

A. The Contractor shall be responsible for the protection of all fire protection systems equipment against breakage or damage at all times until final acceptance of the job

B. All openings left in floor for passage of supply pipes shall be covered and protected. Due precautions shall be taken against freezing during cold weather. All pipes shall be protected with suitable coverings as soon as set. All open ends of pipes shall be closed by a plug fitting to prevent obstruction and damage.

C. The Contractor shall frequently clean up and remove from the Site all rubbish, scrap materials and debris caused by his Work, and upon completion of the Work and before final payment is made, he shall remove from the site all surplus material, temporary structures, tools and all debris resulting from his operation.

1.10 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including the General Conditions of the Contract and Supplementary General Conditions and Division 1 - General Requirements, apply to work of this Section. This Contractor shall comply with all applicable sections of Divisions 21 through 23.

PART 2 - PRODUCTS

2.1 PIPE AND FITTINGS

A. Pipe joints above ground shall be screwed, flanged, welded, or mechanical couplings. Welded joints are not acceptable in pipe less than 2” in diameter. No welding permitted except with certified welders in shop. No field welding of sprinkler pipe will be permitted. No field made weld-o-lets are permitted.

B. Above ground piping shall be roll grooved Schedule 40 black steel pipe. Schedule 10 (Thin wall) piping is not permitted.

C. Screwed fittings above ground shall be gray cast iron suitable for 175 psi cold water working pressure and so rated.

D. Sprinkler piping and fittings for dry pipe systems shall be galvanized, schedule 40 minimum. All fittings on galvanized piping shall be galvanized in accordance with ASTM A153.

E. Mechanical fittings shall be as follows:

1. Grooved end fittings shall be UL/FM approved, full flow, short radius ductile iron conforming to ASTM A536, or carbon steel conforming to ASTM A53 with factory grooved ends designed to accept mechanical couplings.

2. Grooved mechanical couplings shall be UL/FM approved, consisting of two ASTM A536 ductile iron housings, a pressure-responsive, synthetic rubber gasket, and plated steel bolts and nuts.

a. Rigid Type: Housings shall be cast with offsetting, angle-pattern bolt pads to provide system rigidity and support and hanging in accordance with ASME B31.1 and B31.9

1) 1-1/4” through 4”: “Installation Ready” stab-on design, for direct ‘stab’ installation onto grooved end pipe without prior field disassembly and no loose parts. Victaulic FireLock EZ Style 009.
2) 5” and larger: Standard rigid couplings. Victaulic FireLock Style 005 or Style 07 Zero-Flex.

b. Flexible Type: Use in seismic areas where required by NFPA 13.
   1) 2” through 8”: “Installation Ready” stab-on design, for direct ‘stab’ installation onto grooved end pipe without prior field disassembly and no loose parts. Victaulic Style 177 QuickVic.
   2) 10” and larger: Standard flexible couplings. Victaulic Style 77.

3. Coupling gaskets shall be listed for use as follows:

Fire Protection Service	Temperature Range	Gasket Recommendation
Water/Wet Systems	Ambient	C-Shape, Grade EPDM, Type A

4. Flange adapters shall be ASTM A536 ductile iron, flat faced, designed for incorporating flanges with ANSI Class 125 or 150 bolt-hole patterns to a grooved piping system. Victaulic Style 741 or 744.

F. All sprinkler pipe threading shall be completed with fixed diameter threading dies.

2.2 CHECK VALVES

A. All swing check valves shall be 175 psi non-shock cold water service, iron body, bronzed trim, horizontal swing with renewable bronze seat and rings. All check valves two (2) inches and smaller shall be bronze, screwed, horizontal swing type. All check valves two and one half (2½) inches and larger shall be flanged or grooved type. Provide automatic ball drip where valve is subject to freezing. All check valves shall include removable face plate

B. All water check valves shall be 175 psi working pressure, iron body with spring actuated double bronze plate and rubber seat with UL Listing and FM approval.

C. Provide valves with an elevated pressure rating for work in buildings more than 350 feet tall.

D. Grooved end check valves shall have a pressure rating up to 365 psi CWP, ductile iron body, stainless steel or EPDM coated ductile iron disc, stainless steel spring, nickel-plated or welded-in nickel seat.

   1. 2” through 3”: Victaulic FireLock Series 717H and 717HR (365 psi CWP).

2.3 GLOBE AND ANGLE VALVES

A. Valves shall be furnished with renewable disc, non-shock, and shall back seat in the fully opened position to allow repacking under full pressure without removing the valve from the line. Valve shall be rated for 175 psi working pressure.

B. Provide valves with an elevated pressure rating for work in buildings more than 350 feet tall.

2.4 AUTOMATIC FIRE SPRINKLER HEADS

A. Sprinkler heads shall have a temperature rating of 165ºF except for heads in areas of high temperature and in close proximity to heat sources which shall be temperature rated in accordance with NFPA 13.

B. Sprinkler heads in ceilings to be concealed pendant.

C. Sprinkler heads shall be Underwriters' Laboratories approved cast brass quick response wet type with 1/2" discharge orifice where scheduled as K-Factor 5.6 and 17/32" discharge orifice where scheduled as K-Factor 8.0. Sprinkler heads with reduced orifice shall be provided where approved by code and required to address a limited water supply condition.

D. Any and all sprinkler heads placed in location where they are liable to be accidentally hit in the normal course of building occupancy shall be provided with heavy wire guards. Guards shall be listed, supplied, and approved for use with the sprinkler, by the sprinkler manufacturer. Locations include, but are not limited to, above cable trays, within mechanical or storage rooms below 8 feet, and loading docks.

E. In the instance where sprinkler escutcheon are used (horizontal sidewalls & pendent), the escutcheon shall be UL Listed with the specific sprinkler head.

F. The sprinkler heads in all areas are to be installed on a true axis line in both directions with a tolerance of ±1/2". At the completion of the installation, if any heads are found to exceed the above shall be corrected and any adjoining work that may be disturbed in reinstalling heads shall be repaired or replaced at no additional cost to the Owner. All heads installed in hung ceilings shall be located on the centerlines of tiles.

G. Sprinkler heads shall be as follows. Substitution of equivalent products from approved manufacturers permitted:

Area	Head	Reliable Model #	Victaulic Model #	Tyco Model #
Finished spaces and corridors	Fully recessed, concealed type. Off white painted cover.	G5	V3801	RFII
Unfinished spaces and corridors	Standard upright/sidewall head, brass finish	F1FR	V3404	TY-FRL
Mechanical Rooms, storage, room without finished ceilings	Standard upright/sidewall head, brass finish with wire guard.	F1FR	V3404	TY-FRL
Mechanical rooms, storage room with finished ceilings	Standard semi recessed pendant head.	F1FR	V3404	TY-FRL

2.5 INSPECTOR'S TEST AND DRAIN CONNECTION ASSEMBLY

A. Victaulic Co. No. 720 TestMaster II or approved equal.

2.6 INSPECTOR TEST CONNECTIONS AND DRAINS

A. Furnish and install Inspector Test Connections and drains, piped to suitable plumbing drains, to allow for testing and maintenance of all parts of the system. Provide additional supplemental drains at all system low points.

2.7 MISCELLANEOUS

A. Nameplate data information: The nameplates shall be installed on each main riser and shall include the following design data: building designation, location of remote area, design density, area of application, and system demand (GPM and PSIG at base of riser).

B. Control valve signs: The Contractor shall provide a description sign, minimum dimensions seven (7) inches by nine (9) inches, for every valve in the system which controls water to sprinkler heads. Signs shall be single faced, white letters on a red background, with a space designating who to notify if valve needs to be closed. Signs shall be fastened to each valve with lightweight chain.

C. Miscellaneous signs: Signs for alarm test valves, main drains, auxiliary drains, etc. shall have minimum dimensions of two (2) inches by six (6) inches. Signs shall be single faced, white letters on a red background. Each sign shall be fastened to each valve with lightweight chain.

D. Provide (2) 11 x 17 copies of approved system diagram. One shall be mounted in a glazed frame as directed by Architect, the second shall be provided to the Owner for file.

E. Provide a sign at the base of each riser describing the design criteria of the system.

2.8 PIPE HANGERS

A. Provide products which are Underwriters Laboratories listed.

B. Provide pipe hangers and supports of which materials, design, and manufacture comply with ANSI/MSS SP-58, MSS SP-69, MSS SP-89.

C. Assume the responsibility for the proper transfer of the loads of the piping system to the structure. No additional cost to the Owner should be expected for any corrective work during construction. All pipe supports shall be of type and arrangements as hereinafter specified and shall be so arranged as to prevent excessive deflection and avoid excessive bending stresses between supports. All auxiliary steel for pipe supports shall be furnished and installed by this Contractor, where overhead construction does not permit fastening of hanger rods in required locations.

D. Supports and hangers shall be provided for all horizontal and vertical piping. The hanger design shall conform to the ASA Code for Pressure Piping.

E. All bracket clamps and rod sizes indicated in these Specifications are minimum size only. This Contractor shall be responsible for structural integrity of all supports. All structural hanging material shall be selected for a factor of safety of five (5).

F. Pipe supports shall be of the following type and figure number as manufactured by Anvil.

Pipe Hanger Schedule:

Item	Anvil Fig. #	Piping Sizes
Beam Clamp	92	All
Beam Clamp w/Retaining Clip	87	All
Clevis Hanger	260	8" and Smaller
Pipe Saddle	264	4" and Larger
	192	2, 2-1/2", 3"
Riser Clamp	261	All
Stand Off Pipe Clamp	103	All
Brackets	195, 199	All
Steel Washer Plates	60	All
Concrete Insert	CB 282	All

G. Pipe Supports in Pipe Chases: Supports shall securely hold piping prevent vibration, etc. Provide supplemental pipe supports and channels as required.

H. In grooved piping systems, Victaulic Style 009, 005, and 07 rigid couplings may be used with IPS steel piping systems, which meet the support and hanging requirements of NFPA 13. An adequate number of Victaulic Style 177, 75 and 77 flexible couplings shall also be used to compensate for thermal expansion/contraction of the pipe.

PART 3 – EXECUTION

3.1 GENERAL INSTALLATION

A. The Contractor shall investigate the conditions affecting the work and shall arrange his work accordingly, providing such fittings, valves, and accessories as may be required to meet such conditions. The Contractor shall field verify all dimensions and conditions governing his work at the building. Materials shall not be fabricated or delivered to the site before the approved shop drawings and equipment submittals have been received by the Contractor.

B. Entire installation shall be in accordance with approved shop drawings. When unforeseen job site conditions will not permit piping to be installed as shown on the drawings, necessary changes will be made to accomplish a coordinated system without additional cost to the Owner, even though pipe may have been delivered to the site cut to pre-determined lengths.

C. Provide gate valves of size and at locations shown on the drawings and any additional valves required by local authorities. Locate all valves where readily accessible. Provide chain wheel operators or permanent ladders for all valves not accessible from the floor. All main line valves shall be electrically monitored and secured with a chain and padlock which will lock the valve in an open position.

D. Provide check valves of size and at location shown on the drawings and any additional check valves that might be required by local authorities.

E. Provide valved test drains as required by NFPA. Pipe test drains to spill to nearest floor drain, or receptor. Make provisions to drain all parts of the piping system for service including additional drains at all system low points.

F. Hydraulic calculations shall be performed in accordance with the requirements of NFPA 13 and 14. The Contractor shall calculate the demand point for the system so that it remains ten (10) percent below the final water supply curve at the connection to the public water system. The demand point for the systems shall include an allowance for the inside and outside hose demand. The basis for the hydraulic calculations shall be determined by a waterflow test performed by the Contractor and acceptable to the Authority Having Jurisdiction.

G. Be responsible for trenching, bedding material, removal of waste material, paving removal and replacement, barricades, and any materials necessary for vehicle and person access across work areas.

3.2 PIPING INSTALLATION

A. Perform the work in a professional workmanlike manner, according to the best practices of the trade. All sprinkler piping must be substantially supported from the building structure and only approved type hangers shall be used. Sprinkler piping in all areas shall be concealed unless otherwise noted on the contract drawings. In those noted locations and in areas with no ceiling, piping shall be installed as high as possible using necessary fittings and auxiliary drains to maintain maximum height. Any deviations found necessary shall be immediately brought to the attention of the Architect. All piping discharging outside (main drains, Inspectors Test Connections, etc) shall do so on paved surfaces or splash blocks.

B. All inside piping shall be joined by means of screwed, flanged, flexible gasketed joints, or other approved method. Risers, feed mains, cross mains, and branch lines may be shop welded using approved welding fittings and conforming to the standards as set forth in the latest edition of NFPA 13. Welding and torch cutting shall not be permitted as a means of installing or repairing sprinkler system piping on-site.

C. Provide escutcheons on penetrations of interior walls. Chrome or white -plated escutcheons shall be provided where exposed piping passes through finished floors, walls, partitions, and ceilings. Secure plates to pipe with set screws or spring clips. Color is subject to architect/owners approval. All escutcheons for sprinkler heads must be UL Listed with the specific sprinkler head.

D. It is the intent that each part of the Fire Protection Systems shall be complete in all details and all lines provided with all control valves as indicated on Drawings, or as may be required for the proper control of the pipe lines under this Section so that any fixture, line or piece of apparatus may be cut out for repair without interference or interruption of the service to the rest of the building, including every 100 ft of standpipe.

E. Run piping straight and as direct as possible. In general, form right angles with or parallel to walls or other piping. Risers shall be erected plumb and true.

F. After cutting, all pipes shall be reamed out to full bore and before erection the inside of all pipes shall be thoroughly cleaned.

G. No piping or work shall be concealed until all required tests have been satisfactorily completed and work has been approved by the Architect and all other authorities having jurisdiction.

H. Where complete concealment is impossible because of obstructions such as beams, ducts, lights, piping, etc., the Contractor shall not install any work before first consulting with the Architect and his instructions (written or revised Drawings) shall be followed.

I. Piping shall be supported from structural steel only, piping shall not be hung from other piping, ducts, conduits, metal deck or from equipment of other trades. Provide necessary structural members, hangers and supports of approved design to keep piping in proper alignment and prevent transmission of injurious thrusts and vibrations. In all cases where hangers, brackets, etc., are supported from concrete construction, care shall be taken not to weaken concrete or penetrate waterproofing.

J. All hangers and supports shall be capable of screw adjustment after piping is erected. Hangers supporting piping expanding into loops, bends and offsets shall be secured to the building structure in such a manner that horizontal adjustment perpendicular to the run of piping supported may be made to accommodate displacement due to expansion. All such hangers shall be finally adjusted, both in the vertical and horizontal direction.

K. The Architect must approve method of supporting pipes from building structure before work is started. The Contractor shall bear all responsibility for materials and workmanship as described in this Section, and shall make sure that all hangers and supports are properly and permanently connected to building structure.

L. Pipe hangers shall be of the clevis type with threaded rod support. Chains, straps perforated iron or wire hangers are not permitted.

M. All piping running on walls shall be supported by means of hanger suspended from heavy angle iron wall brackets. No wall hooks will be permitted.

N. Lateral bracing of horizontal pipe shall be provided where required to prevent side sway or vibration. The lateral bracing shall be of a type approved by the Architect and shall be installed where directed by the Architect. All piping shall be seismically restrained in accordance with NFPA 13.

O. All anchors shall be separate and independent of all hangers, guides and supports. Anchors shall be of heavy blacksmith construction suitable in every way for the work approved by the Architect. Anchors shall be welded to the pipe and fastened to the structure with anchor type bolts.

P. All horizontal steel pipe shall be supported at maximum intervals as follows: Steel pipe - up to 1-1/2" - 12'-0"; 1-1/2" and larger 15'-0". In no case shall a pipe extend more than 12" past a hanger without additional support.

Q. Trapeze type hangers shall be made up of angles bolted back-to-back or channels for supporting parallel lines of piping. Trapeze type hangers shall be supported with suspension rods having double nuts, and securely attached to construction with inserts, beam clamps, steel fishplates, cantilever brackets, lag screws or other approved means. Kindorf or other materials typically used for the support of electrical equipment or conduit are not acceptable. Piping supported by trapeze hangers shall be provided with hold down clamps at the trapeze hangers.

R. Maximum weights on hanger rods shall be such that stress in tension shall not exceed 9,000 psi, using root area of threaded portion. In no case shall hanger sizes be less than 3/8" for pipe up to 4", 1/2" for pipe 5", 6" and 8".

S. Supports for vertical piping shall be double bolt riser clamps, with each end having equal bearing on the building structure located at alternate floors but it shall be no more than 25 feet between supports.

T. All hangers, rods, inserts, clamps, stanchions, brackets, etc., shall be dipped in zinc chromate primer before installation and provided with one (1) coat of approved type paint after installation.

U. All pipe supports shall be installed to avoid interference with other piping, hangers, electrical conduits and supports, building structures and equipment.

V. A Victaulic factory-trained field representative shall provide on-site training for contractor's field personnel in the proper use of grooving tools and installation of grooved piping products.

W. Grooved joint piping systems shall be installed in accordance with the manufacturer's guidelines and recommendations. The gasket style and elastomeric material (grade) shall be verified as suitable for the intended service as specified. Gaskets shall be molded and produced by coupling manufacturer. Grooved end shall be clean and free from indentations, projections, and roll marks in the area from pipe end to groove for proper gasket sealing. Factory-trained representative shall periodically review the product installation. Contractor shall remove and replace any improperly installed products.

X. Painting: Paint all exposed piping. All exposed piping in finished areas shall be painted Red in accordance with building code. All bulk main piping 3 inch and larger shall be identified “SPRINKLER-WATER”.

Y. Piping shall be pitched to drain to inspector test connection or drum drip. Branch piping in dry systems shall be pitched at 1/2” per 10’, mains shall be pitched at ¼” per 10’.

Z. Flushing valves shall be provided on the mains, cross-mains, branch lines and run outs of new sprinklers systems, to facilitate post-construction cleaning and flushing of the system. Valves shall be sized per NFPA 25, in order to obtain the NFPA required minimum velocity of 10ft/s for any given pipe size.

On piping 2” and smaller, line size ball valves can be applied. In mains larger than 2”, typically there is a need for multiple 2” ball valves (especially on 4” and larger mains) to achieve the required flow. The engineer shall use hydraulic calculations to determine the number of 2” valves required on mains larger than 2”.

AA. Manual inspector’s test and drain valves are also required for zones where Zone Checks are installed.

BB. Threaded fittings are preferred for exposed systems in aesthetically sensitive areas. The use of plain end fittings is discouraged.

3.3 VALVE INSTALLATION

A. Comply with the following requirements:

1. Install valves except butterfly with stems pointing up, and as close to vertical as possible. Butterfly valves to be offset at least 10° from vertical.
2. Install valves where required for proper operation of piping and equipment, including valves in branch lines where necessary to isolate sections of piping. Locate valves so as to be accessible and coordinate location with other trades, walls, etc.
3. Provide drain valves at main shut-off valves, low points of piping and apparatus.
4. Provide separate support where necessary.
5. Furnish all valves as indicated on the plans, or as may be required for the proper control of the pipe lines installed under this Specification. All water valves shall have a minimum working pressure of 175 psi, water rated unless otherwise noted on the Drawings or specified herein. All valves shall be of one manufacturer.
6. All gate valves within the building shall be wedge gate valves with painted iron wheel handles, shall have gland followers in stuffing boxes, and shall be constructed that they may be repacked while open and under pressure. All valves shall have the name of the manufacturer and working pressure cast or stamped thereon.
7. Globe valves shall be of all bronze with composition disc, threaded or brazed joint ends as required by piping system in which they are installed.
8. Drain valves shall be 3/4" heavy cast brass with composition washers with male thread for hose connections.
9. All valves on the exterior fire protection water piping shall comply with Local Fire Department and Water Company requirements.
10. All valves shall have the trademark of the manufacturer and the guaranteed working pressure cast or stamped on the body of the valve. All gates or globes, etc., shall be of one manufacturer and working pressure cast or stamped thereon.
11. All valves used on the sprinkler systems water service, shall be approved by the Underwriters' Laboratories, Factory Mutual and all the other authorities having jurisdiction. Valves shall be iron body bronze mounted OS&Y solid wedge type valves with rising stems for 175 psi minimum working pressures; iron wheel handles shall be painted red.
12. The entire fire protection system shall be supplied with valves so located, arranged and operated as to give a complete regulating control to all fixtures and apparatus
13. Valves, where exposed and used in connection with finished piping, shall be same finish as the pipe.
14. Do not install bronze valves and valve components in direct contact with steel unless bronze and steel are separated by dielectric insulator.
15. Select and install valves with outside screw and yoke stems, except provide inside screw non-rising stem valves where headroom prevents full opening of OS&Y valves.
16. Select and install valves with renewable seats, except where otherwise indicated.

3.4 CHECK VALVES

A. Check valves up to and including 3" shall be all bronze swing check type with threaded or brazed joint ends.

B. Swing Check Valves shall be installed only in horizontal lines unless absolutely impractical. If installed vertically, flow shall be upwards. Do not install in pump discharge piping.

C. Wafer Check Valves shall be installed between 2 flanges in horizontal or vertical position.

D. Horizontal Lift Check Valves shall be installed in horizontal piping line with stem vertically upward.

3.5 AUTOMATIC FIRE SPRINKLER HEAD INSTALLATION

A. All sprinkler heads shall be in alignment, and parallel to ceiling features, walls, etc. The Contractor shall provide one (1) spare sprinkler cabinet complete with sprinkler wrench and 12 sprinklers of assorted temperature ratings of the type necessary and in use throughout each system at each main riser.

B. Conform to spacing and dimensional constraints indicated by the Architect on the reflected ceiling plans. Sprinkler heads shall be centered within ceiling grid. Where no ceiling grid is provided the heads shall be aligned with any fire alarm device or light fixture in the vicinity. Where the contractor's failure to install sprinkler heads in proper alignment requires the removal, replacement or alteration of ceilings to correct the errors the Sprinkler Contractor shall be responsible for the cutting, patching and restoration of finishes as necessary.

C. The sprinkler bulb protector must remain in place until the sprinkler is completely installed and before the system is placed in service. Remove bulb protectors carefully by hand after installation. Do not use any tools to remove bulb protectors.

D. Do not install sprinklers that have been dropped, damaged, or show a visible loss of fluid. Never install sprinklers with cracked bulbs.

3.6 FIRE STOPS AND PENETRATION SEALS

A. All new piping penetrations through fire rated floors and walls shall be sealed with fire resistant sealant to prevent the spread of smoke, fire, toxic gas, and water through the penetration either before, during or after a fire. The fire rating of the penetration seal shall be at least that of the floor or wall into which it is installed.

B. See additional requirements elsewhere in this specification.

3.7 FIRE ALARM WIRING

A. All fire alarm and monitor wiring shall be done under the Electrical Division but the proper operation of signaling devices will be the fire protection Contractor's responsibility.

3.8 PIPE TESTING

A. The entire fire protection piping system shall be tested hydrostatically at not less than 200 psi pressure for two hours, or at 50 psi in excess of the maximum static pressure when the maximum static of pressure is in excess of 150lbs. The hydrostatic test pressure shall be measured at the low point of the individual system or zone being tested. Each complete system (all associated piping and alarms), shall be tested and accepted as a complete unit, with data recorded on an approved “Contractor’s Material and Test Certificate”. System pressure tests shall be against a blank test flange and not against a valve seat.

B. All tests shall be conducted in the presence of the Architect and Owner. Any system failing to meet the specified test requirements shall be repaired and retested at no additional cost, until the test requirements are met.

3.9 MAINTENANCE AND OPERATIONAL INSTRUCTIONS

A. System description, system theory of operation, and system final inspection and acceptance documents of the completed system (as built) shall be submitted in a bound book as described in Division 1. The maintenance manuals and instructions shall include a brief description of the type of system installed, routine-type maintenance work defined by step-by-step instructions that should be performed to ensure long life and proper operation, and the recommended frequency of performance. The instructions shall also include possible trouble spots with diagnosis and correction of each. The theory of operation brochures shall describe the function of each component or subassembly in block-diagram type presentation to a degree that a craftsman will understand the system well enough to operate and maintain it.

3.10 PROTECTION

A. Protect all apparatus, fixtures, materials, equipment, and installations so as to prevent damage as a result of new work. The Contractor shall replace at his own expense any item, which is marred, defaced, broken, or damaged in any way, prior to the date of Notice of Acceptance.

3.11 PAINTING

A. Contractor shall paint all exposed new and existing fire protection systems to allow for rapid identification by fire department at all times. New work shall be painted at time of installation; existing systems shall be painted immediately upon exposure to view. Contractor shall continuously update system painting to remain current and accurate at all times. All systems removed from service shall be suitable marked.

3.12 LABELING

A. All piping, valves, devices, etc., shall be labeled in accordance with the requirements of the code, referenced standards, local laws and fire department directives.

3.13 FIELD QUALITY CONTROL

A. All fire protection systems shall be thoroughly cleaned and flushed with tri-sodium phosphate or a cleaning agent approved by Facilities Engineering prior to final acceptance. Once the system is filled by the Contractor, a sample will be taken to verify the concentration of the cleaning agent within the system.

B. Clean dirt and debris from sprinklers.

C. Remove and replace all sprinklers having any paint on them that is other than the factory finish.

D. Pipe System Cleaning:

1. Clean all pipe lines or sections of lines and connected equipment in new or modified systems and/or flush free of all pipe line debris loosened or introduced as a result of this Contract. This shall include removing all debris that has settled or collected at low points, in equipment, etc. Test equipment used for piping tests may be used to circulate cleaning liquids.
2. Clean and disinfect sprinkler distribution piping as follows:

    a. Purge new and reused distribution piping systems and parts of existing systems that have been altered, extended, or repaired before use.
    b. Flush piping system with clean, potable water until dirty water does not appear at points of outlet.
    c. Fill system with water/tri-sodium phosphate (TSP) solution containing at least 1 gallon TSP liquid per 1000 gallon of system volume, isolate and allow to stand for 24 hours.
    d. Drain system of previous solution to sanitary sewer.
    e. Flush system with clean, potable water until no TSP remains in water coming from system.
    f. Submit water samples in sterile bottles to authorities having jurisdiction.
    g. Prepare reports of purging activities.

E. Each system will have a corrosion coupon and test port rack (1" stub with valve and cap) installed at the alarm valve. The corrosion coupons shall be obtained from the FM Pipe Shop Water Treatment Lab so the water quality and corrosion data can be properly recorded and monitored over time as part of ongoing routine maintenance.

F. New sprinkler systems shall not be treated for MIC upon completion of final system cleaning.

END OF SECTION

SECTION 21 90 00

FIRE SUPPRESSION SYSTEM PROJECT CLOSEOUT

PART 1 – GENERAL

1.1 WORK INCLUDED

A. The contractor shall summarize and document adherence with the requirements of the specifications for project closeout including:

1. Copies of all warranties
2. Operation & Maintenance Manuals
3. Required tests
4. Test and balance reports
5. Record drawings
6. Permit requirements
7. Valve tag list

B. The contractor shall compile a closeout manual which shall include:

1. A list of all required tests and a place for signoff of date completed.
2. A list of all submittals with dates of acceptance by the engineer.
3. A schedule indicating dates for beginning testing and startup of equipment and dates of tests to be witnessed by the engineer, or designated representative, as required by the specifications.
4. Test procedures to be used for life safety systems.
5. Project close out check list.

C. The final closeout manual shall include the following:

1. Test reports as required by the specifications with signoff by the appropriate individual (engineer, architect, building official, etc.).
2. Documentation indicating all equipment is operating properly and is fully accessible for maintenance.
3. Copies of all warranties.

D. This section only includes the requirements for documentation of the contract documents, by the contractor, for project completion. This section does not in any way decrease the scope of any of the drawings or specifications.

1.2 SUBMITTALS

A. Within 90 days after notice to proceed submit a preliminary closeout manual with the following:

1. A list of all required tests.

2. Preliminary schedule showing major milestones for completion of the fire protection systems.

B. Within 30 days of the first major milestone submit the completed closeout manual as described in Part 1.

C. Within 2 weeks of substantial completion submit a completed "Project Closeout Check List", and the Final Closeout Manual.

Listed below is a checklist for use by the contractor. This list is not all inclusive for this project.

Project Close-Out Summary – Fire Protection

☐ All required submittals have been submitted and either been approved or modified in accordance with the Engineer's "make corrections noted" comments.

☐ Access doors have been installed as required for concealed equipment, valves, etc.

☐ All equipment has been installed with the manufacturers recommended and code required service clearances and is fully accessible for required maintenance.

☐ All equipment and piping is labeled per specifications.

☐ All action items are complete as listed in the action items reports. Submit a list of action items with sign off by Architect or Engineer for record. Punch list to be completed prior to turn over of building.

☐ Fire sprinkler system tested per specifications.

☐ Operation and maintenance manuals submitted with table of contents and required documentation for extended warranties.

☐ Factory Testing documented and submitted for record.

☐ Record drawings submitted to Engineer and Architect per specifications.

☐ All punchlist items have been addressed and closed.

PART 2 – PRODUCTS (Not Used)

PART 3 - EXECUTION

3.1 EQUIPMENT STARTUP AND TESTING

A. Prior to completion and punchlist by the engineer, the contractor shall startup and test each piece of equipment as required by the specifications. The contractor shall provide documentation of all required tests with signoff of by the appropriate individual (engineer, architect, and building official).

3.2 TESTING AND ADJUSTMENT FOR FIRE PROTECTION WORK

A. All tests shall be made in the presence of the Architect or their representatives, and the local authorities having jurisdiction of the work to be tested, as may be directed; and at least 72 hours notice shall be given in advance of all tests. Contractor shall perform equivalent test prior to scheduling supervised test.

B. The Work of this Contractor shall include the furnishing of all testing instruments, gauges, pumps, smoke machines, and other equipment required or necessary for tests, required by laws, rules and regulations and as specified.

C. Provide all other tests required by local inspectors and all other authorities having jurisdiction.

D. All appurtenances shall be operated after installation to determine whether or not they meet the requirements of the Specifications.

E. All defects disclosed in the work be tests and otherwise shall be made good or the Work replaced without additional cost to the Owner. No caulking on screwed joints, cracks or holes will be acceptable.

F. Tests shall be repeated after any defects disclosed thereby have been made good or the work replaced if it is deemed necessary.

G. All tests shall be made at the expense of the Contractor.

H. Tests are not permitted to be made with air except as noted.

I. Contractor to provide required test plug tee fittings during erection of pipe system.

J. If the pipe installation fails to meet testing requirements, the Contractor shall determine at his own expense the source or sources of leakage, and he shall repair or replace all defective materials or workmanship. The completed pipe installation shall meet the requirements of the tests after the leaks have been corrected.

K. All piping which is to be enclosed in partitions or hung ceilings shall be tested and made tight when directed by the Construction Supervisor and in adequate time to permit the installation of partitions and ceilings. When necessary, the Contractor shall drain the piping and/or take precautions as required to prevent damage by freezing.

L. The Contractor shall also be responsible for the Work of other trades that may be damaged or disturbed by the tests, or the repair or replacement of his Work, and he shall, without extra charges, restore to its original condition any Work so damaged or disturbed.

M. Before any paint is applied, the fire standpipe system shall be tested hydrostatically at not less than 200 psi pressure for two (2) hours minimum, and in accordance with all requirements of the authorities having jurisdiction and NFPA latest edition.

N. Any fees charged by the Fire Department for false alarms attributed to the construction of the fire suppression system will be the responsibility of the Contractor until such defects are corrected and false alarms due to system installation no longer occur.

3.3 LIFE SAFETY SYSTEMS

A. The contractor shall provide a detailed test procedure, with instrumentation to be used, for approval by the engineer and building official prior to any testing.

B. All life safety systems shall be fully and successfully tested by the contractor before being witnessed by the engineer or building official Once tested by the contractor and fully operational, the systems shall be demonstrated to the engineer. Once accepted by the engineer the system shall be demonstrated to the building and fire officials.

3.4 COORDINATION WITH OTHERS

A. The Division 21 through 23 contractor shall coordinate his requirements with the General Contractor to ensure the other building systems are completed to the point that they will not adversely affect the operation of the Division 21 through 23 systems.

3.5 PUNCH LISTS

A. The contractor shall submit in writing that the project is ready for final review by the engineer.

B. Once the project is ready for final review the engineer will create a punch list of any corrections or deficiencies.

C. The contractor shall complete all punch list items and provide a letter to the architect after completion stating all items have been completed or reasons why they were not completed.

D. Upon receipt of this letter the engineer will verify that the punch list has been satisfactorily completed.

END OF SECTION

SECTION 22 05 00

COMMON WORK RESULTS FOR PLUMBING

PART 1 – GENERAL

1.1 REFER TO RELATED SECTIONS

A. Section 23 05 01 – Mechanical and Electrical Coordination
Section 23 05 02 – Basic Mechanical Requirements
Section 23 05 03 – Basic Mechanical Material and Methods

1.2 DESCRIPTION OF WORK

A. Except as otherwise specified under "Related work Not Included", the work of this Contract consists of furnishing all labor, materials, equipment and appliances necessary and required to completely do all Plumbing Work as indicated on the Drawings or described or referred to in the Specifications, including, but not limited to the following:

1. Domestic water meter assemblies complete with remote readers and removal of existing master meter, all in accordance with water company requirements. Obtain service layout.
2. Interior alteration work, removals, replacements, relocations, etc. to the existing plumbing and fire protection systems in all renovated areas as indicated on the Drawings.
3. Complete interior storm water drainage systems with leaders, roof and area drains, and piping system conveying storm water drainage to site storm drainage system.
4. Complete interior sanitary, soil, waste and vent piping systems, including all required connections to all plumbing equipment, and connections to the existing interior piping or to the site sanitary sewer system.

   Note: Where existing soil and waste capped or plugged outlets are found to be inaccessible or where the elevation cannot be met, the Contractor shall have an option to cut into the existing stack or to run the new piping down to the next floor and connect to an existing outlet. The Contractor shall include this optional work in the base bid scope of work.
5. Complete interior domestic cold water system including connections to existing interior piping systems, and connection to all equipment requiring cold water. Provide a water meter on the domestic cold water pipe serving as the cooling tower make-up feed.
6. Disconnecting all fixtures and equipment to be removed, even if the fixture or equipment is to be removed and under another Division or Section of these Specifications. Scope includes cutting and capping all mains back to nearest active main.
7. Plumbing fixtures and trim for same.

8. Furnishing of access doors for installation under another Division or Section of these Specifications.
9. Excavation and backfill for all work herein specified.
10. Make all plumbing connections required for equipment furnished under other Divisions or Sections of these Specifications.
11. Hose bibbs, shock absorbers, and backflow preventers.
12. Sleeves, hanger and supports.
13. Insulation for piping and equipment.
14. Apply for and obtain and pay for all permits, certificates, inspections and approvals required in connection with all Plumbing Work.
15. Shop drawings, samples and instructional manuals, tests and adjustments.
16. Installation of all fixtures furnished by Owner and/or furnished under other Divisions or Sections of the Specifications.
17. Provide roughing (water supplies, soil, waste, and vent piping) for all equipment furnished and/or installed under other Divisions or Sections of these Specifications.
18. All interlocking control wiring and conduit.
19. Color coding and stenciling of all piping systems.
20. Cutting and rough patching.
21. Cap flashing and prime painting.
22. Tests for all systems provided under this Section.
23. Where due to Union regulations or trade agreements, any of the work shown on the Drawings or specified herein is not considered Plumber's Work, this Contractor shall subcontract the work in question, but this Contractor shall be held responsible for the complete installation.
24. It is not the intention of these Specifications to describe nor the Contract Drawings to show in detail, all the various pieces of apparatus and appurtenances and their connections. This Contractor shall, as part of the Contract, furnish and install all incidentals, such as pipe, fittings, valves, etc., required to complete the installation of the equipment. This Contractor shall refer to Architectural Drawings and Plumbing Drawings for exact location of fixtures including type and quantities. This Contractor shall be responsible for providing isolation valves in locations suitable to isolate equipment, risers, building sections, etc. This Contractor shall be responsible for providing and connecting all fixtures and equipment.
25. All work described in the Specifications and not shown on the Drawings, or vice versa, shall be installed in a manner similar to the work shown or described.
26. Plumbing Contractor shall provide temporary water service on the site to the locations indicated by the Construction Manager, on the site temporary fire protection water, all in accordance with requirements of the state and local codes, the Water Company and the Fire Department. Plumbing Contractor to pay all fees and obtain all permits required in connection with the water services.
27. Prepare and submit to the Engineer, all drawings, applications, test reports, correspondence, etc., as required in connection with the approval and installation of the backflow preventors and/or double check valves, as indicated on the Drawings or as required by the New York State Department of Health. Contractor shop drawings shall be suitable for filing with authority approving the installation. Engineer shall sign and seal as Engineer of Record.

1.3 RELATED WORK NOT INCLUDED

A. The following principal items of work shall be provided under other Sections; the General Contractor shall be responsible for coordinating the purchase of this work from other trades:

1. Finish painting.
2. Installation of access doors. This Contractor shall furnish access doors.
3. Base flashing for roof drains, and piping passing through roofs.
4. All electrical power wiring conduits, etc., for pumps, equipment, etc., shall be provided under Division 26.
5. Drainage piping from HVAC equipment to and spilling over floor drain, mop sink, sump or roof, except as noted.
6. Temporary toilets and water supply.
7. Finish patching.
8. Sheet metal gutters and leaders.

1.4 VISITING THE PREMISES

A. This Contractor, before submitting his bid on the work, shall visit the site and familiarize himself with all visible existing conditions. As a result of having visited the premises, this Contractor shall be responsible for the installation of the work as it relates to such visible existing conditions.

B. The submission of a bid will be considered as acknowledgment on the part of the bidder of his visitation to the site.

1.5 QUALITY ASSURANCE

A. Manufacturer's Instructions

1. In addition to the requirements of these Specifications, comply with the manufacturer's instructions and recommendations for all phases of the work.

B. Standards and Codes
Comply with the latest editions of the following:

Building Code of Connecticut
Connecticut Plumbing Code.
National Fire Codes (N.F.P.A.)
Local Gas Utility Rules and Regulations.
Local Municipal Rules and Regulations.
Local Fire Department requirements.
Local Water Company Rules and Regulations.
Other State and Local Authorities having jurisdiction.
F.M. and/or F.I.A. regulations.

C. All work and material not specifically described, but required for a complete and proper installation of the work of this Section, shall be provided by the Contractor and shall be new, first quality of their respective kinds, and subject to approval of the Architect.

D. All water supply connections to plumbing fixtures and other equipment to be installed under this Division shall be in accordance with the rules relative to submerged inlets and protective methods to be applied to prevent contamination of water as required by Local and State Regulations.

E. Manufacturing firms regularly engaged in manufacture of this material with characteristics and capacities required, whose products have been in satisfactory use in similar service for not less than 10 years.

F. Provide product produced by the manufacturers, which are listed in Section "Approved Manufacturer's List".

G. Provide equipment whose performance, under specified conditions, is certified by the manufacturer.

H. All piping shall be domestically manufactured and shall be by the same manufacturer.

I. All work shall be done by a licensed Plumbing Contractor.

1.6 ALTERATION WORK

A. All equipment, piping, plumbing fixtures, etc. to be removed shall be disposed of, turned over to the owner or salvaged as directed by the Owner. They shall not be removed from the premises without the Owner's approval.

B. All existing to remain piping that is rendered inoperable or orphaned by demolition shall be reconnected to nearest active systems during the completion of work in a given space. See additional requirements for shut-down coordination.

C. In instances where the removal of existing wall finishes reveals piping or systems that are not indicated for demolition, but are located in an area that conflicts with the proposed floor plan, the existing piping or system shall be relocated to a position that does not conflict with future finishes.

D. No dead ends shall be left on any piping upon completion of job.

E. Existing piping not planned for reuse, and not specifically noted or shown on Drawings to be abandoned shall be completely removed. All existing, unnecessary piping related to work being removed shall be completely removed.

F. The existing system shall be left in perfect working order upon completion of all new work.

G. Locations and sizes of existing piping are approximate. Exact sizes and locations of all existing piping shall be verified at the site.

H. No removed existing piping, fittings, valves, etc. shall be reused.

I. This Contractor shall not interrupt any of the services of the existing facility, nor interfere with the services in any way without the express permission of the Owner. Such interruptions and interferences shall be made as brief as possible and only at the time approved by the Owner.

J. Under no circumstances shall this Contractor or his workmen be permitted to use any part of the facility as a shop, except parts designated by the owner for such purposes.

K. Provide branch shut-off valves as required to install new work without continuous shut-down of entire building water supply and gas supply.

1.7 REPLACEMENT OF SURFACING

A. Where required by operations under this Section, the Contractor shall remove and replace all damaged street pavements, curbs, sidewalks, walkways, grassed areas and landscaped areas which are to remain, in a manner equal to their original condition when new.

B. In those cases where final surfaces cannot be placed immediately, a temporary surfacing of two inches of bituminous concrete shall be placed and maintained. This shall be removed before placement of final surfacing.

C. Landscaping and grassed areas shall be preserved and/or replaced to the satisfaction of the Architect.

D. See additional requirements elsewhere in this specification.

1.8 COOPERATION WITH OTHERS

A. The Plumbing Contractor shall cooperate with other trades whose work is to be correlated with his work, in order to avoid field interference, improper elevations, or inaccessible work. Any extra expense occasioned by lack of cooperation by this Contractor shall be borne by him.

PART 2 – NOT USED

PART 3 – NOT USED

END OF SECTION

SECTION 22 05 23

PLUMBING VALVES

PART 1 - GENERAL

1.1 SUBMITTALS

A. Manufacturer's Data: Submit manufacturer's product data including:

1. Dimensions
2. Sizes
3. End Connections
4. Weights
5. Installation instructions
6. Instructions on repacking and repairing valves.
7. Range of flow for balancing valves and plug valves.
8. Pressure reducing valves.
9. Backflow preventors.
10. Backwater valves.
11. All other applicable valves.

B. Valve Tag List: Refer to Section 22 05 53 of the Specifications.

PART 2 – PRODUCTS

2.1 GENERAL

A. Where type or body material is not indicated, provide valve with pressure class selected from MSS or ANSI standards, based on the maximum pressure and temperature in the piping system.

B. Except for balancing or when otherwise indicated, provide valve of same size as connecting pipe size.

C. Unless specifically required by note or symbol, all water valves shall be ball or gate valves. If ball, butterfly, globe, plug, or balancing valves are called out by note or symbol, only that type of valve is acceptable.

D. Butterfly valves may be used in lieu of gate valves larger than 6" in non-balancing applications when pressure and temperature ratings are adequate.

E. Where pipe sizes overlap, contractor has the option of threaded or flanged valves.

F. All valves shall be domestically manufactured.

G. Valves used for domestic water service shall be bronze or stainless steel. Iron and brass body valves are not acceptable. Comply with NSF-61 for lead free potable water piping.

H. All valves shall be of a design which the manufacturer lists for the service and shall be of materials allowed by the latest edition of the ASME Code for pressure piping for the pressure and temperature contemplated, unless a higher grade or quality is herein specified.

I. Valve packing compression is to be independent of the stem, ball or handle systems. All valve stems are to be blowout proof. Packing shall be accessible without disturbing the insulation.

2.2 GLOBE VALVES

A. Manufacturers:

1. Design Basis: Milwaukee
2. Other Acceptable Manufacturers:
   a. Crane
   b. Nibco
   c. Powell
   d. Gruvlok
   e. Stockham
   f. Hammond

B. Globe valves shall be of all bronze with composition disc, threaded or brazed joint ends as required by piping system in which they are installed.

C. All iron valves in potable water systems shall be NSF 61 listed and FDA approved epoxy coated cast iron valve bodies with bronze seats

D. Except where otherwise noted, all valves for use with copper tubing shall be as follows:

2” AND SMALLER	UNDER 300 PSI	Milwaukee Model UP1502 Bronze, 125 PSI SWP, 200 PSI WOG, Rising Stem, Screw Bonnet, Bronze Disk, MSS SP-80, Type 1, Solder Ends. Milwaukee Model 502 for Threaded Ends.
2 ½” AND LARGER	UNDER 200 PSI	Milwaukee Model F-2981 Iron, 125 SWP, 200 WOG, Non-Shock, Solid Disc, Bolted Bonnet, Gland Packed, Flanged Ends

2.3 SWING CHECK VALVES

A. Manufacturers:

1. Design Basis: Nibco
2. Other Acceptable Manufacturers;
   a. Crane
   b. Milwaukee
   c. Powell
   d. Stockham
   e. Victaulic (for Grooved Pipe Systems)
   f. Gruvlok
   g. Hammond

B. Check valves up to and including 2" shall be all bronze swing check type with threaded or brazed joint ends.

C. For domestic water use up to 2” piping: Horizontal swing, regrinding type ASTM B 584 Alloy C87850 body, 300 PSI CWP, Y Pattern, Renewable PTFE Seat and Disc, MSS-SP-80, NSF-61 for potable water.

1. Model: UP509

2.4 SILENT/WAFER CHECK VALVES

A. Manufacturers:

1. Design Basis: Milwaukee
2. Other Acceptable Manufacturers:
   a. Metra Flex
   b. Hammond
   c. Nibco
   d. Tyco
   e. Victaulic (for Grooved Pipe Systems)
   f. Gruvlok
   g. Stockham

2” AND SMALLER	UNDER 200 PSI @ 250 °F	Milwaukee Model UP548T Bronze Body and Trim, Center Guided, Single Disc, 250 PSI Rating.

B. All iron valves in potable water systems shall be NSF 61 listed and FDA approved epoxy coated cast iron valve bodies with bronze seats

C. Where application or building height causes working pressure to exceed 125 psi, provide silent check valves 3” & up: Milwaukee 1800, 250 lb. WSP, semi-steel.

D. Grooved end spring-loaded check valves shall be suitable for pressures up to 365 psi and operating temperatures up to 230 deg F.

1. 2” through 3”: Ductile iron body, stainless steel disc and spring, nickel-plated seat, 365 psi CWP.

2.5 GATE VALVES

A. Manufacturers:
1. Design Basis: Milwaukee
2. Other Acceptable Manufacturers:
a. Crane
b. Nibco
c. Stockham
d. Gruvlok
e. Hammond

B. For domestic water use up to 3” piping: 300 PSI CWP, Screw-in Bonnet, Solid Wedge Disc, Non-Rising Stem, Gland Packed, Threaded Ends.

1. Model: UP105

C. All iron valves in potable water systems shall be NSF 61 listed and FDA approved epoxy coated cast iron valve bodies with bronze seats

D. All gate valves within the building shall be wedge gate valves with painted iron wheel handles, shall have gland followers in stuffing boxes, and shall be constructed that they may be repacked while open and under pressure. All valves shall have the name of the manufacturer and working pressure cast or stamped thereon.

E. All gate valves 3" and smaller shall be all bronze with brazed or screwed joint ends as required by the piping system in which they are installed.

2.6 BALL VALVES

A. Manufacturers:

1. Design Basis: Milwaukee
2. Other Acceptable Manufacturers:
a. Apollo
b. Dyna Quip
c. Hammond
d. Nibco
e. Victaulic (for Grooved Pipe Systems)
f. Watts
g. Gruvlok
h. Stockham

B. Cast bronze, 150, SWP, 600 WOG (min), ASTM 584 Alloy C89833 ball, two piece design, blow-out proof stem, adjustable packing gland nut (allowing handle to be removed without leaking) TFE seats, MSS-SP-110, NSF-61 for potable water.

1. Model: UPBA400 - full.port.

C. Options: Provide the following where required:

1. Extended stems for insulated valves.
2. Memory stop device for balancing applications.
3. Tee handle for tighter areas.
4. Hose end and cap for drain.
5. Mounting pads for actuator.
6. Provide “stop and drain” for compressed air.
7. Ball Valves up to 3” may be used for all water services as an alternate to gate valves, globe valves and balancing cocks.
8. Ball valves shall be bronze body, 316 stainless steel ball and stem, Teflon seats and seals threaded ends, 400 psig cold W.O.G. Worchester No. 411T-SE or equal.

2.7 CIRCUIT SETTERS (CS)

A. Manufacturers:

1. Design Basis: Tour & Andersson

2. Acceptable Manufacturers:
   a. Bell & Gossett/ITT
   b. Taco
   c. Victaulic

B. All valves to be of bronze body/brass ball construction with glass and carbon filled TFE seat rings. Valves to have differential pressure read-out ports across valve seat area. Read-out ports to be fitted with internal EPT insert and check valve. Valve bodies to have ¼” NPT tapped drain/purge port. Valves to have memory stop feature to allow valve to be closed for service and then reopened to set point without disturbing balance position. All valves to have calibrated nameplate to assure specific valve setting. Valves to be leak-tight at full rated working pressure.

C. All valves 2” and smaller to be y-pattern, globe type, Ametal brass copper alloy body, EPDM o-rings, 4-turn digital hand wheel for balancing with concealed memory feature with locking, tamper-proof setting, soldered or threaded end connections, 250 deg F temperature rating and maximum 400 PSI pressure rating. Victaulic/Tour & Andersson Series 786, 787, 78K.

1. Install Series 78U union port fitting and Series 78Y strainer/ball valve combination to complete terminal hookup at coil outlet.

2. All valves 2-1/2” and larger to be y-pattern, globe type, ductile iron body, EPDM o-rings, multiple-turn digital readout hand wheel for balancing with concealed memory feature with locking, tamper-proof setting, flanged or grooved end connections. 250 deg F temperature rating and maximum 350 PSI pressure rating. Victaulic/Tour & Andersson Series 788 and 789.

D. Valves ½” to 2” pipe size, NPT or sweat valves 2 ½’ and 3” pipe size, NPT, flanged, or grooved.

2.8 DOMESTIC WATER PRESSURE REDUCING VALVE

A. Manufacturer (2½” and smaller):

1. Design Basis: Watts Model 223S
2. Other Acceptable Manufacturers:
    a. Febco
    b. Wilkins
3. Construction:
    a. Seal: Renewable, stainless steel.
    b. Strainer: Stainless steel.
    c. Diaphragm: High temperature resistant.

B. The valve shall maintain a constant downstream pressure regardless of varying inlet pressure. This valve shall be a hydraulically operated diaphragm-actuated, angle pattern valve. It shall contain a resilient synthetic rubber disc, having a rectangular cross-section, contained on three and one-half sides by a disc retainer and forming a tight seal against a single removable seat insert.

C. The diaphragm assembly containing a valve stem shall be fully guided at both ends by a bearing in the valve cover and an integral bearing in the valve seat. This diaphragm assembly shall be in the only moving part and shall form a sealed chamber in the upper portion of the valve separating operating pressure from the line pressure.

D. The diaphragm shall consist of nylon fabric bonded with synthetic rubber and shall not be used as a seating surface. Packing glands and/or stuffing boxes are not permitted and there shall be no pistons operating the valve or pilot controls. All necessary repairs shall be possible without removing valve from the line.

E. The pilot control shall be a direct-acting, adjustable, spring-loaded, normally open, diaphragm valve designed to permit flow when controlled pressure is less than the spring setting. The control system pressure is less than the spring setting. The control system shall include a fixed orifice.

2.9 BACKFLOW PREVENTER

A. Backflow Preventer, Reduced Pressure Zone Type, Food Service Applications

1. Design Basis: Watts No.SS009QT Series

2. Other Acceptable Manufacturers:
    a. Febco
    b. Wilkins
3. Construction: Stainless steel trim and body, complete with test cocks, resilient seat, shut-off valves, and air gap fitting.
4. Complies with ASSE STD 1013

B. Backflow Preventer (Reduced Pressure Zone Type) (Cooling Towers)

1. Manufacturer:
    a. Design Basis: Watts No. 994 Series
    b. Construction: Stainless steel trim and body, complete with test cocks, resilient seat, shut-off valves, and air gap fitting.
    c. Other Acceptable Manufacturers:
    d. Febco
    e. Wilkins
2. Complies with ASSE STD 1013.
3. Extend relief valve drain to nearest acceptable floor drain.
4. The reduced pressure backflow preventer shall consist of two separately spring loaded “Y” type check valves and one differential relief valve having two diaphragms separated by a spacer. This device shall automatically reduce the pressure in the “zone” between the check valves. Should the pressure differential, normally 4.5 psi, drop to 3.0 psi, the relief valve shall open, dumping the liquid to atmosphere and maintain the proper differential. A small hose in the spacer will bleed to atmosphere if either diaphragm is damaged, giving visual evidence of diaphragm failure. Both check valves shall be serviceable without removing the device from the line. RPZ shall be rated to 150 psi working pressure and 212°F water temperature. Backflow preventers 2” and smaller shall have bronze bodies and bronze trim. 2-1/2” and larger shall have cast iron bodies with epoxy coating and bronze trim. Backflow preventers shall be similar to Watts 900 or approved equal.

C. Backflow Preventer (Atmospheric Vacuum Breaker)

1. Manufacturer:
    a. Design Basis: Watts No. 008 Series (3/8” through1”)
    b. Construction: Bronze body, ball valve shut offs.
    c. Other Acceptable Manufacturers:
        1) Beeco
        2) Febco
        3) Wilkins
2. Complies with ASSE STD 1020.
3. Provide vacuum breakers on water supply piping to each fixture and equipment with submerged inlets, and on faucets and outlets, within the building, to which hose can be, or is attached, forming a submerged inlet. Set vacuum breakers in exposed readily accessible locations and at least 6’-6” above finished floor. Vacuum breakers shall be chrome plated brass, T&S Brass No. B-929-A watts 008 or approved equal. Vacuum breakers shall comply with ASSE STD 2010.

2.10 BACKWATER VALVE

A. Provide backwater valve where indicated on the Drawings.

B. Backwater valve shall be similar to Zurn No. 1095-6 or MIFAB BV 1000, cast iron, hub inlet and offset spigot outlet, cast iron cleanout and plug for caulking into top hub of cleanout opening, automatic type bronze valve seat and flapper which hangs open during periods of non-operation.

PART 3 - EXECUTION

3.1 GENERAL

A. Comply with the following requirements:

1. Install valves with stems pointing up, and as close to vertical as possible.
2. Install valves at each piece of equipment, fixture or appliance so that the supply and return services can be shut off to remove the item without draining the remainder of the piping system.
3. Install valves where required for proper operation of piping and equipment, including valves in branch lines where necessary to isolate sections of piping. Install isolation valves at each concession, bathroom group and riser. Locate valves so as to be accessible.
4. Combination balancing and shut-off valves may be used instead of a separate balancing valve and shut-off valve if the valve has a memory stop and the manufacturer lists its use as a leak-proof service valve.
5. Provide drain valves at main shut-off valves, low points of piping and apparatus.
6. Provide separate support where necessary.
7. Do not allow meter connections of balancing valves to point downward.
8. Install valves so bypass valves are accessible.
9. Furnish all valves as indicated on the plans, or as may be required for the proper control of the pipe lines installed under this Specification, so that any fixture, line or piece of apparatus may be cut out for repair without interference or interruption of the service to the rest of the Building. All water valves shall have a minimum working pressure of 125 psi, water rated unless otherwise noted on the Drawings or specified herein. All valves shall be of one manufacture. Provide valves with elevated pressure rating matched to service conditions where pressure exceeds 125 psi..
10. Drain valves shall be 3/4" heavy cast brass with composition washers with male thread for hose connections.
11. Provide at the high point of hot water piping system a 1/2" automatic IBBM air relief valve, 125 PSI, WOG Class. Pipe drain to spill over adjacent floor drain or service sink.
12. All valves on the exterior domestic and fire protection water piping shall comply with Local Water Company.

13. All valves shall have the trademark of the manufacturer and the guaranteed working pressure cast or stamped on the body of the valve. All gates or globes, etc., shall be of one manufacturer and working pressure cast or stamped thereon.
14. The exterior valves shall conform to all applicable requirements of American Water Works Association C500-61 Standard for Gate Valves for Fire Water Work Service.
15. The entire plumbing systems shall be supplied with valves so located, arranged and operated as to give a complete regulating control to all fixtures and apparatus
16. Install check and globe valves on downstream side of the shutoff valve on hot water circulating riser and branch lines.
17. Valves, where exposed and used in connection with finished piping, shall be same finish as the pipe.
18. Provide shut-off valves and check valves on each pump discharge line.
19. Install valves where required for proper operation of piping and equipment including valves in branch lines necessary to isolate sections of piping. Locate valves so as to be accessible.
20. Install valves with bodies of metal other than cast iron where thermal or mechanical shock is indicated or can be expected to occur.
21. Do not install bronze valves and valve components in direct contact with steel, unless bronze and steel are separated by dielectric insulator. Install bronze valves where corrosion is indicated or can be expected to occur.
22. Select and install valves with outside screw and yoke stems, except provide inside screw non-rising stem valves where headroom prevents full opening of OS&Y valves.
23. Except as otherwise indicated, install gate, ball, and globey valves to comply with ANSI B31.1. Where throttling is indicated or recognized as principal reason for valve, install globe valves.
24. Limit selection and installation of valves with non-metallic discs to locations indicated and where foreign material in piping system can be expected to prevent tight shutoff of metal seated valves.
25. Select and install valves with renewable seats, except where otherwise indicated.

B. All valves of a given type shall be of one manufacturer.

C. Provide extended stems on insulated system to prevent interference of operator with insulation.

D. Provide chain wheel operators for valves more than 7’ – 0” AFF in mechanical rooms and wherever shown on drawings.

3.2 VALVE APPLICATION

Domestic Hot and Cold Water ½” – 2”	Ball Valve
Domestic Hot and Cold Water 2½ ” – 10”	Gate Valve

3.3 CHECK VALVE INSTALLATION

A. Swing and Check Valves:

1. Install only in horizontal lines unless absolutely impractical. If installed vertically, flow shall be upwards.
2. Do not install in pump discharge piping.

B. Silent Check Valves:

1. Install in all pump discharge lines.
2. Silent check valves may be installed in vertical pipes with flow down upon Engineer's review for each instance.

C. Installation of Check Valves:

1. Wafer Check Valves: Install between 2 flanges in horizontal or vertical position.
2. Horizontal Lift Check Valve: Install in horizontal piping line with stem vertically upward.
3. Vertical Lift Check Valve: Install in vertical piping line with upward flow with stem vertically upward.

3.4 BACKFLOW PREVENTOR

A. Provide backflow preventors as follows:

1. Reduced pressure at cooling towers, and make-up for hydronic systems.
2. Vacuum breaker at all hose bibs.
3. Reduced pressure on domestic water entry.
4. Vacuum breaker at all mop sinks.

B. Provide reduced pressure type master backflow preventer on main domestic water supply and to each fixture and equipment requiring same as indicated on the Drawings and governed by the applicable codes. This shall include, but not be limited to, mechanical equipment, kitchen equipment and equipment specified in other divisions.

C. Provide drain opening and pipe to nearest floor drain or service sink.

3.5 CIRCUIT SETTERS

A. All circuit setters shall be installed per manufacturer's recommendations. Provide manufacturers recommendation for required straight pipe for inlet and outlet connections to provide accurate ratings. Setting shall be as required for proper balanced flow to equipment.

B. Provide circuit setters on all hot water return lines and any other lines requiring controlled flow.

END OF SECTION

SECTION 22 05 29

PLUMBING PIPE SUPPORTS AND ANCHORS

PART 1 - GENERAL

1.1 STANDARDS

A. Comply with MSS Standard Practice SP-58, SP-69 and SP-89, published by Manufacturer's Standardization Society of the Valve and Fitting Industry for type and size.

1.2 SUBMITTALS

A. Submit manufacturer's product data on the following:

1. Hangers other than clevis type.
2. Anchors.

B. Submit structural calculations for trapeze type supports.

PART 2 – PRODUCTS

2.1 PIPE HANGERS

A. General:

1. Use adjustable pipe hangers on suspended pipe. Trapeze hangers may be used at the Contractor's option. Contractor shall be responsible for sizing supports.
2. Chain, wire or perforated strap hangers will not be permitted.
3. Isolate hangers in contact with dissimilar materials with dielectric hanger liners. Tape is not acceptable.
4. Provide supports between piping and building structure where necessary to prevent swaying.

B. Hanger Rods:

1. Exposed in public areas: Zinc electroplated steel.
2. Concealed or in service areas: Black threaded steel.
3. Outside, exposed to weather: Hot dipped galvanized.

C. Spot Concrete Inserts: Steel case and expander plug for threaded connection with lateral adjustment, top slot for reinforcing rods and lugs for attaching to forms.

1. Size inserts to match size of threaded hanger rods.
2. Inserts to be UL and FM listed.

3. Minimum 1000 lb. Capacity with ½" rod.

D. Channel Type Inserts:

1. Standard channel support with anchor tabs on 4" centers, and nail holes for attaching to forms.
2. Styrofoam inserts to prevent wet concrete seepage.
3. Minimum 2000 pounds/foot capacity.

E. Expansion Anchors:

1. For use only in renovations or where modifications to piping layouts require installation away from pre-installed insert locations.
2. Inserts shall be of the drill, insert, expand type. Power driven fasteners are not acceptable for piping.
3. Contractor shall select the appropriate type based on the following:

Rod Size	Maximum Working Load
3/8	600 pounds
½	1100 pounds
5/8	1800 pounds
¾	2700 pounds
7/8	3700 pounds

F. Steel Structure Attachments:

1. Contractor may select welded or mechanically attached. All mechanically attached supports shall have jam nuts or other means to prevent loosening. Maximum loading requirements are as follows:

Rod Size	Maximum Working Load
3/8	600 pounds
½	1100 pounds
5/8	1800 pounds
¾	2700 pounds
7/8	3700 pounds

G. Single Hangers:

1. Piping 2" and smaller: MSS type 1, Clevis hanger or type 7 adjustable swivel ring hanger. Minimum 180 pounds design load.
2. Piping 2" and smaller (steel): Clevis hanger, Anvil Fig. No. 260, F & M Fig. No. 239, Paterson Fig. No. 100.
3. Piping 2" and smaller (copper): Adjustable wrought iron, Anvil Fig. No. CT-65, F & M Fig. No. 364, Paterson Fig. No. 100 CT
4. Piping 2½" and larger: MSS type 1 Clevis hanger.
5. Piping 2½" to 4" (steel): Adjustable swivel pipe roll, Anvil Fig. No. 181, F & M Fig. No. 2729, Paterson Fig. No., 16.

6. Piping 2½” to 4” (copper): Adjustable wrought ring, Anvil Fig. No. CT-69.
7. Piping 5” and above: Two rod roller hanger, Anvil Fig. No. 171, F & M Fig. No. 170, Paterson Fig. No., 142.
8. Bare copper pipe: Above hangers, plastic or Neoprene coating, sized for copper pipe O.D. and copper coated for identification.
9. Insulated pipe: Hangers to be sized for O.D. of insulation. Hangers shall not penetrate any insulation.
10. Cast iron pipe above hangers sized for O.D. of cast iron pipe.
11. Hanger wire, cable or perforated metal strapping are not acceptable.

H. Trapeze hangers and wall supports:

1. Channel strut or structural steel shapes. Contractor shall follow channel strut manufacturers guidelines for loading or provide structural steel supports designed by a professional Engineer, licensed in the state where the project is located.
2. All piping shall be attached to the support by means of a channel strut clamp, U-bolt, or pipe rollers which will maintain lateral position of the pipe but allow longitudinal movement. Provide dielectric isolation between all dissimilar metals.
3. All insulation shall be continuous at supports. Do not notch or penetrate insulation.
4. Kindorf or similar materials used for support of small piping shall not be used for piping 3” or larger.
5. ½” through 3”: Unistrut type channel and steel clamp.
   a. Use Hydrosorb cushions on copper pipe.
6. 4” and Over: Welded steel bracket and wrought steel clamp.

I. Vertical Supports: Provide steel riser clamp at each floor penetration or every 14 foot supported from wall bracket. Do not anchor riser clamps. In exposed locations, coordinate clamp locations with Architect.

J. Hangers:

1. General: Adjustable wrought steel clevis with locking nut attachment.
2. Multiple or Trapeze: Steel channels with welded spacers and hanger rods.
3. Hanger Sizes and Spacing:
   a. For drain piping, conform to the code requirements for spacing, and the following table for hanger rod sizes.
   b. For plumbing piping, conform to the following table:

PIPE TYPE	PIPE SIZE	MAXIMUM HORIZONTAL SPACING	MAXIMUM VERTICAL SPACING	MINIMUM HANGER ROD SIZE
Steel Pipe	½”	6’-0”	At every story height	3/8”
	¾” thru 1¼”	8’-0”		3/8”
	1½” and 2”	10’-0”		3/8”
	2½” thru 3½”	12’-0”		1/2"

PIPE TYPE	PIPE SIZE	MAXIMUM HORIZONTAL SPACING	MAXIMUM VERTICAL SPACING	MINIMUM HANGER ROD SIZE
Copper or copper- alloy tubing	1¼” and smaller	6’-0”	At each story height no greater than 10’	3/8”
Copper or copper- alloy tubing	1½ ” and larger	10’-0”	At each story height no greater than 10’	3/8”
Copper Pipe	½” thru 1” 1¼” thru 2” 2½” thru 3” 4”	8’-0” 10’-0” 10’-0” 10’-0”	At every story height no greater than 10’	3/8” 3/8” 1/2" 5/8”
Cast Iron Soil	2” 3” to 5”	5’ And Each Joint 5’ And Each Joint	At base and at each story height no greater than 15’	3/8” ½”

K. Insulated Pipe Supports:
1. Size pipe supports for outside diameter of pipe insulation.
2. It is not acceptable to cut or notch insulation at support locations.

L. Pipes over five inches and over 120º: Provide cast iron roller supports.

M. Beam clamps - Hangers supported from floor steel shall be approved I beam clamps. I beam clamps for hangers supporting piping 2 inches and smaller shall be C & P Fig. No. 148 adjustable beam clamps. For piping 2-1/2 inches and larger, I beam clamps shall be wrought steel. C & P Fig. No. 268 or equal.

N. Hangers for copper piping shall be copper plated.

2.2 INSULATION INSERTS

A. Pipe shall be protected at the point of support by an insert of high density, 100 psi, waterproofed calcium silicate, or Hi-Low Temp insert, encased in a sheet metal shield. Insert to be same thickness as adjoining pipe insulation. Insulation insert to extend one inch beyond sheet metal shield on all “cold” lines. If pipe hanger spacing exceeds ten feet and for all pipe roller applications, utilize double layer shield on bearing surface.

B. Provide 180º insulation inserts when utilizing clevis hangers. Provide 360º insulation inserts at all trapeze and wall supports.

2.3 PIPE ANCHORS

A. Manufacturers:
1. Design Basis: Flexonics

2. Other Acceptable Manufacturers:
   a. Adsco
   b. Keflex
   c. Hilti

B. Model AC with threaded ends and welded angle brackets for steel pipe.

C. Model AC copper tube with solder ends and steel angle brackets brazed to tubing for copper tube.

D. Anchors may be field fabricated similar to manufactured products specified.

2.4 PIPE GUIDES

A. Manufacturers:

1. Basis of Design: B-line.
2. Other Acceptable Manufacturers:
   a. Fee & Mason
   b. Anvil
   c. M-Co
   d. PHD

B. Any of the Following:

1. Spider Type: B3281-7.
2. Roller Type: 2 sets of rollers on opposite sides of pipe.
3. Slide Type: B3893 with hold down lugs.
   a. Not for use with cold piping.
4. Light duty, 1½" and smaller copper: U bolt or channel strut clamp (B2417) allowing clearance from O.D. of pipe or insulation.

2.5 ROOF MOUNTED PIPING

A. Manufacturers:

1. Miro Industries, Inc.
2. Portable Pipe Hangers, Inc.
3. Approved Equivalent.

B. Description: Where roofs are not being replaced, piping on roof shall be supported by an engineered prefabricated portable pipe system specifically designed to be installed on the roof without roof penetrations, flashing or damage to the roofing material. The system shall consist of recycled rubber or plastic bases, hot dipped galvanized or stainless steel frame with threaded rods and suitable pipe hangers and supports. The system shall be custom designed to fit the piping and conduits to be installed and the actual conditions of service.

C. Piping on areas of roof being replaced shall be installed on pipe curbs bearing on roof structure and flashed into roofing material.

D. Provide seismic restraints as required for seismic zone.

PART 3 – EXECUTION

3.1 INSTALLATION OF PIPE SUPPORTS

A. Adequately support piping from the building structure with adjustable hangers to maintain uniform grading where required and to prevent sagging and pocketing.

1. Provide supports between piping and building structure where necessary to prevent swaying.
2. Do not support pipe from other pipe or equipment.
3. Provide thrust restraints at all changes in direction on 8” and larger cast iron piping with no hub or hub and spigot fittings.

B. Install hangers to provide minimum ½” clear space between finished covering and adjacent work.

1. Place a hanger within one foot of each horizontal elbow.
2. Space hangers generally as called for in Table in Part 2, Products.

C. Use hangers, which are vertically adjustable 1-½” minimum after piping is erected.

D. Use inserts for suspending hangers from reinforced concrete slabs and sides of reinforced concrete beams wherever practicable.

1. Set inserts in position in advance of concrete work.
2. Where concrete slabs form finished ceiling, finish inserts flush with slab surface.
3. Do not penetrate concrete “TT” legs for piping inserts. Do not penetrate the stressed (i.e. lower) chords of any structural member.

E. Provisions for Movement: Install hangers and supports:

1. To allow controlled movement of piping systems.
2. To permit proper movement between pipe anchors.
3. To facilitate the action of expansion joints, expansion loops, bends and offsets.
4. To isolate force due to weight or expansion from equipment connections.

F. In general, attach hangers to upper chord of roof trusses and floor joists, using long rods to facilitate pipe movement.

G. Anchors:

1. Arrange piping such that pipe expansion and contraction is accommodated by controlled movement of the pipe within the pipe supports. Provide sufficient offsets in branch piping to accommodate movement of main piping due to

expansion and contraction. Where this is not possible due to magnitude of expansion or building geometry, securely anchor piping where required for a proper installation and to force the pipe expansion in the proper direction.

2. Anchors shall be suitable for the location of installation and shall be designed to withstand not less than five times the anchor load.
3. Anchor vertical pipes by means of clamps welded around pipes and secured to wall or floor construction. Anchor at bottom of riser only but provide guides for vertical thermal movement.
4. All anchors shall be separate and independent of all hangers, guides, and supports. Anchors shall be of heavy blacksmith construction suitable in every way for the work approved by the Architect. Anchors shall be welded to the pipe and fastened to the structure with bolts.
5. Anchors shall be fabricated and assembled in such a form as to secure the piping in a fixed position. They shall permit the line to take up its expansion and contraction freely in opposite directions away from the anchored points: and shall be so arranged as to be structurally suitable for particular location, and line loading. Submit details for approval.

H. Assume the responsibility for the proper transfer of the loads to the piping systems to the structure. No additional cost to the owner should be expected for any corrective work during construction.

I. Provide necessary structural members, hangers, and supports of approved design to keep piping in proper alignment and prevent transmission of injurious thrusts and vibrations. In all cases where hangers, brackets, etc., are supported from metal decking and/or concrete construction, care shall be taken not to weaken decking and/or concrete or penetrate waterproofing. Hangers supporting piping expanding into loops, bends and offsets shall be secured to the building structure in such a manner that horizontal adjustment perpendicular to the run of piping supported may be made to accommodate displacement due to expansion. All such hangers shall be finally adjusted, both in the vertical and horizontal direction, when the supported piping is hot.

J. Provide supplemental bolted steel in all locations where drilling of slab will create unacceptable noise in adjacent spaces.

K. Where piping is run near the floor and not hung from the ceiling construction but is supported from the floor, such supports shall be of pipe standards with base flange and adjustable top yoke similar to C & P Fig. 247 or equal.

L. All vertical piping shall be anchored by means of heavy steel clamps securely bolted or welded to the piping, and with end extension bearing on the building.

M. Vertical runs of pipe not over 15 feet long shall be supported by hangers placed not over one foot from the elbows on the connecting horizontal runs.

N. Vertical runs of pipe over 15 feet long but not over 60 feet long and not over 6 inches in size, or not over 30 feet long and not over 12 inches in size, shall be supported on heavy steel clamps. Clamps shall be bolted tightly around the pipes and shall reset securely on the building structure without blocking. Clamps shall be welded to the pipes or placed below couplings. Clamps shall be type 8, Federal Specification WW-H-171C, unless other types are approved.

O. Hanger rods shall be attached to preset concrete inserts with steel reinforcing rod through the insert and both ends hooked over the reinforcing mesh. For pipes 4 inches and larger, rods shall extend through concrete slab above where they shall be attached to steel bearing plates 6" x 6" x 1/4".

P. Piping shall not be hung from other piping, ducts, conduits or from equipment of other trades and no vertical expansion shields will be permitted. Hanger rods shall not pierce ducts.

Q. All piping running on walls shall be supported by means of hanger suspended from heavy angle iron wall brackets. No wall hooks will be permitted.

END OF SECTION

SECTION 22 05 53

PLUMBING IDENTIFICATION

PART 1 - GENERAL

1.1 SUBMITTALS

A. Submit manufacturer's product data on the following:

1. Plastic Pipe Markers and method of application.
2. Engraved Plastic Laminate Sign.

PART 2 - PRODUCTS

2.1 GENERAL

A. Except as otherwise indicated, provide manufacturer's standard products.

B. Where more than a single type is specified for an application, selection is Installer's option, but provide a single selection for each application.

2.2 PLASTIC PIPE MARKERS (TYPE A)

A. Provide manufacturer's standard pre-printed, flexible or semi-rigid, permanent, color-coded, plastic-sheet pipe markers, complying with ANSI A13.1.

B. For Pipes Less Than Six Inches (including insulation if any): Provide full-band pipe markers, extending 360º around pipe at each location, fastened by one of the following methods:

1. Snap-on application of pre-tensioned semi-rigid plastic pipe marker.
2. Adhesive lap joint in pipe marker overlap.
3. Taped to pipe (or insulation) with color-coded plastic adhesive tape, not less than ¾" wide; full circle at both ends of pipe marker, tape lapped 1-½".

C. For Pipes Six Inches and Larger (including insulation if any): Provide either full-band or strip-type markers, but not narrower than 3 x letter height, taped to pipe (or insulation) with color-coded plastic adhesive tape, not less than 1-½" wide; full circle at both ends of pipe marker, tape lapped 3".

D. Lettering: Manufacturer's pre-printed wording which conforms to contract document system descriptions.

E. Where work is an extension or alteration of an existing system, new markers shall match existing terminology for systems which are modified or added by this work.

F. Arrows: Print each pipe marker with arrows indicating direction of flow, either integrally with piping system service lettering or as a separate unit of plastic (to accommodate both directions).

2.3 STENCILING (TYPE B)

A. Using a color contrasting to the surface to identify, spray or brush paint through neatly cut stencils.

B. Lettering shall conform to wording on contract documents. Size shall be in accordance with ANSI A13.1.

2.4 BACKGROUND COLOR AND STENCILING (TYPE C)

A. In addition to the requirements above, paint a background color band in accordance with ANSI A13.1.

2.5 VALVES TAGS

A. Brass Valve Tags: Provide manufacturer’s standard 19 ga brass tag; approximately 1-½” round wit ½” high black filled numbers and 3/16” top hole.

1. Numbers shall be sequential in accordance with schedule below.
2. Provide separate numbering for each legend sequence. Provide separate sequences for the following:
    a. Plumbing (PLBG)
    b. Domestic Cold Water (DCW)
    c. Domestic Hot Water (DHW)
    d. Domestic Hot Water Return (DHWC)
    e. All other systems (No legend)

B. Valve Tag Fasteners: Manufacturer’s standard chain (wire link or beaded type), or S-hooks.

2.6 VALVE SCHEDULE

A. Provide schedule for each piping system, as defined on the drawings, and below, typewritten and reproduced on 8-½” x 11” bond paper.

B. Tabulate valve number, piping system, system legend (as shown on tag), location of valve (room or space), and variations for identification (if any).

C. Provide piping schematic for each system as defined below in Part 3.

D. In addition to mounted copies, furnish extra copies for maintenance manuals as specified.

E. Valve Schedule Frames: For each page of the valve schedule, provide a glazed frame, with screws for removable mounting on masonry walls.

2.7 ENGRAVED PLASTIC-LAMINATE SIGNS

A. General: Provide engraving stock melamine plastic laminate, 1/16" thick, black with white core (letter color).

B. Fastening:

1. Screws
2. Rivets
3. Permanent Adhesive

C. Lettering and Graphics:

1. Coordinate names, abbreviations and other designations used in the mechanical identification work, with the corresponding designations shown, specified or scheduled in the construction documents.

PART 3 - EXECUTION

3.1 GENERAL

A. Where identification is to be applied to surfaces which require insulation, painting or other covering or finish, install identification after completion of covering and painting.

B. Install identification prior to installation of acoustical ceilings and similar removable concealment.

3.2 PIPING SYSTEM IDENTIFICATION

A. General: Install pipe markers on piping of the following systems and include arrows to show normal direction of flow.

1. Domestic water piping (hot, cold, tempered; 120º hot, 180º hot, hot water re-circulating, etc.).
2. Plumbing vent and sanitary (above grade) piping.
3. Storm piping.

B. Locate pipe markers and color bands as follows wherever piping is exposed to view in occupied spaces above accessible ceilings, in accessible maintenance spaces, including chases, and above ceiling:

1. Near each valve and control device.
2. Near each branch, excluding short take-offs for fixtures and terminal units. Mark each pipe at branch, where there could be a question of flow pattern.
3. Near locations where pipes pass through walls, floors, or ceilings, or enter non-accessible enclosures.
4. Near major equipment items and other points of origination and termination.
5. Spaced intermediately at maximum spacing of 50’ along each piping run.
6. Within 6’ of access doors above otherwise non-accessible ceilings and chases.

C. Type:

1. Normally exposed to view - Type A or C.
2. Normally concealed from view - Type B.

3.3 VALVE IDENTIFICATION

A. Provide valve tag on every valve, cock and control device in each piping system; exclude check valves, valves within factory fabricated equipment units, plumbing fixtures faucets, hose bibs, and shut-off valves at plumbing fixtures, and similar rough-in connections of end-use fixtures and units. List each tagged valve in valve schedule for each piping system.
   1. Shut off valves located at least 10’ from fixture(s) shall be provided with valve tag unless otherwise directed by Engineer.

B. Mount framed valve schedules with piping schematics where directed by Architect.

C. Identify each valve tagged on as-built drawings.

3.4 NON-POTABLE WATER IDENTIFICATION

A. Provide an engraved plastic laminate sign.

1. Legend: “Non-Potable Water”.
2. Location: At each outlet of piping between backflow preventer and equipment served. (e.g. Boiler Room hose bibb).

END OF SECTION

SECTION 22 05 93

TEST-ADJUST-BALANCE

PART 1 - GENERAL

1.1 RESPONSIBILITY

A. A work of this section shall be completed by a sub-contractor of the Plumbing contractor.

B. The Balancing Contractor shall not be a sub-contractor of any other Division 21, 22 or 23 Contractor.

1.2 QUALITY ASSURANCE

A. Qualification:

1. The firm shall be an independent testing and balancing firm specializing in testing and balancing of environmental systems.
2. The firm shall have an experience record of not less than five (5) years experience in the testing and balancing industry.

B. Registration: Work shall be done under the supervision of a professional engineer registered in the jurisdiction of the work. Engineer shall be available for all meetings and interpretation of all materials in the report.

C. Pre-qualification of Testing and Balancing Contractor.

1. The firm must have experience and qualifications satisfactory to the consulting mechanical engineer and must be accepted by him prior to bidding.
2. Firms desiring approval to provide work under this section shall submit a booklet indicating procedures and data forms that they would use in the performance of the work.
3. Only firms which have been approved by the engineer may provide work under this section.

PART 2 - PRODUCTS

2.1 PRODUCTS (Not applicable)

PART 3 - EXECUTION

3.1 GENERAL

A. Sequence work to commence after completion of system and start-up procedures and schedule completion of work before Substantial Completion of Project.

B. Examine the installed work and conditions under which testing is to be done to ensure that work has been completed, cleaned and is operable.

C. Notify the Contractor in writing of conditions detrimental to the proper completion of the test-adjust-balance work.

1. Do not proceed with the work until unsatisfactory conditions have been corrected.
2. Provide Engineer/Architect with a copy of the notification.

D. Adjust flows to within 10% of values shown. If design flows cannot be obtained within specified limits the Balancing Contractor will perform the following (at the minimum):

1. Measure and record major pressure drops in the system.
2. Consult with the Engineer and Installer as required.
3. Upon receiving written directions to proceed and after any corrections are performed, re-balance affected portion of system.

E. Optimization: Work closely with the plumbing contractor to optimize setpoints.

1. Establish the minimum water differential pressure for variable or bypass flow system.
2. Establish the position of valve and sequencing relays.
3. Confirm suitable operation of all backflow prevention devices.
4. Confirm proper operation of hot water return system.
5. Confirm proper flow through all heat exchangers.

F. Patch holes in insulation and housings which have been cut or drilled for test purposes, in a manner recommended by the original Installer.

G. Make all final readings for each system at the same time, and after all adjustments have been made.

H. Mark equipment settings, including control positions, balancing cocks, circuit setters, valve indicators, to show final settings at completion of test-adjust-balance work.

1. Mark with paint or other suitable permanent identification material.

I. Check all new thermal overloads.

1. Identify improperly protected equipment in report.

J. All piping and equipment shall be tested; labor including standby electrician, materials, instruments and power required for testing shall be furnished unless otherwise indicated under the particular section of the Specification.

K. Tests shall be performed in the presence and to the satisfaction of the Architect and such other parties as may have legal jurisdiction.

L. In no case shall piping, equipment, or accessories be subjected to pressure exceeding their ratings.

M. All defective work shall be promptly repaired or replaced and the tests shall be repeated until the particular system and component parts thereof receive the approval of the Architects.

N. Any damage resulting from tests to any and all trades shall be repaired and damaged materials replaced, all to the satisfaction of the Architect.

O. The duration of tests shall be as determined by all authorities having jurisdiction, but in no case less than the time prescribed below.

P. Equipment and systems which normally operate during certain seasons of the year shall be tested during the appropriate season. Tests shall be performed on individual equipment, systems, and their controls. Whenever the equipment or system under test is interrelated and depends upon the operation of other equipment, systems and controls for proper operation, functioning and performance, and latter shall be operated simultaneously with the equipment or system being tested.

Q. All piping shall be tested to a hydrostatic pressure at least 1-1/2 times the maximum designed working pressure unless a higher pressure is required elsewhere (but not less than 50 psi) for a sufficiently long time to detect all leaks and defects; and after testing shall be made tight in the most approved manner. Tests shall be repeated once after leaks and defects have been repaired. When automatic-control valves and similar devices are incapable of withstanding test pressures applied to piping, such devices shall be removed, or otherwise protected during tests. After completion of such tests, devices shall be installed and tested with the operating medium to operating pressures.

3.2 DOMESTIC WATER SYSTEMS

A. Before any adjustments are made:

1. Check temperature control valve operation.
2. Check pump rotation.
3. Adjust pressure reducing valve.
4. Remove any roughing strainer screens in systems.

B. Procedure:

1. Measure and report all domestic water recirculation systems by all of the below means which are applicable.
   a. System, pump, branch, or terminal flow measuring stations.
   b. Terminal or heat exchanger pressure drop, compare to submittal data.
   c. Plot operating point on system graph.

3.3 DETAILED REQUIREMENTS

A. Measure, adjust and report the following:

1. Pumps (including ejectors and sump pumps):
   a. Water flow
   b. Inlet and outlet pressure
   c. Motor amps and KW
2. Heat Exchangers:
   a. Cooler fluid inlet and outlet temperatures
   b. Cooler fluid flow
   c. Warmer fluid inlet and outlet temperatures
   d. Warmer fluid flow

3.4 REPORT

A. Provide a general information sheet listing:

1. Instruments used:
   a. Most recent calibration date.
2. Method of balancing.
3. Altitude correction.
4. Manufacturer’s performance data for all air devices used.

B. Provide data sheets for all equipment, including motors and drives, listing:

1. Make
2. Size
3. Serial number
4. Capacity Rating
5. Amperage
6. Voltage input
7. Thermal heater size for each motor
8. Operating speed of driver and driven devices
9. Any additional pertinent performance data

C. Include design and final values for all items listed in Detailed Requirements, and totals for each system.

D. Provide data sheets showing:

1. Instrument used
2. Velocity reading
3. Manufacturer’s free area factors

E. Provide recap sheet with explanation for each device not meeting specified performance.

F. Provide a set of prints with equipment, inlets and outlets marked to correspond to data sheets.

END OF SECTION

SECTION 22 07 00

PLUMBING INSULATION

PART 1 - GENERAL

1.1 SUBMITTALS

A. Submit manufacturer's product data on the following:

1. Insulation.
2. Jackets, coatings and protective finishes.
3. Sealers, mastics and adhesives.
4. Fitting covers.

1.2 FLAME AND SMOKE RATINGS

A. Provide insulation tested on a composite basis (insulation, jacket, covering, sealer, mastic and adhesive) complying with the following for:

1. Flame Spread: 25 or Less
2. Smoke Developed: 50 or Less
3. Method: ASTM E84 (NFPA 255), UL 723

B. Accessories such as adhesives, mastics, cements, tapes and cloths for fittings shall have component ratings as listed above. All products shall bear UL labels indicating the above are not exceeded.

1.3 PRODUCT DELIVERY

A. Deliver insulation products in factory containers bearing manufacturer's label showing fire and smoke hazard rating, density and thickness.

B. Protect insulation against, dirt, water, chemical and mechanical damage. Do not install damaged insulation; remove from project site.

C. Store insulation in original wrappings and protect from weather and construction traffic.

1.4 DEFINITIONS

A. Exposed Location: Located in mechanical rooms or other areas exposed to view.

B. Concealed Location: Located in pipe chases, furred spaces, attics, crawl-spaces, above suspended ceilings, or other locations not exposed to view.

1.5 STANDARDS

A. Comply with the latest edition of National Commercial and Industrial Insulation Standards.

B. Provide certifications or other data as necessary to show compliance with these Specifications and governing regulations. Include proof of compliance for test of products for fire rating, corrosiveness, and compressive strength.

PART 2 - PRODUCTS

2.1 PIPE INSULATION

A. Manufacturers:

1. Design Basis: Johns-Manville
2. Other Acceptable Manufacturers:
    a. Armacell
    b. Foster
    c. Owens-Corning
    d. Knauf
    e. KFlex USA
    f. Imcoa
    g. Pittsburgh Corning

B. Materials:

1. Fiberglass Pipe Insulation with Vapor Barrier: Johns-Manville Micro-Lok heavy density pipe insulation with AP-T jacket or Owens-Corning Fiberglass Corp. ASJ/SSL-11.
2. Fiberglass Pipe Fitting Insulation: Johns-Manville "Zeston" fitting covers with factory-cut fiberglass insulation insert. Insulation blanket with foil tape and tie wire will not be accepted.
3. Flexible Unicellular Pipe Insulation: Armstrong Armaflex, II or Therma-cel By Nomaco.
4. Cellular glass with vapor barrier coating: Pittsburgh Corning.
5. Rigid Closed Cell Insulation: ITW Insulation Trymer 2000 XP(not for use indoors).
6. Vapor Barrier Mastic: Foster 30-65 or Childers CP-34; permeance shall be 0.03 perms or less per ASTM E96. Mastic must meet California Dept. of Public Health (CDPH) Standard Method Ver. 1.1,2010 Small Scale Environmental Chamber Test for VOCs. for CA Specification 01350 and LEED IEQ 4.2.
7. Weather Barrier Mastic: Foster 46-50 or Childers CP-10/11. For use on hot service pipe.
8. Lagging Adhesive: Foster 30-36 or Childers CP-50AMV1.
9. Fiberglass Adhesive: Foster 85-60 or Childers CP-127.

C. Thickness: (Thickness listed below are minimum required. Provide thickness required by Local Building or Energy Codes).

1. Service (Domestic) Water Piping:
   a. Hot:
      1) 1½ ” and Smaller: 1½ ”
      2) 2” and Larger: 2”:
      3) Non Recirculated Runouts up to 2” and 8 feet long: ½"
   b. Cold: 1½”
2. Storm Water:
   a. All Sizes: 1”
3. Repairs to Existing Insulation: Match thickness of existing insulation.
4. All Heat Traced Piping:
   a. Size 2” and smaller: 1”
   b. Size 2½” and larger: 2”
5. Waste/Sanitary:
   a. All waste receptors, and associated branch pipe back to main, receiving waste from cooling tower drains and A/C condensate drains shall be provided with 1” of insulation.

D. Application: Unless otherwise indicated, use the following:

1. Inside, concealed: Fiberglass with a maximum K factor of 0.22 BTU/inch per sq. ft. per degree F. per hour at 75˚F. mean temperature with factory-applied all service vapor proof jacket. Density shall be not less than 3 lbs. per cubic foot. For hot pipe insulation, insulation shall be suitable for 250˚F.
2. Inside, exposed: Fiberglass pipe insulation with vapor barrier and PVC jacket (jacket not required in mechanical rooms).
   a. A vapor barrier mastic compatible with the PVC shall be applied around the edges of the adjoining pipe insulation and on the fitting cover throat overlap seam. The PVC fitting cover is then applied and shall be secured with pressure sensitive pearl gray Z-Tape along the circumferential edges. The tape shall extend over the adjacent pipe insulation and have an overlap on itself at least 2" on the downward side.
   b. 2 or more layers of the Hi-Lo Temp insulation inserts shall be applied with the first layer being secured with a few wrappings of fiberglass yarn.
   c. Qualifications for Using Insulation: Use one Hi-Lo Temp insert for each additional 1" of pipe insulation.
   d. Fitting Cover: the temperature of the PVC fitting cover must be kept below 150˚F by the use of proper thickness of insulation and by keeping the PVC cover away from contact with, or exposure to, sources of direct or radiant heat.
3. PVC: 1½” thick fiberglass (duct) insulation, or 1” heavy density pipe insulation installation to meet ASTM E84 (NFPA 255) flame spread and smoke developed ratings.
4. Direct contact between pipe and hangers will not be accepted. Hangers shall pass outside of a metal saddle which shall cover a section of high density insulation of sufficient length to support pipe without crushing insulation. Hangers shall not

pierce insulation and all vapor barriers shall be unbroken and continuous. High density insulation shall be one of the following:
   a. Foam glass.
   b. Fiberglass, high density, minimum of 7 lb. material or heavier.
   c. High density calcium silicate insulation.
5. Provide vapor barrier dams at locations and intervals recommended by the insulation manufacturer, maximum 20' spacing.

PART 3 - EXECUTION

3.1 GENERAL

A. Verify acceptability of all materials which are to be used in air plenums (above ceiling, etc.). Materials must meet all requirements of Local Building Code and Authority having jurisdiction.

B. Insulation Packing:

1. Piping:
   a. Wherever piping penetrates walls, partitions, floor slabs, etc., the space between the piping and the sleeve shall be packed with mineral wool and sealed with approved type non-hardening caulking compound for sleeves through exterior walls.
2. Material:
   a. Packing material shall be rockwool insulation as manufactured by United Stated Gypsum Co. or equal and shall comply with Fed. Spec. HH-1-558, Form A, Class 4, K=0.24, melting point 2000˚F.

C. All Lines That Are Electrically Traced

1. The basic insulation shall be dual temperature, Manville Micro-Lok piping insulation, 1-1/2" thick. The insulation shall be sized to accommodate the electric heat tracing applied against the pipe surface.
2. Finish for insulation shall be .02 aluminum.

D. Contractor shall examine location where this insulation is to be installed and determine space conditions and notify the Architect in writing of conditions detrimental to proper and timely completion of the Work.

E. Do not proceed with the Work until unsatisfactory conditions have been corrected.

3.2 GENERAL INSTALLATION

A. Install insulation in accordance with manufacturer's written instructions, and with recognized industry practices, to ensure that insulation complies with requirements and serves intended purposes.

B. Coordinate with other work as necessary to interface installation of insulation with other components of systems.

C. All insulating materials shall be applied only by experienced workmen, in accordance with the best covering practice. All piping equipment shall be blown out, cleaned, tested and painted prior to the application of any covering. Adhesives, sealers and mastics shall not be applied, when the ambient temperature is below 40˚F, or surfaces are wet.

3.3 PIPE INSULATION

A. Insulate the following:

1. Domestic hot water piping.
2. Domestic cold water piping above ground and under slab.
3. Roof drain bodies and all horizontal storm water piping.
4. All existing piping which is currently insulated and which is modified as a result of this work.
5. Heat traced piping.
6. All storm piping.

B. Installation:

1. Install insulation on pipe system subsequent to testing and acceptance of tests.
2. Install insulation materials with smooth and even surfaces. Insulate each continuous run of piping with full length units of insulation, with a single cut piece to complete the run. Do not use cut pieces or scraps abutting each other.
3. Clean and dry pipe surfaces prior to insulating. Butt insulation joints firmly together to ensure a complete and tight fit over surfaces to be covered.
4. Extend piping insulation without interruption through pipe clamps, hangers, walls, floors and similar piping penetrations, except where otherwise indicated.
5. Install protective metal shields and saddles where needed to prevent compression of insulation.
6. Except as noted, cover valves, flanges, fittings and similar items in each piping system with equivalent thickness and composition of insulation as applied to adjoining pipe run.
    a. Install factory-molded, pre-cut or job-fabricated units (at Installer's option), except where a specific form or type is indicated.
    b. Do not cover:
        1) Valve operators. Provide extended valve stems as required to maintain continuous insulation and vapor barrier.
        2) Nameplates or identification tags.
    c. Provide removable access for:
        1) Strainers.
        2) Other components requiring access for service.
7. Mark location of unions and flanges covered by insulation with permanent paint or ink, or approved label.

8. Maintain integrity of vapor-barrier jackets on insulation of cold pipes and storm drainage piping, and protect to prevent puncture or other damage. Insulation on cold surfaces where vapor barrier jackets are used shall be applied with a continuous, unbroken vapor seal. Hangers, supports, anchors, etc., that are secured directly to cold services shall be adequately insulated and vapor sealed to prevent condensation.
9. Inserts shall be installed at hangers for insulated piping. Inserts between the pipe and pipe hangers shall consist of rigid pipe insulation of equal thickness to the adjoining insulation and shall be provided with vapor barrier where required. Insulation inserts shall not be less than the following lengths:

2-1/2" pipe size and smaller	6" long – 18 GA
3" to 6" pipe size	9" long – 16 GA

10. Provide 18 gauge galvanized metal shields between hangers or supports and pipe insulation. Form shields to fit insulation. Extend shields up to centerline of pipe. Make shields same length as that specified above for inserts.
11. Where insulation is specified for piping, insulate similarly all connections, vents, drains, and any piping connected to system.
12. Fill surface imperfections such as chipped edges, small joints or cracks and voids or holes with insulation material and smooth all such areas with a skim coat of insulating cement.
13. Seal ends of sections with Foster 30-65 or Childers CP-34 vapor barrier mastic and reinforcing mesh to crate moisture dams at:
    a. 20 ft. intervals.
    b. Valves and fittings.
    c. All hangers and supports.
14. Replace existing insulation removed or damaged because of work of this project.
15. Insulate new pipes and replace insulation on existing pipes to remain where insulation was removed or damaged by demolition or revisions.
16. Insulate between fingers of spiders in alignment guides.
17. Insulate between pipe and pipe slide.
18. All domestic water piping installed within piping chases behind fixtures (“crotons”) must be fully insulated to the back of the wall behind the fixture.
19. All equipment shall be insulated, including circulator pumps, circuit setters, strainers, etc. Provide valve and trim extensions as required to maintain the minimum insulation thickness.
20. Perform all work in a neat and workmanlike manner. Poor work (as determined by Architect or Engineer) will be cause for rejection.
21. Specialties shall be insulated to match those of the systems to which they are connected.
22. No insulation shall be installed until the piping systems have been hydrostatically tested as specified elsewhere to the satisfaction of the Engineer.

3.4 OUTDOOR PIPE INSULATION

A. Install insulation with butt joints of half pipe sections staggered. Insulation shall be held in place with strapping tape. Install aluminum jacket with all joints lapped to shed water. Apply a bead Foster 95-44 or Childers CP-76 metal jacketing sealant at all transverse and longitudinal seams. Secure with aluminum bands, minimum of 2 per jacket section.

3.5 PROTECTION AND REPLACEMENT

A. Replace damaged insulation which cannot be repaired satisfactorily, including any damage to continuous vapor barrier or damage due to moisture saturation. The insulation installer shall advise the Contractor of required protection for the insulation work during the remainder of the construction period, to avoid damage and deterioration.

3.6 ASBESTOS REMOVAL

A. It is understood and agreed that this work does not contemplate handling of, or design including use of, asbestos or any hazardous waste material. Therefore, Owner and Contractor agree to hold harmless, defend and indemnify consultant (A/E) for all claims, lawsuits, expenses or damages arising from or related to the handling, use, treatment, purchase, sale, storage or disposal of asbestos, asbestos products or any hazardous waste materials.

B. In the event asbestos is encountered the Contractor shall immediately cease work in the area of the asbestos shall contact the Owner for instructions.

C. Site Monitoring:

1. Follow Section 1910.1001 Code of Federal Regulations Title 29, Part 1910 (OSHA Asbestos Regulations).
2. Provide daily sampling during removal instead of at six month intervals.
3. Stop work and notify Architect immediately if levels exceed those of Subparagraphs b (2) or b (3) of regulations.

END OF SECTION

SECTION 22 10 00

PLUMBING PIPING AND ACCESSORIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Supplemental Conditions of the Construction Contract and Division 1 Specification Sections (General Requirements), apply to this Section.

1.2 SUBMITTALS

A. Submit manufacturer’s data on the following:

1. Water hammer arresters.
2. Roof drains, floor drains, and cleanouts.
3. Water meter
4. Trap primers.
5. Cleanouts.
6. Dissimilar Metals.
7. Pipe Sleeves.
8. Stack Sleeves.
9. Drip Pans.
   a. Locker Level

1.3 STANDARDS

A. Materials shall comply with the latest editions of the following standards.

1. Plumbing Code of New York City
2. Plumbing Code of New York State
3. Cast iron: ASTM A-74-87
4. Cast iron pipe fittings ASTM A-888
5. Cast iron pipe couplings ASTM C-564
6. Copper pipe:
   a. Type K, L, M: ASTM B88
   b. DWV: ASTM B306-88
7. Ductile iron pipe: ASTM A377-89
8. All potable water piping and fixtures should be compliant with NSF-61 requirements for lead free piping
9. All piping shall be domestically manufactured and shall be by the same manufacturer.

1.4 RELATED WORK

A. Section 22 05 29 Pipe Supports and Anchors.

PART 2 - PRODUCTS

2.1 DOMESTIC WATER PIPING AND ACCESSORIES

A. Comply with NSF-61 for lead free potable water piping.

B. Above Ground Inside Building, Size 6” and Under:

1. Pipe: Copper, hard temper, Type L, ASTM B88.
2. Fittings:
   a. Wrought copper, or cast bronze.
   b. ASME B16.22 wrought copper fittings or ASME B16.18 bronze castings with copper tube dimensioned grooved ends (flaring of tube and fitting ends to IPS dimensions is not permitted).
3. Solder:
   a. 95-5 tin antimony (no lead), ASTM B32.

C. Use approved fittings for connections between dissimilar pipe systems.

2.2 TRAP PRIMERS (TP)

A. Manufacturers:

1. Design basis: PPP as noted in Plumbing Fixture Schedule.
2. Construction: Corrosion resistant brass. “O” rings shall have a flexibility range of -40°F to 450°F.
3. Provide distribution units for connector points as shown on plans.
4. Complies with ASSE STD 1018.

2.3 WATER HAMMER ARRESTER (Shock Absorber)

A. Manufacturers:
1. Design Basis: Zurn Shoktrol Z-1700
2. Construction: Stainless Steel, Bellows
3. Other Acceptable Manufacturers:
   a. Josam
   b. Sioux Chief
   c. J.R. Smith
   d. MIFAB-WHB
4. Standards: PDI WH201, ASSE STD 1010.

B. Install permanently sealed water hammer arrestors on all hot and cold water branches and headers to plumbing fixtures whether it is indicated on the Plumbing Drawings or not.

C. Shock absorbers are to be of size and location in accordance with the manufacturer's recommendations and with DPI Standard WH 201 and shall be PDI approved. Provide accessibility to all shock absorbers.

D. Provide shock absorbers at the top of water risers and at all quick closing valves, solenoid valves and at equipment such as sterilizers, washers, etc.

2.4 WATER METER

A. Provide meter, pit, and cover in accordance with Water Supplier's standards and instructions.

1. Meter shall be furnished by the Contractor in accordance with Water Supplier's standard specification.

B. Meter shall be located in building or in an exterior pit as indicated.

2.5 SANITARY AND VENT PIPING (WITHIN BUILDING)

A. Above Ground:

1. Cast iron hub and spigot, neoprene gasket.
2. Cast iron no hub, neoprene gasket and stainless steel sleeve joint (as allowed by jurisdiction). ASTM A888, CISPI 301.

B. Underground:

1. Cast iron hub and spigot, with oakum packing and caulked molten lead in one continuous pour or neoprene gaskets. ASTM A74.

2.6 HEAVY DUTY NO HUB COUPLINGS

A. Use on the following:

1. Sanitary vent piping 4" and larger.
2. Sanitary piping 3" and larger.
3. All storm piping.

B. 1-1/2", 2", 3" and 4": 3" wide 304 stainless steel shield; (4) minimum stainless steel clamps; fixed and "floating" eyelet.

C. 5" and over: 4" wide 304 stainless steel shield, with six (6) stainless steel clamps mounted in series.

D. Torque to minimum 80 inch pounds or per manufacturer's recommendation.

E. Acceptable manufacturers: Husky Series 2000 or Mission Heavy Weight.

2.7 STANDARD DUTY NO HUB COUPLINGS

A. Standard duty couplings shall conform to CISPI 310-85: 0.008" thick corrugated stainless steel. ASTM A888.

B. Use of the following:

1. Sanitary vent piping up to and including 3" piping.
2. Sanitary piping up to and including 2" piping.
3. As allowed by jurisdiction.

C. Torque to inch pounds per manufacturer's recommendation.

D. Acceptable manufacturers: Tyler, Mission, AB&I, Clamp All, Huskey.

2.8 SOIL AND VENT PIPING ACCESSORIES

A. Use approved fittings for connections between dissimilar pipe systems.

B. Acceptable Manufacturers:
1. Josam
2. Wade
3. Zurn
4. J.R. Smith
5. Jones Spec
6. Watts Ancon

C. Cleanout Plugs:

1. Material: Cast bronze or brass.
2. Type: Countersunk.
3. Threads: ANSI B2.1.

D. Wall Cleanout Covers:

1. Type: Frameless, round, low profile plate.
2. Material: Stainless steel or chrome plated brass.
3. Attachment: Single exposed flush screw.
4. Finish:
   a. Non-painted surfaces: Bright polished.
   b. Surfaces to be painted: Prime coat.

E. Floor Cleanouts:

1. Body: Standard round Duco cast iron.
2. Attachment: Bronze screws.
3. Sleeve: Full thickness of floor slab.
4. Top:
   a. Shape:
      1) Where floor covering has rectangular pattern: Square.
      2) Other areas: Round.
5. Cover:
   a. For Vinyl Tile and Similar Floor Coverings: Recessed to receive inset of floor material.
   b. For carpeted floor covering provide carpet cleanout marker.
   c. Other areas: Nickel bronze scoriated finish.

F. Vandal-Proof Caps

1. Material: Duco cast iron.
2. Attachment: Recessed Allen set screw.

2.9 STORM WATER PIPING (INSIDE BUILDING)

A. Above Ground:

1. Cast iron, hub and spigot, neoprene gasket joints.
2. Cast iron no hub, neoprene gasket and heavy duty no hub couplings.

B. Underground:

1. Cast iron hub and spigot, with oakum packing and caulked molten lead in one continuous pour or neoprene gasket.
2. Cast iron, hub and spigot, neoprene gasket joints.

2.10 STORM DRAINAGE PRODUCTS

A. Roof Drain: (RD)

1. Material: Cast Iron
2. Dome: Cast Iron
3. Include:
   a. Combined flashing collar and gravel stop.
   b. Extension for insulation.
   c. Under-deck clamp.
   d. Sump receiver.
   e. Expansion joint.

B. Overflow Roof Drain: (OD)

1. Same as Roof Drain Type 1 except:

a. Provide removable water dam. Top of water dam shall be 4” above low point of roof.

2. Provide (1) overflow roof drain for every roof drain shown.

C. See Plumbing Fixture Schedule and Plumbing Fixture specification for additional information.

2.11 DISSIMILAR METALS

A. Connections between pipe, fittings, hangers and equipment of dissimilar metals shall be insulated against direct contact one with the other, by using a high quality or grade of dielectric insulated material

B. Dielectric unions or insulated couplings shall be installed between copper or brass piping material and steel piping material or steel tanks. Unions or insulated couplings shall be used for pipe sizes 2” and smaller, and dielectrically gasketed flanges and sleeves for pipes 2-1/2” and larger.

C. Dielectric fittings shall be installed between copper and steel piping systems to prevent galvanic corrosion. Body shall be ductile iron or steel, zinc electroplated, with LTHS high temperature, polyolefin polymer lining and grooved or threaded ends. Victaulic Style 47.

2.12 PIPE SLEEVES

A. Any pipe required in walls and floors shall be provided with a pipe sleeve.

B. Provide watertight sleeves for all pipes penetrating exterior foundation walls and waterproof floor areas and where such areas are noted on the Architectural and Structural Drawings.

C. Except where indicated or specified otherwise, provide and install Schedule 40 galvanized steel sleeves for all piping passing through concrete walls or floor slabs. Sleeves shall be securely set in the framework and where not specified otherwise shall be of such length as to extend flush with each face of the wall in which they are installed, 3" above unfinished floor and 2" above the finished floor or tile, as applicable. Sleeves in kitchen and laundry areas shall be chrome plated.

D. Sleeves shall have an internal diameter of at least 1" larger than the outside pipe size diameter of the pipe passing through them. Sleeves in exterior foundation walls shall be James B. Clow and Sons, No. F-1430 or F-1435, or approved equal, extra-heavy cast iron wall sleeves with intermediate integral flange. Cast iron wall sleeves with intermediate integral flange. Cast iron sleeves shall be set with end flush with wall faces.

E. Where sleeves penetrate waterproofing, install caulking between pipes and pipe sleeves as follows:

1. Pack oakum to a depth of 1" between pipe and pipe sleeve at a location permitting 3" of sealant to be installed above the oakum.
2. Fill space above oakum to a depth of 3" with sealant similar and equal to Igas Joint Sealer as manufactured by Silka Chemical Corporation.

F. Sleeves for gas piping shall extend 4 inches beyond exterior face of wall and 1 inch beyond inner face.

G. Sleeves in waterproof floors shall be as manufactured by Zurn Inc. or equal, cast iron sleeve with integrally cast flange and flashing device.

2.13 STACK SLEEVES

A. Stack sleeves for pipes passing through roof shall be equal to Zurn Z-195-10 or MIFAB R1900 with cast iron body, adjustable flashing ring, rust resistant bolts, and under deck clamp. The adjustable flashing ring shall be caulked after it is in the proper position. The space between the flashing sleeve and the pipe passing through same shall be caulked watertight.

2.14 CLEANOUTS

A. Provide easily accessible cleanouts at base of vertical stacks and leaders; at ends of horizontal drainage lines and at intervals not exceeding 50 ft.; at each change of direction; on hand holes of running traps; and where indicated to make entire drainage system accessible for roding. Provide at least 18 inch clearance to permit access to cleanout plugs.

B. Cleanouts for cast iron pipe shall consist of tapped extra heavy cast iron ferrule caulked into cast iron fittings, and extra heavy brass screw plug with solid hexagonal nut.

C. Cleanouts turning out through walls and up through floors shall be made by long sweep ells of "Y" and 1/8 bends with plugs and face or deck plates to conform to architectural finish in room. Where no definite finish is indicated on the Architectural and/or Mechanical Drawings, wall plates shall be chrome plates cast brass and floor plates shall be nickel bronze. Screws in cleanouts in finished areas shall be vandal-proof.

D. Cleanouts shall be full size at the pipe up to 6" inclusive. On larger size piping 6 inch size plugs shall be used.

E. The following list indicates the various types of cleanout desired at various locations indicated on the Drawings. These cleanouts have been selected from the catalog of Zurn and are representative of quality design and finish desired. Cleanouts of Josam Mfg. Co., or J.R. Smith, or MIFAB, or approved equal may be submitted provided they meet fully in every respect (such as material, weight, clamping features, finish, etc.). The characteristics and quality of the cleanout shall be as follows:

1. Cleanout fitting in vertical stacks shall consist of tapped tees, capable of receiving a rough brass raised head cleanout plug; Zurn 1460-8 or MIFAB #C-1400S-9.
2. Cleanouts in Mechanical Equipment Room shall be Zurn 1420-25 or MIFAB #C1100 XR-4-Z.
3. Cleanouts in finished areas shall be Zurn Z-1420-3 or Z-1400HD or MIFAB #C1100 TS-1 with recess for tile floors.
4. Cleanouts in Dex-O-Tex waterproof floors shall be Zurn No. Z-1405-18 or MIFAB #C1100XR-4-Z with extra heavy duty top.
5. Cleanouts for 3 or more fixtures piped horizontally shall be extended to wall cleanouts, and shall be Zurn No. Z-1470 or MIFAB #C1430.

F. All cleanout plugs shall be brass and lubricated with graphite before installation.

G. Cleanouts will not be allowed to be located in inaccessible locations.

2.15 DRIP PANS

A. In so far as possible, piping shall not be installed within the ceiling or exposed in operating and delivery rooms, nurseries, food preparation centers, food serving facilities, food storage areas, central services, electronic data processing areas, electric closets, and other sensitive areas.

B. When overhead piping in these areas in unavoidable, provide aluminum drip pans with indirect waste extended and spilled to a safe place.

PART 3 - EXECUTION

3.1 GENERAL

A. Testing: Test in accordance with the applicable Plumbing Code.

B. Connections to Equipment Furnished Under Other Sections:

1. Make final connections to all equipment shown on drawings as connected to supply and/or drain piping.
2. Furnish all devices necessary for final connection, including:
   a. Tail pieces
   b. Stops
   c. Supplies

C. Corrosion Protection:

1. Provide isolation between concrete or mortar and any copper pipe.
2. All below grade piping shall be adequately protected from corrosion.

D. Comply with Section 22 05 29 Pipe Supports and Anchors for pipe support requirements.

3.2 INSTALLATION OF DOMESTIC WATER PIPING AND PRODUCTS

A. Install all horizontal water piping level and parallel to building construction (except piping noted to be drained down slope toward drain at 1/8" /ft. min.). Make any changes in direction with fittings, don't kink or bend. All vertical piping to be plumb. Provide dielectric isolation between uninsulated pipe and hangers. Provide plastic grommets when going through metal studs. Tape is not acceptable for dielectric isolation.

B. Water Hammer Arrestors: Install arresters as shown on the drawings and as described in this specification. At minimum any branch line connected to a flush valve shall have one arrestor.

C. Disinfection:

1. After installation of all fixtures served, fill all domestic water lines with a chlorine-water solution of 50 parts per million minimum.
2. Hold solution in pipe for at least 24 hours.
3. Open and close all valves 3 times during chlorination.
4. Waste chlorine solution from each outlet.
5. Measure solution at end. If not 10 ppm, repeat.

D. Meters:

1. Install water meter in accordance with Water Supplier's standard.

E. It is the intent that each part of the plumbing systems shall be complete in all details and all lines provided with all control valves as indicated on Drawings, or as may be required for the proper control of the pipe lines under this Section so that any fixture, line or piece of apparatus may be cut out for repair without interference or interruption of the service to the rest of the building.

F. The Contractor shall examine carefully the architectural plans and details and familiarize himself with all conditions relative to the installation of piping, particularly where same is concealed behind furring or in hung ceilings. In no case shall the Contractor permit his pipes to be exposed beyond finished plaster lines unless specifically shown on Drawings. He shall consult with the other trades in the building and install his piping in such a way as to least interfere with the installation of other trades. All piping installed in finished areas shall be completed concealed within hung ceilings, furrings, soffits, pipe spaces.

G. The water piping shall all be installed so as to drain, and branches shall not be trapped, but shall have continuous pitch. Where necessary to raise or lower mains, the same shall be provided with a drip and shall be properly valved and capped.

H. Piping shall be installed, whether indicated or not, so as to rise and/or drop to clear any and all conduits larger than 1", lighting fixtures, ductwork and heating mains, to maintain the desired clear heights. The Contractor shall consult with the other trades and facilitate the erection of the equipment and piping.

I. Run piping straight and as direct as possible, in general forming right angles with or parallel to walls or other piping. Risers shall be erected plumb and true.

J. After cutting, all pipes shall be reamed out to full bore and before erection the inside of all pipes shall be thoroughly cleaned.

K. No piping or work shall be concealed or insulated until all required tests have been satisfactorily completed and work has been approved by the Architect and all other authorities having jurisdiction.

L. Expansion loops and anchors shall be provided on all hot water and hot water circulation mains. Expansion loops shall be made with four elbows and three lengths of pipe, except as otherwise noted on the drawings. All loops shall be prestressed.

3.3 INSTALLATION OF SANITARY AND VENT PIPING

A. Couplings: Apply standard and heavy duty couplings as specified.

B. Gaskets: Install gaskets in accordance with manufacturer’s recommendations for the use of lubricants, cements, and other special installation requirements.

C. Joint Adapters: Make joints between cast iron pipe and other types of pipe with standard manufactured cast iron adapters and fittings.

D. Cleaning Piping:

1. Clear the interior of pipe of dirt and other superfluous material as the work progresses.
2. Place plugs in the end of uncompleted pipe at the end of the day or whenever work stops.

E. Test Plugs:

1. Provide test plugs in floor drains and roof drains at the time of installation.
2. Leave test plugs in place for the duration of construction until sewer or drainage system is complete.

F. Expansion:

1. Provide a vertical expansion joint at each connection to roof drain unless an offset is provided.
2. Where piping crosses building expansion joints, provide expansion joints to allow for building movement.

3. Refer to Section 22 30 00 for additional requirements.

G. Vent Flashing:

1. Provide 4 lb. sheet lead (24” x 24” minimum).
2. Extend lead 5” above the vent and turned down into vent pipe.

H. Vent Location: Do not install vents within 2 ft. of roof edge, parapet, wall line, or an “on-the-roof structure” and within 10 ft. of any air intake.
.

I. The size of storm, soil, waste, water, and vent piping shall be as determined by the local rules and regulations for plumbing and drainage, except where specifically noted to be larger by the Specifications or plans; and all fixed rules of installation as set forth in the Rules and Regulations shall be followed as part of the Specifications.

J. The Contractor shall examine carefully the architectural plans and details and familiarize himself with all conditions relative to the installation of piping, particularly where same is concealed behind furring or in hung ceilings. In no case shall the Contractor permit his pipes to be exposed beyond finished plaster lines unless specifically shown on Drawings. He shall consult with the other trades in the building and install his piping in such a way as to least interfere with the installation of other trades. All piping installed in finished areas shall be completed concealed within hung ceilings, furrings, soffits, pipe spaces, etc.

K. Branch connections of the drainage systems shall be made with "Wye" and long "Tee-Wye" fittings, short 1/4" bends, common offsets and double hubs will not be permitted. Short "Tee-Wye" fittings are to be used in vertical piping only.

L. Piping shall be installed, whether indicated or not, so as to clear any and all conduits, lighting fixtures, ductwork and heating mains, to maintain the desired clear heights. The Contractor shall consult with the other trades and facilitate the erection of the equipment and piping. Gravity systems shall have priority.

M. Run piping straight and as direct as possible, in general forming right angles with or parallel to walls or other piping. Risers shall be erected plumb and true.

N. After cutting, all pipes shall be reamed out to full bore and before erection the inside of all pipes shall be thoroughly cleaned.

O. No piping or work shall be concealed or insulated until all required tests have been satisfactorily completed and work has been approved by the Architect and all other authorities having jurisdiction.

P. Cleanouts shall be provided at foot of all stacks, all changes of directions, at the ends of branch runs where shown, every 50'-0" and as required by Code, and shall be terminated as described under cleanouts.

Q. The house drains must be run at a minimum grade of 1/8" per foot downward in the direction of flow. Wherever possible, a 1/4" per foot pitch shall be maintained. Branch connections to stacks from fixtures shall pitch 1/4" per foot where possible. Attention is again called to the necessity of maintaining the ceiling heights established. All piping installed in finished areas shall be completed concealed within hung ceilings, furrings, soffits, pipe spaces, etc.

R. Furnish and install complete systems of ventilating pipes from the various plumbing fixtures and other equipment to which drainage connections are made. Ventilating pipes shall be connected to the discharge of each trap and shall be carried individually to point 6" above the ultimate overflow level of the fixture before connecting with any other vent pipe; in general, this will be approximately 3'-6" above the finished floor. Branches shall be arranged to pitch back to fixtures.

S. The individual vent pipes shall be collected together in branch vent lines and connected to vent stacks, in general paralleling soil and waste stacks. Wherever possible, vent stack offsets shall be made with 45 degree fittings. The heels of vent stacks shall be connected to adjacent soil stacks for purpose of draining condensation where possible. The waste of a fixture shall be connected to the base of each vent stack for the purpose of washing out any scales or dirt which may accumulate, or the soil stack shall be used to wash out the heel of the vent.

T. The tops of all soil and waste stacks shall be extended as additional ventilating pipes. The tops of all ventilating stacks shall run independently through the roof. Pipes smaller than 4" size shall be increased to 4" by means of approved increasers before passing through the roof slab.

U. Vent piping sized less than 1½" will not be allowed, even if shown on the drawings or permitted by Code.

V. All open vent pipes that extend through a roof shall be terminated at least 24 inches above the roof, except that where a roof is to be used for any purpose other than weather protection or maintenance, the vent extension shall be run at least 7 feet above the roof.

3.4 INSTALLATION OF STORM DRAINAGE PIPING (ABOVE GROUND WITHIN BUILDING)

A. Couplings: Use heavy-duty couplings on all no hub storm piping above grade. Do not use no hub couplings on piping more than 20 feet below the drain fixture unless offsets are made down through buildings in no more than 20 feet increments. Utilize galvanized steel pipe with screwed or grooved mechanical fittings.

B. Gaskets: Install gaskets in accordance with manufacturer's recommendations for the use of lubricants, cements, and other special installation requirements.

C. Joint Adapters: Make joints between cast iron pipe and other types of pipe with standard manufactured cast iron adapters and fittings.

D. Cleaning Piping:

1. Clear the interior of pipe of dirt and other superfluous material as the work progresses.
2. Place plugs in the end of uncompleted pipe at the end of uncompleted pipe at the end of the day or whenever work stops.

E. Test Plugs:

1. Provide test plugs in floor drains and roof drains at the time of installation.
2. Leave test plugs in place for the duration of construction.

F. Roof Drains:

1. Install drains on the center line of roofing reinforcement.
2. Clamp flashing into drain flashing collar.
3. Install domes immediately after completion of roof installation.

G. Expansion:

1. Provide a vertical expansion joint at each connection to roof drain unless an offset is provided.
2. Where piping crosses building expansion joints, provide expansion joints to allow for building movement.
3. Refer to Section 22 30 00 for additional requirements.

H. Downspout Nozzles: Install with flange secured to wall at base of concealed storm leaders that discharge through the building wall above grade.

I. Cleanouts shall be provided at foot of all stacks, all changes of directions, at the ends of branch runs where shown, every 50'-0" and as required by Code, and shall be terminated as described under cleanouts.

J. The house drains must be run at a minimum grade of 1/8" per foot downward in the direction of flow. Wherever possible, a 1/4" per foot pitch shall be maintained. Branch connections to stacks from fixtures shall pitch 1/4" per foot where possible. Attention is again called to the necessity of maintaining the ceiling heights established. All piping installed in finished areas shall be completed concealed within hung ceilings, furrings, soffits, pipe spaces, etc.

K. Piping shall be installed, whether indicated or not, so as to clear any and all conduits, lighting fixtures, ductwork and heating mains, to maintain the desired clear heights. The Contractor shall consult with the other trades and facilitate the erection of the equipment and piping. Gravity piping shall have priority.

L. Run piping straight and as direct as possible, in general forming right angles with or parallel to walls or other piping. Risers shall be erected plumb and true.

M. After cutting, all pipes shall be reamed out to full bore and before erection the inside of all pipes shall be thoroughly cleaned.

N. No piping or work shall be concealed or insulated until all required tests have been satisfactorily completed and work has been approved by the Architect and all other authorities having jurisdiction.

O. Branch connections of the drainage systems shall be made with "Wye" and long "Tee-Wye" fittings, short 1/4" bends, common offsets and double hubs will not be permitted. Short "Tee-Wye" fittings are to be used in vertical piping only.

P. Connection to roof drain shall be installed in conjunction with the roofing called for under another Division or Section of these Specifications and at such times as designated by this Contractor, so that the building is adequately protected during construction from damage by storm water. All piping shall be adequately and properly supported, and all joints shall be made up as hereinafter specified.

3.5 TRAP PRIMERS

A. Install all trap primers and required distribution units as shown on plans and as required by manufacturers recommendations.

END OF SECTION

SECTION 22 11 00
SAFETY SHOWERS AND EYEWASHES

PART 1 - GENERAL

1.1 RELATED SECTIONS

A. Section 22 40 00 for Products

1.2 GENERAL REQUIREMENTS

A. Installations must meet the following Codes and Standards:

1. ANSI/ISEA Standard Z358.1 - 2009, American National Standard for Emergency Eyewash and Shower Equipment.
2. NFPA 70, National Electrical Code (NEC)
3. Building Codes of New York State
4. Occupational Safety and Health Administration (OSHA)
5. ICC/ANSI Standard A117.1 – Accessible and Usable Buildings and Facilities

1.3 DEFINITIONS

A. The following definitions are included in the ANSI Z358.1 Standard:

1. Combination Unit: An interconnected assembly of emergency equipment supplied by a single source of flushing fluid.
2. Drench Hose: A supplemental device consisting of a flexible hose connected to a flushing fluid supply and used to provide fluid to irrigate and flush face and body areas.
3. Emergency Shower: A device specifically designed and intended to deliver flushing fluid in sufficient volume to cause that fluid to cascade over the entire body.
4. Eye/Face Wash Equipment: A device used to provide fluid to irrigate and flush both the face and the eyes simultaneously.
5. Eyewash: A device used to provide fluid to irrigate and flush the eyes.
6. Flushing fluid: Potable water, preserved water, preserved buffered saline solution or other medically acceptable solution manufactured and labeled in accordance with applicable government regulations.
7. Personal Wash: A supplementary device that supports plumbed and/or self- contained units, by delivering immediate flushing fluid to the eyes or body.

1.4 PLUMBING CONNECTIONS

A. All new installations must be supplied with tempered water. Tempered water is anywhere between 60°F and 100°F, with the ideal temperature being set at 85°F.

B. The tempered water service to emergency showers must have a shut off valve. The valve must be accessible with a 6-foot ladder to provide shut off capability in order to service the fixture. The shut off valve shall have a removable handle.

C. Domestic cold and hot water lines to eyewashes and showers will be insulated. Provide PVC jacketing on exposed piping subject to damage.

D. Strainers are required in the hot and cold water lines ahead of tempering valves and eyewashes, or showers.

PART 2 - PRODUCTS

2.1 PREFERRED MANUFACTURERS

A. Emergency Showers and Eyewashes:

1. Bradley
2. Encon
3. Watersaver

B. Thermostatic Mixing Valves:

1. Bradley
2. Encon
3. Lawler

2.2 EMERGENCY SHOWERS

A. A plumbed emergency shower is required in a workplace where a risk assessment indicates the potential for significant skin exposure to concentrated corrosives (acids and bases), cleaners, disinfectants, or other chemicals or substances that could be injurious to the eyes or skin. During renovations, existing emergency showers must be upgraded to meet current standards.

B. Emergency showers shall meet the following requirements:

1. Constructed of stainless steel or high impact plastic.
2. A privacy curtain is preferred, but not required.

3. The shower must deliver a minimum of 20 gallons per minute for 15 minutes.
4. The shower head shall be installed between 82- and 96-inches above the finished floor.
5. The center of the water spray pattern shall be at least 16-inches from any obstructions.
6. The water pattern must be a least 20-inches in diameter when measured at 60- inches above the finished floor, and shall have the flushing fluid dispersed throughout the entire pattern.
7. The stay-open activation valve shall open in one second or less, and shall remain on without requiring the further use of the operator's hands. It shall remain activated until manually shutoff.
8. The activation pull must be located out of the normal pathway in the room. For standard emergency showers, the activation pull shall not be more than 69-inches above the finished floor; for ADA emergency showers, the activation pull shall not be more than 48-inches above the finished floor.

2.3 EMERGENCY EYEWASHES

A. A plumbed eyewash is required in a workplace wherever persons are subject to exposure to concentrated corrosives (acids and bases), cleaners, disinfectants, or other chemicals or substances that could be injurious to the eyes. During renovations, existing emergency eyewashes must be upgraded to meet current standards.

B. Allowable Devices:

1. Sink mounted, swing-a-way eyewashes, free standing eyewashes, and combination emergency shower/eyewash units are preferred in lab applications.
2. Faucet mounted eyewashes are not acceptable devices for new installations or renovations.
3. If drench hoses are required by the program, they must meet the performance requirements of an eyewash.
4. Hand held eyewash bottles are considered as supplemental equipment and will not be accepted as the sole means of an eyewash installation within a workspace. The use of these devices must be approved by EH&S and Facilities Engineering on a case by case basis.

C. Emergency eyewashes and eye/face washes shall meet the following requirements:

1. Constructed of stainless steel or high impact plastic.
2. The eyewash equipment must deliver a minimum of 0.4 gallons per minute for 15 minutes.

3. For standard freestanding eyewashes, the nozzles should be positioned between 33 and 45-inches above the finished floor, and for ADA eyewashes, the nozzles should be positioned between 33 and 36-inches above the finished floor. A minimum of 6-inches shall be provided from the wall or nearest obstruction. The nozzles must be easily accessible to the operator with no obstructions.
4. The eyewash must be installed with sufficient space to allow the user to hold their eyelids open with both hands while the eyes are being rinsed.
5. Nozzles shall be protected from airborne contaminants with caps.
6. The spray pattern of eyewash and eye/face wash equipment shall conform to the relevant section in the ANSI Standard using an eyewash test gauge.

END OF SECTION

SECTION 22 30 00

PLUMBING EQUIPMENT

PART 1 - GENERAL

1.1 SUBMITTALS

A. Submit manufacturer’s product data for the following:

1. Warranty and service policies.
2. Escutcheons.
3. Traps.
4. Thermostatic mixing valve.
5. Unions.
6. Hose Bibbs.
7. Thermometers.
8. Pressure Gauges.
9. Vacuum Breakers.
10. Fixed air gaps.
11. Drains.
12. Water Meter(s)

PART 2 - PRODUCTS

2.1 PIPE EXPANSION COMPENSATORS

A. Any breaks or damage to the piping system or to the Work of other Sections within the period of the guarantee due to improper provision for expansion and contraction must be replaced at this Contractor's expense.

B. This Contractor is to provide for expansion of pipes by providing expansion compensators and/or expansion loops and shall provide anchors at pump discharge and suction line. All expansion loops shall be pre-stressed.

C. Make adequate provisions for proper expansion and contraction of piping. At connections of branches to water mains, risers and at connections to heaters, coolers and other equipment, provide sufficient number of elbow swings to allow for proper expansion and contraction of piping. Provide adequate elbow swings, expansion compensators, expansion loops or approved type extension joints, wherever noted, indicated, or required to allow for proper expansion and contraction of mains and risers.

D. All lines in which expansion joints are installed must be securely anchored and guided in accordance with Manufacturer's recommendations.

G. Provide expansion loops/joints in all hot water and hot water circulating piping which exceeds 145 feet developed length, horizontally or vertically without offsets, and as indicated on the drawings.

2.2 ESCUTCHEONS

A. This Contractor shall provide escutcheons on all exposed pipe wherever they pass through floors, ceilings, walls or partitions.

B. Escutcheons for pipes passing through outside walls shall be Ritter Pattern and Casting Co., No. 1, solid, cast brass, flat type secured to pipe with set screws.

C. Escutcheons for pipes passing through floors shall be Ritter Pattern and Casting Co., No. 36A, split hinged, cast brass chromium plated type.

D. Escutcheons for pipes in unfinished areas shall be cast iron, secured with set screws.

2.3 TRAPS

A. Each fixture and piece of equipment requiring connection to the drainage system shall be separately trapped by means of a water seal trap placed as close to the fixture as possible.

B. All running traps on drains, etc., shall have inlet handhold cleanouts and brass plug cleanouts in bottom. Cast iron trap in ground shall have bottom plug omitted. All exposed P traps shall have bottom cleanouts and shall be chromium plated brass.

2.4 PUMPS

A. General:

1. Statically and dynamically balance rotating parts.
2. Construction shall permit complete servicing without breaking piping or motor connection.
3. Pumps operate at 1750 rpm unless scheduled otherwise.
4. Pump connections shall be flanged.

B. Sump Pumps

1. Manufacturers:
   a. Design Basis: As scheduled.
   b. Other Acceptable Manufacturers:
      1) Weil
      2) Zoeller
      3) Aurora
      4) Hydromatic
      5) Pacific
      6) Swaby

2. Motor: Open drip-proof
3. Shaft: Stainless steel
4. Bearings:
   a. Intermediate: Grease lubricated ball bearing
   b. Casing: Self-lubricating
5. Impeller: Cast iron
6. Cover:
   a. Material: Cast iron
   b. Sump Diameter: 36”
7. Pumps shall be complete with cast iron strainers, base plate, suction plate, casing and impeller and stainless steel shaft. Unit to be furnished with 20" O.D. split floor plate and discharge pipe.
8. Pump to be directly connected by means of a flexible coupling to an electric motor.
9. Sump depth and pump capacities shall be as indicated on the drawings.
10. Pumps shall be automatically controlled by a NEMA 1 pedestal mounted float switch with float, float rod and float buttons.
11. Provide for duplex installation one (1) NEMA 1 pedestal mounted automatic alternator to distribute operation to both units on each successive cycle and operate both units when one unit cannot handle the load.
12. Furnish and install cast iron basins with covers to accommodate two (2) pumps, controls and inspection opening. Size of sumps shall be as indicated on the drawings.
13. Provide each unit with a float operated high water alarm and two (2) sets of auxiliary contacts.
14. Provide in each discharge line a gate and check valve.

C. Sump Basins:

1. Acceptable Manufacturers:
   a. AK Industries.
   b. Topp Industries.
   c. Fiberbasin Incorporated.
2. Material: Fiberglass reinforced polyester.
3. Minimum Wall Thickness:
   a. At Flange: ½”
   b. At Hubs: 3/8”
   c. Other Areas: 3/16”
   d. Top flange to be extended for support to suspend unit from structural slab.
4. Connections: To accommodate piping shown on drawings.
5. Cover Attachment: Tapped bronze inserts in flange for bolt down cover.
6. Size: As shown on drawings, or, if not shown, of size determined by pump manufacturer.
7. Basin Cover:
   a. Material: Steel.
   b. Provision for Lifting: Ring or handle.
   c. Cut-Outs: For removal of cover without disturbing piping or wiring.

2.5 THERMOSTATIC MIXING VALVE

A. Temperature Limiting Devices: Leonard Model 170-LF (3/8”), Model 270-LF (1/2”) or Model 370-LF (3/4”). Valve shall be listed to ASSE 1070 and 3rd party approved as lead free. Valve shall be rated to 125 psig, 3/8” inlets/outlet (170-LF), 1/2” inlets/outlet (270-LF), 3/4” inlets/outlet (370-LF), 0.25 GPM minimum flow (170-LF and 270-LF) or 0.5 GPM minimum flow (370-LF) and a maximum of 2.7 GPM flow capacity at 15 psi system pressure drop (170-LF) or 7.5 GPM (270-LF and 370-LF). Valve to include locking temperature regulator and integral hot and cold supply checks. Valve options maybe include a dial thermometer, ball valve on the outlet, chrome plated (-CP) finish. Bi-metal thermostat shall be warrantied for a minimum of 10 years.

B. For single drench or combination shower applications, use Leonard Model TM-600-LF (-CP for chrome plating). Valve shall be listed to ASSE 1071 and 3rd party approved as lead free. Valve to have an internal cold water bypass of 20 GPM and provide 33 GPM flow capacity at 30 psi pressure drop. Valve to be of rough bronze construction, or if installed a non-mechanical room environment, the valve shall be chrome plated. Valve shall be rated to 125 psig, 3/4” inlets and 1” outlet, color-coded outlet dial thermometer, hot and cold supply check stops, and wall mounting bracket. Valve shall be factory pre-assembled and tested. Bi-metal thermostat shall be warrantied for a minimum of 10 years.

2.6 UNIONS

A. Where required: On inlet and outlet of all apparatus and equipment having connections 2" and smaller. Where valves are adjacent to equipment unions shall be on downstream side of valves.

B. Type:

1. Steel piping: Malleable iron, WOG female pattern, brass seat, ground joint, 300 lb.
2. Copper tubing: Ground joint, 150 lb. WOG pattern.
3. For piping over 2" flanged joints to be used.

C. Gaskets shall be 1/16" thick similar to Garlock or Cranite factory cut, one piece.

2.7 HOSE BIBBS

A. Hose bibbs shall be Chicago Faucets #952, MIFAB #HY-9241, or approved equal, with vacuum breaker and loose key except as specified herein. Combination hot and cold hose bibbs shall be Chicago #305-VBC.P., MIFAB #HY-8500, or approved equal; modify for piped mounting less loose flange.

2.8 THERMOMETERS

A. Thermometers shall be the adjustable angle, red reading mercury type with 7" black baked enamel case, black on white scale, range from 30˚F. to 240˚F., and separable brass socket. Thermometers shall be so installed and adjusted that they are easily readable from a normal standing position on the floor, U.S. Gauge "Multi-angle".

2.9 PRESSURE GAUGES

A. Pressure gauge shall have 3-1/2" diameter black enamel cast aluminum case threaded brass ring with heavy glass, phosphor bronze bushed rotary precision movement and dial range of 0 to 200 psi for water service; Trerice Co. No. 500X or approved equal, with brass tee handle cock.

2.10 FLOW CONTROL FITTINGS

A. Provide flow control fittings as manufactured by the Dole Valve Company or approved equal. Flow control valves are to be installed in accordance with the manufacturer's recommendations and shall be provided for all sinks, lavatories and electric water coolers.

B. All Lavatories: Dole Model #FMA 3/8" male pipe inlet and 3/8" female pipe outlet for rigid hot and cold supply risers. Flow rate 0.5 gpm.

C. All sinks including equipment with sinks, mop receptors, service sinks and kitchen sinks, showers: Dole Model #FMC male pipe inlet and 1/2" female pipe outlet for hot and cold supply risers. Flow rates 2.5 gpm for service sinks and mop receptors 3 gpm for kitchen and casework sinks, 2.5 gpm for showers.

D. Electric Water Coolers: Dole Model #F3/4C male pipe inlet and 3/8" female pipe outlet for cold supply riser. Flow rate 0.5 gpm.

E. All exposed to view flow control fittings shall be chrome plated nickel, or nickel plated.

2.11 DRAINS

A. Drains shall have heavy cast iron, with double drainage flange and weep holes, with outlet connections as indicated and of sizes indicated on Drawings. Drains (except as noted) shall be furnished with high polished brass tops consisting of one-piece rim secured to the body and vandalproof spanner type screws, solid brass grate with reinforcing members on underside. Removable sediment basket shall be of heavy duty one-piece construction as specified hereinafter. All strainers or grates shall be secured with vandalproof spanner type screws, unless otherwise specified.

B. All drains in membrane waterproof floor shall be equipped with 6 lb. lead flashing or 20 oz. soft rolled sheet copper and secured to the flashing flange with brass bolts and cast iron clamping device. Flashings shall bond not less than 1'-0" on all sides into membrane waterproofing.

C. On roofs, furnish and set, in conjunction with the roofer, and when directed by the General Construction Contractor, approved roof drains of cast iron unless otherwise indicated.

D. Flashing of 6 lb. or 20 oz. soft rolled sheet copper 34" x 34" shall be furnished and installed at each roof drain by means of non-puncturing type flashing clamping device.

E. Set all drains in such a way that the floor finish and top of the drain will be plumb and flush with finish floor without requirements for future additional extension, modifications, etc.

F. When Dex-O-Tex and/or vinyl waterproof floor is indicated on the Architectural Drawings, all drains must be provided with required flanges.

G. Provide trap primers in all locations where a hose bib is not shown within 10’ of a drain.

H. All drains, except as noted, shall be similar to or equal to Zurn, J.R. Smith, Josam, Wade or Ancon and shall be as follows:

1. Roof Drains R.D. Type A - Similar and equal to no. Z-100-ERC or MIFAB #R 1200 BUV dura-coated cast iron body with combination flashing collar and gravel stop, cast iron dome, underdeck clamp and sump receiver and perforated extension collar to accommodate roof insulation. Drain must be applicable for each roof construction.

2. Floor Drains F.D. Type A (Mechanical and Concealed Equipment Rooms) - Similar and equal to No. Z-505 or MIFAB #F1340-Y-14-4-F-50 Funnel cast iron body and flashing collar with cast iron tractor grate and flat bottom strainer. No. Z-414 cast iron funnel attached to grate, where indicated on the Drawings.

3. Floor Drains:

a. Refer to Architectural drawings for exact locations and additional installation requirements.
b. Install floor drains with P-traps and vent as required.
c. Install drains on the center line of sheet lead pan and/or membrane in waterproofed areas and in floors above lowest floor.
d. Clamp pan and/or membrane into drain flashing collar.
e. Install strainers immediately after completion of finish floor installation.
f. Coordinate locations with mechanical equipment.
g. Install trap primers at all drains where a hose bib is not shown within 10’ of drain.
h. Provide extra heavy duty grates/strainers in locations subject to vehicular traffic.

2.12 WATER METERS

A. All water meters must be approved by the Department of Environmental Protection (DEP) prior to purchasing.

B. Make-up water meters for evaporative cooling towers shall use:

TURBINE METERS

Manufacture	Size Range
Elster (Amco)	1½” to 12”
Badger	2” to 12”
Hersey	1” to 6”
Neptune	1½” to 12”, 16”, 20”
Sensus	1½” to 6”, 16”

SINGLE-JET AND ELECTROMAGNETIC METERS

Manufacture	Size Range
Elster (Amco)	1½”+
Metron-Farnier	5/8” to 6”
Neptune	4” to 10”

DISPLACEMENT METERS

Manufacture	Size Range
Elster (Amco)	5/8” to ¾”
Badger	5/8” to 2”
Hersey	5/8” to 2”
Neptune	5/8” to 2”
Sensus	5/8” to 2”

C. Provide a DEP approved OEM strainer at the inlet to all water meters.

D. Provide FM/UL approved strainers all fire service and combined service meters.

E. Turbine and compound meters may be purchased and installed only upon approval of the DEP of satisfactory quantity of water required will be drawn at a rate to insure proper registration. Compound meters are not acceptable for buildings with house pumps, roof tank, or where flow rate is always greater than 5gpm.

F. Acceptable water meters flow shall be straight through the meter at all flow rates. All water measured by the meter shall be recorded on a single totalizing register.

G. Meters and strainers shall meet or exceed the latest AWWA Standard C701 at both normal flow ranges and sustained flow limits. Meters shall comply with latest 4064 Class B standards. Domestic water meters must be approved for potable water use by the DEP.

H. Meters shall be installed in accordance with the manufacturer’s written recommendations. Provide a minimum of five (5) pipe diameters of straight pipe immediately in front of the meter assembly and a minimum of three (3) pipe diameters of straight pipe immediately downstream of the meter assembly. Throttling valves, control valves, check valves, backflow preventers and pressure reducing valves shall not be installed upstream of any water meter regardless of pipe separation. Reducer connections to meter assemblies, where used, shall be of the tapered, concentric type. Reducing flanges and eccentric step type reducers are unacceptable.

I. Meters shall be installed with a DEP approved inlet valve and outlet valve immediately upstream and downstream of the water meter in addition to the house control valve. Meters settings shall include the installation of a test tee or test valve downstream of the meter and before the outlet valve.

J. The meter must be installed with an approved seal wire through all connection fittings that would prevent the removal of the water meter without breaking the seal wire.

K. All meters shall be installed as per approved DEP meter installation drawings.

L. The meter must be installed in a clean pipeline, free of any foreign materials. Install the meter with direction of flow as indicated by the arrow cast into the meter body.

M. The meter shall consist of a fully epoxy coated cast iron main case with the flow direction cast into it and a removable measuring element for easy maintenance. Water meter bodies shall be composed of an alloy with no more than 0.25% lead.

N. Meter shall be selected to accurately record flow with a 100:1 turndown ratio and a working pressure of 175 psi.

O. Meters shall be supplied with DEP approved remote receptacles and connecting cable/wire (22 gauge minimum). Remote receptacle shall be located on the exterior of the building, 42” above the ground. Location of remote receptacles must be approved by both DEP and the Architect.

P. Provide direct read register with pulse output suitable for output to BMS.

Q. Provide connection to BMS and hourly logging for each meter.

PART 3 - EXECUTION

3.1 SUMP PUMPS

A. Provide union in discharge piping above floor.

B. Provide gate valve above floor.

C. Provide lift check valve close to pump discharge.

D. Install and adjust float control.

E. Test pump staging and float operation by flooding pit to simulate operation. Test shall be observed by Engineer or Owner Representative.

F. The alignment of all pumps shall be checked and each pump shall be properly aligned after the piping is completed and before the pumps are placed in service.

G. Mechanical seals and shaft sleeves shall be replaced by this Contractor without charge in the event the unusual wear of faulty operation occurs during guarantee period.

H. Where pump's components are or may come in contact, although the materials may basically be similar, use hardness differentials of at least 50 Brinell to prevent seizure and reduce wear.

I. Provide shaft packing or seals compatible with the pump design, fluid handled and in accordance with the manufacturer's recommendations.

J. Balance pump's impellers and all other moving components statically and dynamically.

K. Completely align and level pumps, motors and bases. Where pumps and motors are shipped as a unit, realign them in the field.

L. Grout equipment base plates completely to provide a rigid-non- deflecting support.

M. Install and align mechanical seals in accordance with the manufacturer's recommendation.

N. Provide water supply for cooling and lubrication of seals and/or packing where required.

O. Provide flexible connection for pumps. Provide spring hangers for piping for pump to partition or wall penetration.

P. Pump operation must be stable without pulsation, vibration or internal recirculation. Pump operating characteristic curves must meet the following requirements:

1. The pump operating point must fall on or below an impeller diameter curve which is not more than 85% of the maximum diameter impeller which can satisfactorily operate in the casing.
2. The pump operating point must fall below the point of no flow head pressure.
3. Pump operating point must be to the right of the midpoints of the peak efficiency curves. Selected efficiency shall be not more than 3% points below maximum efficiency.
4. A 10% increase in head pressure over the specified will result in not more than a 20% reduction in GPM and will not affect the stability of the pump

Q. Where initial and ultimate operating conditions are specified, these shall be achievable by changing the pump impeller with no modifications to the casing.

R. Upon completion of the installation, test all equipment under field operating conditions to demonstrate capability of the equipment to meet specification requirements.

S. Submit results of factory tests with the equipment shop drawings. Include result of factory and field tests in the Instruction Manual.

T. Perform field tests to demonstrate the ability of the pumping equipment to meet contract requirements. Compile and certify the following data:

1. Water flow, GPM, at rated head.
2. Shutoff head.
3. Operating kilowatts for measured voltage, amperes, power factor.

3.2 DRAINS

A. Contractor shall protect drains immediately upon installation. Drain grates shall be covered throughout construction to prevent construction debris from entering the drainage system.

B. Contractor shall test all drains just prior to turnover to confirm all drains, traps and pipes are clear and draining properly.

C. Drains, traps and pipes that are found to be clogged upon testing shall be cleaned and/or replaced, water jetted and scoped by a camera immediately, at no additional cost to the owner.

D. The contractor shall be responsible for a set period of time after project completion to clean drains, traps and pipes that do not appear clogged upon testing.

END OF SECTION

SECTION 22 40 00

PLUMBING FIXTURES

PART 1 - GENERAL

1.1 SUBMITTALS

A. Submit manufacturer's product data for plumbing fixtures and accessories, in accordance with Division 1.

PART 2 - PRODUCTS

2.1 GENERAL

A. All manufacturers are listed in alphabetical order and not by preference.

B. Provide factory fabricated fixtures.

C. All fixtures used for potable water service should be compliant with NSF-61. Provide fixtures which meet or exceed standards of the Federal Reduction of Lead in Drinking Water Act, Safe Drinking Water Act and Lead Contamination Control Act, NSF Standard 61, Section 9. All components in the waterway to be lead free.

D. See Architectural Drawings for fixture requirements. Fixtures specified in this plumbing specification shall be provided only if a suitable fixture is not specified in the architectural drawings or specifications.

2.2 PLUMBING FIXTURES

A. Refer to Architectural drawings for design basis of all plumbing fixtures.

B. All fixture trimmings, including faucets, strainers, escutcheons, shower head and arm, water closet supplies, stops, waste trap, escutcheons, visible hanger or chair carrier nuts shall be made of brass and shall be polished chromium plated. All material to be specified as chromium plated and shall be thoroughly and evenly applied and guaranteed not to strip or peel. All chromium plating on plumbing fixture trim shall be in accordance with Federal Spec. WW-P-54lb for grade "R" plating. Manufacturer shall submit certification that all chrome plating on finished trim meets aforementioned Federal Specification. All plated work shall be highly buffed. Plastic, zinc or white metal will not be approved.

C. All fixtures shall be free from imperfections, true as to line, angles, curves and color, smooth, watertight, nameplate in every respect and practically noiseless in operation. Fixtures as specified are given as a typical standard and they or other approved fixtures shall be furnished, set and connected in good substantial, neat and workmanlike manner.

D. All fixtures, specified to be vitreous ware, shall be fixed vitreous china ware of the best quality, non-absorbent and burned so that the whole mass is thoroughly fused and vitrified, producing a material white in color which, when fractured, will show a homogenous mass, close grained and free from pores. The glazing and vitreous china fixtures shall be white, thoroughly fused and united to the body, without discoloration, chips, or flaws, and shall be free from craze. Warped or otherwise imperfect fixture will not be acceptable.

E. Each supply fixture, casework fixture and equipment, shall be separately controlled by its own stops. Locate as required on wall, above floor or as directed.

F. All faucets shall have metal handles.

G. All trim shall be permanently stamped with manufacturer's identification and visible after installation.

H. All fixtures, faucets, flush valves, etc., are to be ADA compliant, unless specifically noted otherwise.

2.3 COMBINATION EMERGENCY SHOWERS/EYE WASH

A. Speakman SE-616 or approved equal. Showerhead cycolac yellow, 8” diameter (equivalent to Model SE-870).

B. Shower valve to be 1” NPTF chrome-plated brass stay-open ball valve activated by stainless steel triangular pull handle.

C. Stanchion shall be 1-1/4” galvanized steel pipe and fittings, with floor flange, painted safety green or as approved by Architect.

D. Eyewash shall be Speakman SE-505 or approved equal, wall mounted, 13½” x 8-3/4”.

E. Eyewash valve to be ½” NPTF chrome-plated brass, stay open ball valve. Activated by stainless steel trigger bar.

F. Spray heads: Twin aerated outlets, individually adjustable for maximum performance.

2.4 EQUIPMENT FURNISHED UNDER OTHER SECTIONS

A. Provide all materials necessary to make final connections to equipment furnished under other Sections of these Specifications including:

1. Tail pieces
2. Stops
3. Supplies
4. P traps, standard and/or offset
5. Escutcheons

B. All fixture trimmings, including faucets, strainers, escutcheons, shower head and arm, water closet supplies, stops, waste trap, escutcheons, visible hanger or chair carrier nuts shall be made of brass and shall be polished chromium plated. All material to be specified as chromium plated and shall be thoroughly and evenly applied and guaranteed not to strip or peel. All chromium plating on plumbing fixture trim shall be in accordance with Federal Spec. WW-P-54lb for grade "R" plating. Manufacturer shall submit certification that all chrome plating on finished trim meets aforementioned Federal Specification. All plated work shall be highly buffed. Plastic, zinc or white metal will not be approved.

PART 3 - EXECUTION

3.1 INSTALLATION

A. General: Install each fixture with P trap with cleanout plug, easily removable for servicing and cleaning.

B. Provide chrome plated, rigid supplies to fixtures with stops, reducers and escutcheons. Flexible supplies will not be permitted.

C. Finish wall and floor penetrations when exposed to view in finished areas with set screw type, chrome plated brass escutcheons.

D. Set plumbing fixtures level and plumb, spaced in accordance with architectural dimensioned drawings, and securely install to be rigid. Install wall mounted lavatories, urinals and water closets with wall carriers mounted to the floor. Solidly attach floor mounted carriers for all fixture to floor using proper fasteners based on floor construction. Securely anchor flush valves behind or within walls to be rigid and not subject to movement due to push or pull action on the valve.

E. Cover fixture bolts with china bolt caps of the same color where required.

F. All wall mounted fixtures to be caulked between fixture and wall.

G. Refer to Architectural drawings and ADA standards for fixture mounting heights.

H. The Contractor shall make all plumbing connections to all equipment and fixtures requiring such connections as shown on Drawings whether the equipment and fixtures are furnished under this Section or other Divisions or Sections. Investigate the equipment furnished under other Divisions or Sections to determine if combination fittings have a means of shutoff or required the installation of check valves, backflow preventors and/or pressure reducing valves. Make final connections to such, including installations of all special traps, supplies, control valves, etc. furnished with such equipment, and furnish all material necessary that is not supplied with the equipment.

I. The Contractor shall leave valved water connections in equipment spaces and other locations where shown for the use of other trades or other Sections. On each valved outlet for equipment with submerged inlets, provide a backflow preventor after the shut-off valve. .

J. Fixture supplies and traps as specified, shall be chrome plated brass, where exposed to view. Where concealed from view in cabinets, etc., they may be rough brass. All fixture supplies shall have stops.

K. As soon as installed, all metal fixture trimming shall be thoroughly covered by this Contractor with noncorrosive grease which shall be maintained until all construction work is completed.

L. Upon completion of the Work, test flush valves and faucets for leaks or drips and adjust same for quiet operation.

M. All fixtures shall be left thoroughly clean. All plated or polished fittings, pipes and appliances shall be coated with non corrosive grease, immediately after installation, and shall be finally polished and free from all marks and foreign substances.

N. Equipment and all connections shall be in accordance with the rules relative to submerged inlets, and shall be provided with all necessary vacuum breakers and check valves, in accordance with the applicable codes.

O. Each fixture shall be separately trapped, using the type and size of trap called for specifically in the Specifications, or the type required by the Plumbing Code. The traps shall be approved type.

P. All fixtures requiring hot and cold water shall have the cold water faucet on the right hand side of the fixture and the hot water faucet on the left hand side of fixture.

Q. The Contractor shall be responsible for protecting against injury from the building materials, acids, tools and equipment, all plumbing fixtures equipment, etc., provided under Plumbing Work Sections.

R. No slip joints will be permitted on water piping.

3.2 CLEANING AND ADJUSTING

A. Cleaning:

1. Clean strainers, traps, aerators, and valves of debris, sand and dirt.
2. At completion, thoroughly clean plumbing fixtures and equipment.
3. All fixtures shall be left thoroughly clean. All plated or polished fittings, pipes and appliances shall be coated with Vaseline, immediately after installation, and shall be finally polished and free from all marks and foreign substances.

B. Adjusting:

1. After cleaning and flushing operations are accomplished, adjust flush valves, faucets, showers, bubblers for proper flow.

3.3 PROTECTION

A. Protect fixtures and related components from damage before, during, and after installation to date of Final Acceptance or Owner move-in. Provide protective coverings or other protection as required.

B. Inspect each installed unit for damage to finish. If feasible, restore and match finish to original at site; otherwise, remove fixture and replace with new unit. Feasibility and match to be judged by Architect or Engineer.

C. Remove cracked or dented units and replace with new units.

D. Contractor shall be responsible for replacing damaged fixtures or components.

3.4 SERVICES TO FIXTURES AND EQUIPMENT FURNISHED UNDER OTHER SECTIONS

A. The list of equipment for the project shall be reviewed by this Contractor, who shall include in the Contract price the costs for installing all equipment as herein specified and as claimed by the Trade Unions as Plumbing Work.

B. Refer to Architectural and Plumbing Drawings for exact locations of equipment and fixtures. Provide all materials, equipment and appliances necessary and required to complete the installation of all Hospital casework and equipment, including but not limited to the following: plumbing, roughing and final connections, valves, stops, trim, escutcheons, fittings, traps, etc. Install faucets, trim, etc., furnished with the equipment provided by others.

C. Unless otherwise detailed on Drawings, roughing of proper size and capacity for equipment indicated on Architectural, Heating and Ventilation, Plumbing or Electrical Drawings or provided under another Division or Section shall be provided and installed in such a manner and location that final connection can be made with a minimum of work and without cutting patching permanent walls, partitions, ceilings or floors. Drawings are of necessity, schematic, for special equipment as exact roughing and requirements may vary with different manufacturers.

END OF SECTION

SECTION 22 90 00

PROJECT CLOSEOUT

PART 1 – GENERAL

1.1 WORK INCLUDED

A. The contractor shall summarize and document adherence with the requirements of the specifications for project closeout including:

1. Copies of all warranties
2. Operation & Maintenance Manuals
3. Required tests
4. Test and balance reports
5. Record drawings
6. Permit requirements
7. Valve tag list

B. The contractor shall compile a closeout manual which shall include:

1. A list of all required tests and a place for signoff of date completed.
2. A list of all submittals with dates of acceptance by the engineer.
3. A schedule indicating dates for beginning testing and startup of equipment and dates of tests to be witnessed by the engineer, or designated representative, as required by the specifications.
4. Test procedures to be used for life safety systems.
5. Project close out check list.

C. The final closeout manual shall include the following:

1. Test reports as required by the specifications with signoff by the appropriate individual (engineer, architect, building official, etc.).
2. Documentation indicating all equipment is operating properly and is fully accessible for maintenance.
3. Copies of all warranties.

D. This section only includes the requirements for documentation of the contract documents, by the contractor, for project completion. This section does not in any way decrease the scope of any of the drawings or specifications.

1.2 SUBMITTALS

A. Within 90 days after notice to proceed submit a preliminary closeout manual with the following:

1. A list of all required tests.

2. Preliminary schedule showing major milestones for completion of the plumbing systems.

B. Within 30 days of the first major milestone submit the completed closeout manual as described in Part 1.

C. Within 2 weeks of substantial completion submit a completed “Project Closeout Check List”, and the Final Closeout Manual.

D. Listed below is a checklist for use by the contractor. This list is not all inclusive for this project.

Project Close-Out Summary – Plumbing

- ☐ All required submittals have been submitted and either been approved or modified in accordance with the Engineer’s “make corrections noted” comments.
- ☐ All equipment has been started up and is functioning within manufacturers’ recommendations without any undue noise or vibration. (Submit a list of equipment with startup dates. Provide list at a point 65% into construction schedule).
- ☐ Access doors have been installed as required for concealed equipment, water hammer arrestors, valves, controls, actuators, etc.
- ☐ All equipment has been installed with the manufacturers recommended service clearances and is fully accessible for required maintenance.
- ☐ All equipment and piping is labeled per specifications.
- ☐ All plumbing piping cleaned, flushed and tested per specifications. Submit testing reports for record. Submit letter stating domestic water disinfection (chlorination) has been completed per the specifications.
- ☐ All action items are complete as listed in the action items reports. Submit a list of action items with sign off by Architect or Engineer for record. Punch list to be completed prior to turn over of building.
- ☐ Contractor to test all drains to verify that they are clear and draining properly upon project completion.
- ☐ Operation and maintenance manuals submitted with table of contents and required documentation for extended warranties.
- ☐ Factory Testing documented and submitted for record.
- ☐ Record drawings submitted per specifications.
- ☐ Water meter installed and tested.

PART 2 – PRODUCTS (Not Used)

PART 3 – EXECUTION

3.1 EQUIPMENT STARTUP AND TESTING

A. Prior to completion and punchlist by the engineer, the contractor shall startup and test each piece of equipment as required by the specifications. The contractor shall provide documentation of all required tests with signoff of by the appropriate individual (engineer, architect, and building official).

3.2 COORDINATION WITH OTHERS

A. The Division 21 through 23 contractor shall coordinate his requirements with the General Contractor to ensure the other building systems are completed to the point that they will not adversely affect the operation of the Division 21 through 23 systems.

3.3 PUNCH LISTS

A. The contractor shall submit in writing that the project is ready for final review by the engineer.

B. Once the project is ready for final review the engineer will create a punch list of any corrections or deficiencies.

C. The contractor shall complete all punch list items and provide a letter to the architect after completion stating all items have been completed or reasons why they were not completed.

D. Upon receipt of this letter the engineer will verify that the punch list has been satisfactorily completed.

END OF SECTION

SECTION 23 05 01

MECHANICAL AND ELECTRICAL COORDINATION

PART 1 - GENERAL

1.1 RESPONSIBILITY

A. The Divisions 21, 22, 23, 24, 25, 26, 27 and 28 contractor(s) shall comply with the provisions of this section. The Divisions 21, 22, 23 and 25 contractor(s) shall verify electrical service provided by the electrical contractor before ordering any mechanical equipment requiring electrical connections. Provide submittals of all mechanical equipment to Division 26, 27 and 28 contractor(s).

B. The final responsibility for properly coordinating the electrical work of this section shall belong to the Divisions 21, 22, 23 and 25 System Contractor performing the work, which requires the electrical power.

1. Each Divisions 21, 22, 23 and 25 contractor shall be responsible for providing power wiring for certain devices as described in the specifications and on the drawings. This work shall be provided by a licensed electrician in accordance with all of the applicable provisions of the Division 26, 27 and 28 specifications, NEC and local codes.

1.2 WORK INCLUDED

A. Carefully coordinate the interface between Divisions 21 through 23 (Mechanical) and Divisions 26 through 28 (Electrical), and Division 23 and 25 (control) before submitting any equipment for review or commencing installation.

1.3 DEFINITIONS

A. Automatic: Pertaining to a function, operation, process or device that, under specified conditions, functions without intervention by human operator.

B. Disconnect Switch: A mechanical switching device used for changing the connections in a circuit, or for isolating a circuit or equipment from a power source.

C. Motor Control Center: A floor mounted assembly of one or more enclosed vertical sections having a common horizontal power bus and primarily containing motor starting units.

D. Control Circuit/Power: The circuit which carries the electrical signals of a control apparatus or system directing the performance of the controller but does not carry the main power circuit.

E. Manual Operation: Operation by hand without the use of any other power.

F. MC: Mechanical Contractor = Divisions 21 through 23 Contractor who furnishes motor.

G. TC: Temperature Controls = Division 22, 23 or 25 Contractor who furnishes control.

H. EC: Electrical Contractor = Divisions 26, 27or 28 Contractor.

I. FA: Fire Alarm Contractor = Division 25 or 28 Contractor who furnishes Fire Alarm System.

J. SC: Sprinkler Contractor

K. EP: Electric to Pneumatic Converter.

L. PE: Pneumatic to Electric Converter.

1.4 RESPONSIBILITY SCHEDULE

A. Responsibility: Unless otherwise indicated, all motors and controls for Divisions 21, 22, 23 and 25 equipment shall be furnished, set in place and wired in accordance with the following schedule:

ITEM -	Furnished By	Set In Place By	Power Wiring By	Control Wiring By
Equipment Motors	MC	MC	EC	--
Automatically or Manually Controlled Starters/Contactors: (Note 4) -Separate -Factory Mounted and Wired	 MC MC	 EC MC	 EC EC	 TC TC
In Motor Control Centers (Note 4)	EC	EC	EC	TC
Motor Speed Controllers: (Note 4) -Separate -Factory Mounted and Wired	 MC MC	 EC MC	 EC EC	 TC TC
Disconnect Switches (Note 1)	EC	EC	EC	--
Thermal Overload Switches (Note 1)	EC	EC	EC	--
Switches (Manual or Automatic other than disconnect) (Note 2)	MC, EC or TC	MC or TC	EC or TC	TC or MC
Control Relays (Note 2)	MC, EC or TC	MC or TC	--	TC
Control Transformers	MC or TC	MC or TC	EC or TC	TC
Thermostat and Controls: Integral with Equipment or Directly Attached to Ducts, Pipes, etc. (Note 2)	MC, EC or TC	MC or TC	MC or TC	TC
Equipment in Temperature Control Panels	TC	TC	TC	TC

ITEM -	Furnished By	Set In Place By	Power Wiring By	Control Wiring By
Standalone Control Panels (BAS) (Note 6)	TC	TC	TC	TC
Valve Motors, Damper Motors, Solenoid Valves, etc.	TC	MC	TC	TC
EP Valves or Switches, P.E. Switches, etc.	TC	TC	--	TC
Fire Alarm System (Note 3)	FA	FA	EC	FA
Duct System Smoke Detectors (Note 5)	FA	MC	--	TC/FA
Relays for Fan Control via duct detectors (Note 5)	MC	MC	EC	TC/FA
Room Smoke Detectors Including Relays for Fan Control (Note 3)	FA	FA	--	FA
Equipment Interlocks	TC	TC	--	TC
Fire/Smoke and Smoke Dampers (Note 7)	MC	MC	EC	FA/TC (Note 7)
Smoke Control Dampers (for smoke management system) (Note 7)	MC	MC	EC	FA/TC (Note 7)
Positive Indication Devices (i.e., current sensors, end switches, airflow sensors)	TC	TC	--	FA/TC (Note 7)

Notes:

1. If furnished as part of factory wired equipment furnished and set in place by MC, wiring and connections by EC. Electrical Contractor shall provide disconnects for all electrical equipment unless otherwise indicated.
2. If float switches, line thermostats, P.E. switches, time switches, or other controls carry the FULL LOAD CURRENT to any motor, they shall be furnished by MC, but they shall be set in place and connected by EC, except that where such items are an integral part of the mechanical equipment, or directly attached to ducts, piping, or other mechanical equipment, they shall be furnished and set in place by MC and connected by EC. If they do not carry the FULL LOAD CURRENT to any motor, they shall be furnished, set in place and wired by TC contractor. Such devices shall be provided at low voltage unless technically impossible
3. Pre-action system initiation signals (such as smoke detectors or general alarm conditions in a pre-action zone) shall be provided by the electrical contractor.
4. Electrical contractor is responsible for wiring from disconnect to starter and from starter to motor, unless factory wired.
5. Temperature control contractor shall provide conduit and wire from auxilary contact in motor starter to the detector so that the unit shuts down in all operating modes. Fire Alarm Contractor to wire from detector to fire alarm panel.
6. Each division shall be fully responsible for any control panels as called for on the drawings or specifications.

a. Electrical Contractor shall provide all power and control wiring to fire/smoke or smoke dampers. HVAC, Controls, Electrical, and Fire Alarm Contractors shall provide parallel control wiring (with fire alarm having priority signal) to dampers and equipment utilized in both normal and smoke control modes, unless otherwise indicated.
b. Fire alarm system shall override automated building control system during smoke exhaust mode.
c. TC shall provide additional required wiring and controls when damper also serves a temperature control or zoning function.

7. FA wires to components necessary for the operation and monitoring of the Smoke Management System. TC wires to components utilized in the control and monitoring of the Automated Building Control System. This often requires dual wiring where components are controlled by both. In such case wiring and relays shall be provided to ensure FA takes precedence in control over TC.

B. Power Wiring by Divisions 21, 22, 23 and 25: The electrical power for certain equipment provided under Divisions 21, 22, 23 and 25 may not be specifically indicated on the electrical drawings and must be provided by and field coordinated by the Divisions 21, 23 or 25 trade requiring such power.

Sufficient power for this purpose shall be furnished as “spare” dedicated circuit capacity in Division 26’s panelboards. All wiring, conduit and electrical devices downstream of the panelboards is the responsibility of the Divisions 21, 23 and 25 trade requiring the power.

1. Such equipment is hereby defined as:
   a. Electrical heat trace. Required heat trace locations, capacities and specification are shown on the plumbing drawings.
   b. Fire protection air compressors, dry-pipe control panels and valves. Required connections are included in the Fire Protection work, and will be shown by that contractor’s engineered system design drawings.
      1) Pre-action system initiation signals (such as smoke detectors or general alarm conditions in a pre-action zone) shall be provided under fire alarm work.
      2) Sprinkler Contractor shall provide pre-action control panel and interconnection between nearest suitable fire alarm panel and location of pre-action valve(s).
      3) Fire Alarm Contractor shall provide interconnection between fire command center alarm panel and/or remote communication fire alarm panel.
   c. Infrared plumbing fixtures. Fixtures requiring power are shown on the plumbing drawings and schedules. Provide junction box and or receptacle as required by manufacturer.
   d. Temperature control panels, control air compressors and line voltage power for 24v control transformers. Required connections are included in HVAC scope and will be shown by that contractor’s control submittal drawings.

e. Motorized dampers and VAV boxes. Required locations and specification are shown on the mechanical drawings and HVAC specifications. HVAC contractor shall provide damper, controls and power.

1.5 GENERAL REQUIREMENTS

A. Connections:

1. Connections to all controls directly attached to ducts, piping and mechanical equipment shall be made with flexible connections.

B. Starters:

1. Provide magnetic starters for all three phase motors and equipment complete with:
   a. Control transformers.
   b. 120V holding coils.
   c. Integral hand-off-auto switch.
   d. Auxiliary contacts required for system operation plus one (1) spare.
   e. Refer to Motors, Starters and Drives, requirements for additional information.

C. Remote Switches and Pushbutton Stations:

1. Provide remote switches and/or pushbutton stations required for manually operated equipment (if no automatic controls have been provided) complete with pilot lights of an approved type lighted by current from load side of starter.

D. Special Requirements:

1. Motors, starters and other electrical equipment installed in moist areas or areas of special conditions, such as explosion proof, shall be designed and approved for installation in such areas with appropriate enclosure.

E. Identification:

1. Provide identification of purpose for each switch and/or pushbutton station furnished. Identification may be either engraved plastic sign permanently mounted to wall below switch, or stamping on switch cover proper. All such identification signs and/or switch covers in finished areas shall match other hardware in the immediate area.

F. Control Voltage:

1. Maximum allowable control voltage 120V. Fully protect control circuit conductors in accordance with National Electrical Code.

G. DDC Control Interface:

1. Fully coordinate the requirements of each division with regard to supplying a complete DDC Control System prior to submitting bid.
2. All power to controllers and controlled equipment shall be furnished via dedicated line voltage circuits.
3. Dedicated control circuits from electrical panelboards to DDC control panels and from electrical panelboards to dedicated DDC J-boxes (for distributed control components such as VAV boxes), and control transformer line voltage connections shall be provided by HVAC Contractor where required.
    a. Exceptions: Where power wiring has been shown on Electrical Drawings.
4. Low voltage wiring from J-boxes to distributed control components, all low voltage connections, all control panels and all control transformers (not part of unitary equipment) shall be provided under Division 23 or 25.
5. Any additional power requirements shall be the responsibility of the Division 23 or Contractor requiring same, and provided at no additional cost to the owner.

1.6 CEILING AND CHASE CAVITY PRECEDENCE

A. Coordinate ceiling cavity space carefully with all trades. In the event of conflict, install mechanical and electric systems within the cavity space allocation in the following order of precedence. A system with higher precedence may direct that systems of lower precedence be relocated from space, which is required for expedient routing of the precedent system.

1. Plumbing waste, cooling coil drain piping, and roof drain mains and leaders.
2. Steam and condensate piping.
3. Hydronic main piping (10” and larger).
4. Plumbing vent piping.
5. Supply, return and exhaust ductwork.
6. Electrical conduit greater than 3” diameter.
7. Hydronic branch and mains (greater than 2”, but less than 10”).
8. Domestic water mains piping.
9. Fire sprinkler mains and leaders.
10. Hydronic branch piping (2” and less).
11. Domestic water branches.
12. Electrical conduit branch feeders.
13. Fire sprinkler branch piping and sprinkler runouts.

B. Light fixtures have precedence in a zone, extending from the face of the ceiling to an elevation 2” above the height of the light fixtures.

C. Examine the contract documents of all trades (e.g. all Divisions 21, 22, 23, 25, 26 and 28 the architectural floor plans, reflected ceiling plans, elevations and sections, structural plans and sections, etc.).

D. Coordinate necessary equipment, ductwork and piping locations so that the final installation is compatible with the materials and equipment of the other trades.

E. Prepare shop drawings for installation of all new work before installation to verify coordination of work between trades.

F. Provide access doors for all equipment, valves, clean-outs, actuators and controls which require access for adjustment or servicing and which are located in otherwise unaccessible locations.

1. For equipment located in "accessible locations" such as lay-in ceilings: Locate equipment to provide adequate service clearance for normal maintenance without removing architectural, mechanical, electrical or structural elements such as the ceiling support system, electrical fixtures, etc. "Normal maintenance" includes, but is not limited to: filter changing; greasing of bearings; using p/t ports for pressure or temperature measurements; and replacement of ballasts, fuses, etc.
2. All system components requiring access shall be grouped together to reduce the quantity of access doors required.

G. See "Basic Mechanical Materials and Methods" for additional access door requirements if section has been included in this specification.

PART 2 – PRODUCTS

2.1 MOTOR HORSEPOWER

A. In general, all motors ½ HP and above shall be three phase, all motors below ½ HP shall be single phase.

B. Voltage and phase of motors as scheduled on the electrical drawings shall take precedence in the case of a conflict between the mechanical and electrical drawings or general condition 2.1. A., above.

C. Work under Divisions 21, 22 and 23 includes coordinating the electrical requirements of all mechanical equipment with the requirements of the work under Divisions 26, 27 and 28, before ordering the equipment.

1. If motor horsepowers are changed under the work of Divisions 21, 22 or 23 without a change in duty of the motor's driven device, coordination of additional electrical work (if any) and additional payment for that work (if any) shall be provided under the section of Divisions 21, 22 or 23 initiating the change. Increases or decreases in motor horsepower from that specified shall not be made without written approval from the Architect/Engineer.

PART 3 - EXECUTION - (Not Used)

END OF SECTION

SECTION 23 05 02

BASIC MECHANICAL REQUIREMENTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. This Section supplements Division 1 - General Requirements.

B. Where contradictions occur between this Section and Division 1, the more stringent of the two shall apply. Architect/Engineer shall decide which is more stringent.

C. Provisions of this section shall also apply to all sections of Divisions 21, 22 and 23.

1.2 DEFINITIONS

A. The definitions of Division 1 and the General Conditions of this specification also apply to Divisions 21, 22, 23 and 25 Contract.

B. “Contract Documents” constitute the drawings, specifications, general conditions, project manuals, etc., prepared by Engineer (or other design professional in association with Engineer) for contractor’s bid or contractor’s negotiations with the Owner. Divisions 21, 22, 23 and 25 drawings and specifications prepared by the Engineer are not construction documents.

C. “Construction Documents”, “construction drawings”, and similar terms for Divisions 21, 22, 23 and 25 Work refer to installation diagrams, shop drawings and coordination drawings prepared by the contractor using the design intent indicated on the Engineer’s contract documents. These specifications detail the contractor’s responsibility for “Engineering by Contractor” and for preparation of construction documents.

D. “(E)” indicates "existing" equipment on site which may or may not need to be relocated as a part of this work.

E. “(R)” indicates existing equipment to be relocated as part of this work.

F. "Furnish" means to "supply" and usually refers to an item of equipment.

G. "Install" means to "set in place, connect and place in full operational order".

H. "Provide" means to "furnish and install".

I. “Equal” or "Equivalent" means "meets the specifications of the reference product or item in all significant aspects." Significant aspects shall be as determined by the Architect/Engineer.

J. "Work by other(s) divisions"; "re:_____ Division", and similar expressions means work to be performed under the contract documents, but not necessarily under the division or section of the work on which the note appears. It is the contractor's sole responsibility to coordinate the work of the contract between his/her suppliers, subcontractors and employees. If clarification is required, consult Architect/Engineer before submitting bid.

K. By inference, any reference to a "contractor" or "sub-contractor" means the entity, which has contracted with the Owner for the work of the Contract Documents.

L. "Engineer" means the design professional firm, which has prepared these contract documents. All questions, submittals, etc. of this division shall be routed to the Engineer (through proper contractual channels).

M. "Piping" includes, in addition to pipe, all fittings, valves, hangers and other accessories related to such piping.

N. "Concealed" means hidden from sight as in chases, furred spaces shafts, hung ceilings, or embedded in construction.

O. "Exposed" means, "not concealed" as defined above. Work in trenches, crawl spaces, and tunnels shall be considered "concealed" unless otherwise specifically noted.

P. "Governmental" means all municipal, state and federal governmental agencies.

Q. Where any device or part of equipment is herein referred to in the singular number (such as "the pump"), such reference shall be deemed to apply to as many such devices as are required to complete the installation as shown on the Drawings.

R. "HVAC" means Heating, Ventilating and Air Conditioning.

S. "Plumbing Contractor" means the Contractor doing Plumbing work.

T. "Fire Protection Contractor" means the Contractor doing Fire Protection work.

1.3 COORDINATION

A. Contract Documents:

1. General: The Contract Documents are diagrammatic showing certain physical relationships, which must be established within the Division's work and its interface with other work. Such establishment is the exclusive responsibility of the Contractor. Drawings shall not be scaled for the purpose of establishing material quantities.
2. Supplemental Instructions: The exact location for some items in this Specification may not be shown on the Drawings. The location of such items may be established by the Architect/Engineer during the progress of the work.

Make reasonable modifications in the layout as needed to prevent conflict with work of other trades.

3. Discrepancies:
   a. Examine Drawings and Specifications of all Divisions of the work.
   b. Report any discrepancies to the Architect/Engineer and obtain written instructions before proceeding.
   c. Should there be a conflict within or between the Specifications or Drawings, the most stringent or higher quality requirements shall apply.
   d. Items called for in either specifications or drawings shall be required as if called for in both.
4. Constructability:
   a. Examine Drawings and Specifications of all Divisions of the work.
   b. Report any issues to the Architect/Engineer which may prevent installation of Divisions 21, 22, 23 and 25 work in accordance with the Contract Documents and the original construction contract.
   c. Report all issues within *30 days* after contract.

B. Be responsible for providing proper documentation of equipment product data and shop drawings to all entities providing service. This coordination shall include, but not be limited to, the following:

1. Fire Protection Contractor shall provide shop drawings to HVAC and Plumbing Contractors.
2. Automatic Temperature Controls, Building Management and Test-Adjust-Balance Contractors shall be provided with equipment product data and shop drawings as appropriate from all other contractors, and shall furnish the same information about control devices (such as valves, test wells, etc.) to the appropriate Contractors.

C. Coordination Drawings:

1. Submit coordination drawings for all HVAC, Plumbing, Fire Protection and Electrical work. The drawings shall be fully coordinated and signed off by all affected trades prior to submission. The coordination drawings shall include the following at a minimum:
   a. All major ductwork, piping, conduit and equipment.
   b. Reflected ceiling plans with light fixtures.
   c. Current architectural floor plans.
   d. Major structural elements.
   e. Elevations of piping ductwork or equipment.
   f. Sections through critical spaces.
2. The drawings shall be at a suitable scale (3/8”=1’-0” minimum) to clearly show information.
3. Any work installed without approved coordination drawings is done at the Contractor’s risk.

D. CAD Drawings:

1. Electronic Auto Cad drawings are available from M-E Engineers. The service charge for the delivery of these files is $200 per floor plan per trade. Contractor will be required to execute a file transfer agreement.

E. Existing Conditions:

1. Inspect existing conditions prior to bidding.
2. Provide proper coordination of mechanical work with existing conditions.

F. Utility Connections:

1. Coordinate the connection of mechanical and electrical systems with the Civil drawings and utility companies.
2. Comply with regulations of utility suppliers.
3. The Contract Documents indicate the available information on existing utilities and services, and on new services (if any) to be provided to the project by utility companies and agencies.
   a. Notify Architect/Engineer immediately if discrepancies are found.
4. Coordinate mechanical utility interruptions one week in advance with the Owner and the Utility Company. Plan work so that the duration of the interruption is kept to a minimum. This shall include premium time, shift labor and multiple crews to accelerate the work and lessen the impact on facility operations.

G. If the project is constructed under multiple bid packages each Contractor shall coordinate their work with the progress of the other contractors performing similar or unrelated work.

H. Coordinate ceiling cavity space carefully with all trades.

I. Coordinate with Electrical Work.

J. Cutting and patching as specified.

K. Chases, Inserts and Openings:

1. Provide measurements, drawings, and layouts so that openings, inserts and chases in new construction can be built in as construction progresses.
2. Check sizes and locations of openings provided. Any cutting and patching made necessary by failure to provide measurements, drawings, and layouts at the proper time shall be done at no additional cost to the Owner.
3. Coordinate roof openings for all roof-mounted equipment. Openings on documents are diagrammatic and do not represent manufacturer specific requirements. Actual opening size, orientation and location, as well as structural coordination, is the responsibility of the mechanical contractor. Provide transitions on ductwork to accommodate actual roof openings.

L. Support Dimensions: Provide dimensions and drawings so that concrete bases and other equipment supports to be provided under other Sections of the Specifications can be built at the proper time.

M. The work throughout shall be executed as quickly as conditions permit in the best and the most thorough manner under the direction of and to the satisfaction of the Engineers, Owners and Architects, who will jointly interpret the meaning of the Drawings and Specifications, and shall have the power to reject any work and materials which, in the judgment, are not in full accordance therewith.

N. The work called for under this contract shall be carried on simultaneously with the work of other trades in a manner such as not to delay the overall progress of the work. Furnish promptly to other trades involved at the project, all information and measurements relating to the work which they may require. Cooperate with them in order to secure the harmony necessary in the interest of the project as a whole.

O. Keep a competent superintendent in charge of the work at all times. Such superintendent shall be replaced if unsatisfactory to the Owner.

P. Upon award of contract, consult with the Architect and negotiate with subcontractors and manufactures, and within thirty (30) days submit five (5) copies of a preliminary list of major equipment, for approval, complete with name of manufacturer, dates of purchase orders, and delivery dates to the site. Also submit within thirty (30) days, five (5) copies of a preliminary schedule of installation of the various systems. The list shall be revised monthly and five (5) copies shall be submitted. The second submittal shall contain the names of manufacturers of scheduled equipment (with names, addresses, and telephone numbers of local representatives).

Q. Maintain a complete file of shop drawings at all times available to the Owner's representatives.

R. Every facility shall be provided to permit inspection of the work by the Owner's representatives during the course of construction.

S. Where items of equipment and/or materials are indicated in the Specifications as being furnished by other trades for installation, assume responsibility for the unloading of such equipment and/or materials from the delivery trucks, and for providing safe storage for same as required pending installation.

T. Where the work is to be installed in close proximity to work of other trades, or where there is evidence that the work is to interfere with work of other trades, assist in working out space conditions to make a satisfactory adjustment.

Prepare composite working drawings and sections at a suitable scale not less than 3/8" = 1'-0" clearly showing how the work is to be installed in relation to the work of other trades. If the installation is made before coordinating with other trades, make all necessary changes in the work without extra charge to the Owner.

1.4 COORDINATION WITH EXISTING OCCUPIED AREAS

A. Minimize disruptions to operation of building systems in occupied areas.

B. Provide temporary connections to prevent long disruptions.

C. Provide multiple crews, premium time labor and/or shift labor to reduce duration of work and impact on the facility.

D. When installation of a new system requires the temporary shutdown of an existing operating system, the connection of the new system shall be performed at such regular time or at overtime when designated by the Owner. Assume all connections to existing operational systems will be on premium time, provide a credit for all work allowed to occur on normal time.

E. The Owner shall be notified of the estimated duration of the shutdown period at least ten (10) days in advance of the date the work is to be performed.

F. When it is necessary to drain down all or part of an existing or new system the Contractor performing such work shall be responsible for providing all labor, materials, equipment, etc for the completion of the system draining and refilling where applicable. The base scope of the project shall include all premium time or shift labor required to accomplish this work.

G. All work shall be coordinated with the Owner or their designated representative who may wish to provide oversight of the process or witness the work at their discretion.

H. Prior to the start of any work the Contractor shall prepare a “Summary of Impact” document which shall detail; the systems to be affected, the areas impacted (in sufficient detail to allow evaluation), the duration of the proposed shut-down under ideal conditions, a summary of the potential risks (possible but unexpected complications) of the shut-down and all measures being taken to address the potential risks, the potential duration of the shut-down should unexpected complications occur, plans for temporary systems to mitigate the impact of the shut-down and any other items relevant to assessing the impact on the facility.

I. The “Summary of Impact” document should also identify any steps that have been taken to limit the scope and duration of the shut-down. This may include identification and testing of isolation valves, an investigation of multiple isolation valves that provide different levels of system isolation and shut-down extent, multiple teams working in multiple areas during a single shut-down to reduce the total quantity of shut-downs, etc.

J. With respect to wet systems, the subcontractor should provide all labor, materials, ladders, tanks, pumps, scaffolding, hoses, equipment, etc. required to perform systems shutdowns including but not limited to the furnishing and installation of temporary valves, system purge, access holes for pumping of low areas, wet taps for drain of low areas, removal and re-installation of heat tracing, insulation, BMS controls as applicable, etc. All recovered materials shall be disposed of properly with manifests and chain of custody documents where required by Codes or Law.

K. No work shall begin until all materials have been delivered to the job site. Contractor shall obtain and store spare quantities of products and materials required to complete the shut-down in the event that the materials planned for use prove to be defective or are damaged during installation. Where the scope of a repair is uncertain the contractor shall obtain and store all reasonable combinations of parts as may be required to adapt to the conditions that may be discovered during the progression of the work.

1.5 RELOCATIONS AND REHABILITATION OF EXISTING SYSTEMS

A. It is expected that the Contractors will regularly encounter situations where; existing systems conflict with the proposed location of new systems, existing systems that are exposed by the work may be in a condition that is not recommended for continued use, existing systems may be "orphaned" by the removal of existing work in adjacent areas, or existing systems may need to be relocated or replaced for any other reason. Each trade Contractor shall submit a completed unit costs table, as detailed in specification section 23 05 01/26 05 01 1.7, to be used for establishing pricing of such relocation/rehabilitation work.

1.6 ENGINEERING BY CONTRACTOR

A. The construction of this work requires the Contractor to perform certain design activities with regard to several of the Contract Mechanical systems or subsystems that can only be fully ascertained with regard to the prevailing site field conditions during construction activities. All such designs and related activities shall be the complete responsibility of the Contractor. Where these design activities require engineering, it is the responsibility of the Contractor to engage the service of a licensed New York State Professional Engineer experienced in the areas related to the design activities performed by the Contractor.

B. Systems or subsystems which require engineering responsibility by the contractor include, but are not limited to:

1. Any system not fully detailed on the drawings.
2. Fire sprinkler and hydraulic calculations.
3. Equipment supports, not fully detailed in the drawings.
4. Pipe supports, hangers and anchors not specified in these documents, or cataloged by the manufacturer and miscellaneous steel as required.
5. Vibration isolators and seismic restraints.
6. Duct supports, hangers and miscellaneous steel as required.
7. Temperature controls.
8. Refrigeration systems.
9. Piping expansion and contraction provisions.
10. Steam piping stress analysis and calculations.
11. Equipment supports, hangers.
12. Ductwork support systems.

C. Contractor's design responsibility shall include system design, any required calculations to support system design, any compliance documents or certifications by any governing body up to and including replacement of design engineer with a different engineer of record, retained and paid by the contractor, as determined by authorities or original design engineer. Where supplemental steel is required to support piping or equipment, the supplemental steel shall be designed to provide a maximum deflection of L/360 at the midspan under the supported load. The piping or equipment shall be isolated from the building structure by means of isolators as required by the mounting type specified for the piping and/or equipment.

D. Contactor shall complete all controlled or special inspections and file all required paperwork in a timely manner. Professional engineer retained by contractor to serve as "special inspector" shall meet all requirements for special inspector as determined by the authority having jurisdiction.

E. Where the contract documents indicate "Verify in Field" or "Contractor to Verify" or other similar terms, the contractor shall be responsible for verifying the extent of the work by performing field investigations prior to submitting their bid. All costs associated with performing the complete scope of work, as determined by the contractor's field verification, shall be included in the contractor's bid price.

1.7 REGULATORY REQUIREMENTS

A. Codes: Comply with the latest editions of the following:

1. International Building Code.
2. International Mechanical Code.
3. International Plumbing Code.
4. Building Code of the State of Connecticut
5. Connecticut State Energy Conservation Code
6. Connecticut State Mechanical Code
7. National Electric Code.
8. ASME Boiler and Pressure Vessel Code.
9. Local Modifications to above Codes.

B. Applicable NFPA Standards.

C. Requirements of Local Utility Companies:

1. Comply with rules and regulations of local utility companies. Include in bid the cost of all valves, valve boxes, meter boxes, meters and such accessory equipment which will be required for the project.

D. Other Regulations: Comply with the latest editions of the following:

1. U.S. and State Department of Labor Safety Regulations pertaining to the completed project.
2. Requirements of Fire Departments serving the project. Including FDNY.

3. Regulations of the Health Department having jurisdiction. Including New York State and New York City D.O.H.
4. Regulations of the Fire Marshal.
5. ASHRAE Energy Conservation Standard 90A.
6. ASHRAE Ventilation Standard 62.
7. ASHRAE 90.1.
8. ASHRAE 13
9. ASHRAE 135
10. Americans with Disabilities Act (ADA).
11. Clean Air Act.
12. Clean Water Act.
13. NFPA National Fire Protection Association
14. ANSI American National Standards Institute
15. ASTM American Society for Testing Materials
16. AWWA American Water Works Association
17. IBR Institute of Boiler and Radiator Manufacturers
18. NEMA National Electric Manufacturers Association
19. SMACNA Sheet Metal and Air Conditioning National Association, Inc.
20. ARI Air Conditioning and Refrigeration Institute
21. UL Underwriters' Laboratories
22. AMCA Air Moving and Conditioning Association
23. ADC Air Diffusion Council
24. AABC Associated Air Balance Council
25. Local Water Company Rules and Regulations

E. Additional Regulations: Follow additional regulations, which appear in individual Sections of these Specifications.

F. All piping shall be domestically manufactured and shall be by the same manufacturer.

G. Contradictions: Where codes are contradictory, follow the most stringent, unless otherwise indicated in Plans or Specifications. Architect/Engineer shall determine which is most stringent.

H. Contract Documents Not in Compliance:

1. Where the Drawings and Specifications do not comply with the minimum requirements of the Codes, either notify the Architect/Engineer, in writing during the Bidding Period, of the revisions required to meet Code requirements, or provide an installation which complies with the Code requirements. After entering into contract, Contractor will be held to complete all work necessary to meet these requirements without additional expense to the Owner.
2. Follow Drawings and Specifications where they are superior to Code requirements.

I. Contractor as Technical Expert

1. When the contractor declares himself to be an expert with regard to how a system must be constructed or what will be required to gain code official approval, it shall be assumed that the contractor was an expert at the time of bid and has included all costs associated with proclaimed "required" work in his base bid.

J. The Contractors bid shall be based on the execution of all work required to allow the contractor to self-certify the work of the project. Self-certification shall be performed if requested by the Owner. Submitting a bid for the contract work shall be considered confirmation by the contractor that he is in good standing with the department of buildings with respect to self-certification.

K. Work of contract shall be bid as described in contract document including all details, notes, plans, routing, etc. Contractor's intentional or unintentional exclusion of scope or assumptions about alternate construction methods, configurations, materials or testing shall be at the contractors risk and the engineer reserves the right to require that the work be constructed per plans. Statements such as "I did not bid it that way", or "I don't have that in my price", shall be understood to be an admission of the contractors error but will have no effect in reducing the contract requirements or increasing the cost to the Owner.

L. Permits

1. Obtain all permits required by authorities and agencies having jurisdiction for the work of this Division.
2. Post permits as required.
3. Obtain all approvals, including controlled inspections, prior to request for final payment.

M. Tap and Connection Fees:

1. Pay fees charged by Utilities for making connections, bringing service to property line, or to meter and similar services.
2. Investment fees or plant development fees, which are charges levied by Utilities to cover the cost of the utility system to be borne by this project, are not part of the work of this Division.

N. Inspections and Tests:

1. Arrange for all required inspections and tests.
2. Pay all charges.
3. Notify Architect/Engineer 48 hours before tests.
4. Submit one copy for Owners records of permits, licenses, inspection reports and test reports.

1.8 RECORD DRAWINGS

A. General Recording Procedure:

1. Maintain a blue-line set of Sprinkler, Plumbing and HVAC Contract Drawings in clean, undamaged condition, for mark-up of installations, which vary, from the Contract Drawings.
2. Record changes drawn to scale and fully dimensioned.
    a. Work concealed behind or within other work, in an inaccessible arrangement.
    b. Mains and branches of piping systems:
        1) with valves and control devices located and numbered.
        2) with concealed unions located.
        3) with items requiring maintenance located (traps, strainers, expansion compensators, tanks, etc.).
    c. Underground piping and ducts, both exterior and interior.
    d. Ductwork layouts, including locations of coils, dampers, filters, boxes and similar units.
    e. Concealed control system devices and sensors.

B. Corrected Drawings:

1. Obtain a set of contract drawings on CAD.
2. Update the CAD files to reflect as-built conditions.
3. Transmit corrected CAD files and plots as a submittal to the Architect/Engineer for Owner's use and record.

C. Temperature Control Drawings:

1. Provide as-built Drawings of work under this contract including:
    a. Ladder wiring diagram.
    b. Pneumatic schematic diagrams.
    c. One line system diagram.
    d. Control schematic of equipment with control devices located and identified.
    e. Wiring or tubing termination diagrams.
    f. List of materials.
    g. Floor plan indicating all device locations.
    h. Control sequences.
    i. Indicate electrical power source for each point of connection to the electrical system.
2. Reproducible temperature control drawings and computer files shall be delivered to the Architect/Engineer prior to Owner's acceptance of project.

1.9 OPERATING AND MAINTENANCE DATA

A. Submission:

1. Submit typed and bound copies of Operating and Maintenance Manuals prior to scheduling systems demonstration for the Owner.
2. Bind each Maintenance Manual in one or more vinyl covered, 3-ring binders, with pockets for folded drawings. Mark the back spine of each binder with system identification and volume number.

B. Required Contents:

1. Manuals shall have index with tab dividers for each major equipment section to facilitate locating information on specific piece of equipment.
2. Identify data within each section with drawing code numbers as they appear on Drawings and Specifications. Include as a minimum the following data:
    a. Alphabetical list of system components, with the name, address and 24 hour telephone number of the company responsible for servicing each item during the first year of operation. Include point of contact for company.
    b. Operating instructions for complete system including:
        1) Emergency procedures for fire and failure of major equipment.
        2) Major start, operation and shut-down procedures.
    c. Maintenance Instructions for each piece of equipment including:
        1) Equipment lists.
        2) Proper lubricants and lubricating instructions for each piece of equipment.
        3) Necessary cleaning, replacement and/or adjustment schedule.
        4) Product Data.
        5) Installation instructions.
        6) Parts lists.
        7) Complete wiring diagrams.
    d. Temperature control diagrams and O&M information as specified above (as-built).
    e. Marked or changed prints locating concealed parts and variations from the original system design (as-built drawings).
    f. Balancing Report.
    g. Valve schedule and associated piping schematics. See “Identification” specification sections.
    h. Copies of any extended equipment warranties, which are greater than one year.

1.10 WARRANTIES

A. The warranty period is one year after Date of Acceptance.

1. During this period, provide labor and materials as required to repair or replace defects in the mechanical system at no additional cost to the Owner. Provide certificate with O&M manual submittal which guarantees same-day service response to Owners call for all such warranty service.
2. Provide certificates for such items of equipment which have warranties in excess of one year. Insert copies in O&M manuals. Such equipment shall include, but not be limited to:

a. Temperature Control Valves five (5) years.
b. Chiller compressors five (5) years.
3. Provide extended manufacturers warranties to cover one full year from date of acceptance if standard warranty starts any time prior to that date.
4. Provide factory trained service personnel for all warranty work on the following equipment:
a. Chillers.
b. Building Management System
c. Cooling Towers
d. Packaged Equipment

B. Refer to Division 1 for additional requirements.

1.11 INDEMNIFICATION

A. Pay all royalties and defend all suits or claims for infringement of any patent rights and save the Owner harm from loss on account thereof.

B. If process or article specified is an infringement of patent, promptly notify the Architect in writing, and any necessary changes shall be as provided in the Contract for changes in the work. If the Contractor performs any work specified knowing it to be an infringement of patent, he shall bear all costs arising therefrom.

C. Take out all necessary insurance, free of extra charge, and agree to indemnify and save harmless the party contracting for services against loss or expense, by reason of the liability imposed by law upon such party for damages because of bodily injuries, including death at any time resulting therefrom, accidentally sustained by any person or persons or on account of damage to property arising out of or consequence of the performance of this Contract, whether such injuries to persons or damaged property are due or claimed to be due by any negligence in the performance of the Contract, the party contracting for services, employees or agents, or any other person.

1.12 SCOPE

A. The Contractor shall:

1. Supply all labor, transportation, materials, apparatus, light, and tools necessary for the completion of the mechanical work.
2. Install, maintain, and remove all construction equipment.
3. Be responsible for safe, lawful, and proper construction execution.
4. Construct, in the best and most workmanlike manner, a complete project and everything properly incidental thereto, as shown on the Drawings, as stated in the Specifications, or reasonably implied therefrom, all in accordance with the Contract documents.

B. Work Included

The Work includes the providing of all labor, materials, equipment, accessories, services and tests necessary to complete and make ready for operation by the Owner, all Heating, Ventilating and Air Conditioning Work, as shown on the Drawings and hereinafter specified, including, but not limited to the following.

1. Provide a brine chilled-water refrigeration plant consisting of two packaged electrical screw chillers, outdoor cooling towers, with grillage beams, condenser and brine chilled water treatment, condenser water and chilled water pumps, break glass stations, monitoring systems, ice out heat exchangers, and wiring, all as hereinafter specified. Provide break glass stations at each entrance to machine room.
2. All motor starters and controllers for equipment furnished by this Contractor. Packaged type units shall be furnished completely pre-wired with panels mounted on the units as specified. All other motor starters and controllers will be turned over to the Electrical Contractor for installation and wiring.
3. Filters.
4. Humidifiers.
5. Fans.
6. Steam to hot water heat exchangers to heat the brine water
7. Water cooled package units complete with energy recovery coils
8. Condensate pumps and piping to floor drain or janitor sink.
9. Steam specialties such as traps, strainers, safety valves, flash tanks, etc.
10. Brine chilled water specialties such as expansion tanks, air vents, air separators, reducing and safety valves, etc.
11. Accessories such as V-belt drives, flow measuring devices, draft gauges, machinery guards, thermostats, pressure gauges.
12. Water treatment for brine chilled and condenser water systems.
13. Piping, fittings, and valves.
14. Sheet metal ductwork and accessories, including dampers, access doors, etc.
15. Registers, grilles and diffusers.
16. Fire dampers, smoke dampers and fire/smoke dampers.
17. Installation of smoke detectors in ductwork.
18. Acoustical duct lining, where specified or shown on drawings.
19. Pipe, duct and equipment insulation.
20. Temperature Control: A complete system of temperature control shall be installed in connection with the HVAC systems, including all thermostats, air piping, damper motors, etc. All control wiring for automatic temperature controls, including interlocking wiring for fans, chillers, pumps, etc. by this Contractor, unless otherwise shown on the electrical Drawings.
21. Painting and pipe identification for all work by this Contractor is previously specified under "Special Requirements for Mechanical and Electrical Work".
22. Test and balancing.
23. Sleeves, pipe inserts and anchor bolts, escutcheons, prefabricated roof curbs, etc., as hereinafter specified.
24. Identification, name plates, tags and charts.
25. Cutting and rough patching.

26. Furnishing and setting of electric motors.
27. Furnishing of starters, motor control centers and motor control devices as specified under “Special Requirements for Mechanical and Electrical Work”.
28. Templates and anchor bolts for equipment bases.
29. Cap flashing for pipe and duct passing through roof.
30. Removal, relocation and/or demolition of existing HVAC work in conjunction with the existing buildings in order to erect the new buildings as indicated on the Contract Drawings.
31. Removal, relocation and/or demolition of any existing hanging rods that are in conflict with the installation of HVAC work.
32. Furnishing of access doors.
33. Energy management (building automation) system.
34. Concrete pads for all HVAC work.
35. Tie-in new chiller plant with the existing and provide new chilled water lines to existing buildings as indicated on Drawings
36. Installation of fire and smoke dampers in the existing ductwork and fan systems.

1.13 SPECIAL INSPECTIONS

A. Contactors shall provide all required special inspections for all work performed. Contractor shall retain a third party Architect or Engineer, independent of the primary design team and contractor, to complete all required inspections and execute all required TR-1 documents and any additional documents that may supplement or replace these documents in the future.

B. Contractors’ special inspection engineer shall be in good standing with the Department of Buildings and shall meet all requirements and qualifications established by the Department of Buildings. This shall include education, formal training, in-service training, corporate structure, certifications, professional development, etc. If, at any time, the Architect or Engineer shall fail to meet the qualification requirements of the Department of Buildings the contractor shall replace the Architect or Engineer with another qualified professional.

C. If at any time the Architect or Engineer shall fail to produce required inspections and associated documentation in a timely manner, the contractor shall replace the Architect or Engineer with another qualified professional.

D. All inspections shall be completed in strict accordance with the requirements established by the Department of Buildings. Records of inspections shall be maintained in accordance with good practice, but in no case less than 6 years from time of filing. Documentation shall be in accordance with requirements established by NYSDOB.

E. The work of the project will be phased and completed on an accelerated schedule. This will create a need for multiple inspections and inspection documentation filings. Architect and Engineers performing inspections shall fully understand the phasing of the work and be prepared to complete inspections and provide filing documents in accordance with the established schedule. The inspector shall expect that multiple inspection visits may be required to support a single inspection filing.

F. Special inspector shall have no financial interest in the construction, installation, maintenance of structures or components that they inspect.

G. Special inspector shall cooperate with any audits or inquiries initiated by NYSDOB or other authorities having jurisdiction.

H. Special inspectors shall limit the scope of their inspections to systems and installations that their education, experience, certifications, etc., qualify them to inspect.

I. Special inspectors shall report any discrepancies or deficiencies to the contractor immediately upon detection and shall follow-up with contractor to confirm that conditions have been corrected or repaired.

J. Special inspection agencies shall carry insurance in the coverage limits established by NYSDOB. At a minimum, this shall be a $500,000 professional liability policy, $1,000,000 general liability and other statutory insurance at statutory limits.

K. Special inspection agencies shall have a full time director in responsible charge that does not serve as an inspector or director for any other testing agencies.

L. Controlled/special inspections shall be provided as follows:

1.	Fire Dampers, Fire Smoke Dampers, Smoke Dampers	BC 1704.16
2.	Fire-Resistant Penetrations and Joints	BC 1704.27
3.	Emergency Lighting	BC 1704.31, BC 2702
4.	Emergency Power System (Generators)	BC 1704.31, BC 2702
5.	Fuel Oil Storage and Piping	BC 1704.17
6.	Ventilation System	BC 1704.16
7.	Smoke Control System	BC 1704.15
8.	Sprinkler Systems	BC 1704.23
9.	Standpipe Systems	BC 1704.24
10.	Mechanical Systems	BC 1704.16
11.	High Pressure Steam	BC 1704.18
12.	High Pressure Gas	BC 1704.19
13.	Refrigeration System	BC 1704.16
14.	Mechanical Demolition	BC 1704.20.4, BC 3306.6
15.	Heating Systems	BC 1704.25
16.	Chimneys	BC 1704.26
17.	Post-installed Anchors (BB# 2014-018, 2014-019)	BC 1704.32
18.	Seismic Isolation	BC 1707.8

1.14 MANDATORY GOVERNING PROVISION

A. Omissions of words or phrases, such as “the Contractor shall,” “in conformity with,” “shall be,” “as noted on the Drawings”, “according to the Drawings”, “an”, “the”, and “all”, may or may not be intentional.

B. Omitted words or phrases shall be supplied by inference.

1.15 PROTECTION OF PROPERTY AND MATERIALS

A. Provide protection against dust migration, rain, wind, storms, frost, or heat, so as to maintain all work, materials, apparatus, and fixtures free from injury or damage.

B. At end of each day’s work, cover all new work likely to be damaged.

C. Do not interrupt the integrity of the building security during periods when the project is staffed or during periods where the project isn’t staffed.

1.16 OWNER FURNISHED EQUIPMENT

A. All equipment called out in the Specifications or shown on the Drawings as “Owner-Furnished Equipment” shall be installed and connected under this Contract. Provide rough-ins, and final connections for all equipment.

B. Furnish and install all shutoff valves and traps and piping for each item of equipment.

C. All such work that is not concealed in the construction or in base cabinets or compartments, shall be polished nickel and chromium plated red brass pipe, with cast brass fittings, cast brass escutcheons, valves, and traps all finished with polished chromium plating over nickel plating.

D. All work in connection with such equipment shall be done under the supervision of the manufacturer and the Contractor shall be responsible for any damage to any of the equipment that may result from his work in connection therewith.

1.17 TEMPORARY FACILITIES

A. Light, Heat, Power, etc.

1. Temporary power and lighting shall be provided by the electrical contractor.
2. Temporary heat shall be provided by the HVAC Contractor.
3. The contractor shall be responsible for maintaining acceptable indoor air quality in adjacent occupied spaces.

B. Use of Permanent Building Equipment for Temporary Heating or Cooling:

1. Permanent building equipment shall not be used without written permission from the Owner. If this equipment is used for temporary heating or cooling, it shall be adequately maintained per manufacturer's instructions and protected with filters, strainers, controls, reliefs, etc. The contractor shall protect all equipment and systems as directed by the engineer. The warranty period shall not start until the equipment is turned over to the Owner for his use. The contractor shall provide extended warranties for parts and labor for all such equipment. Equipment shall not be turned over to the Owner until the temperature controls have been tested and accepted by the Owner and Engineer. Equipment shall be prepared and turned over to owner in as-new condition.

1.18 ROUGH-IN FOR FUTURE CONNECTION

A. Provide rough-in services for all systems which shall extend to future equipment or spaces as shown on the drawings.

1. Provide sufficiently sized branch plumbing lines with isolation valves to serve future equipment.
2. Provide sufficiently sized BMS/ATC master control panel(s) to accommodate a 20% increase in the number of equipment unit controllers and/or connected control points.

1.19 INSTALLATION GENERAL REQUIREMENTS

A. Furnish, apply, install, connect, erect, clean, and condition manufactured materials and equipment as recommended in manufacturer's printed directions (maintained on job site during installation).

B. Provide all attachment devices and materials necessary to secure materials together or to other materials. Erect, install, and secure components in a structurally sound and appropriate manner.

C. Make allowance for ample and normal expansion and contraction for all building components and piping systems that are subject to such.

D. Install materials only when conditions of temperature, moisture, humidity, and conditions of adjacent building components are conducive to achieving the best installation results.

E. Where necessary, temporarily brace, shore, or otherwise support members until final connections are installed. Leave all temporary bracing, shoring, or other structural supports in place as long as practical for safety and to maintain proper alignment.

F. Store and handle materials in a manner to prevent scratching, abrading, distortion, chipping, breaking, rusting, or other disfigurement. Materials damaged for these reasons shall be replaced at no additional cost to Owner.

G. Conduct work in a manner to avoid injury or damage to previously placed work. Any work so impaired or damaged shall be replaced at no expense to Owner.

H. Fabricate and install materials true to line, plumb, and level.

I. Leave finished surfaces smooth and flat, free from wrinkles, warps, scratches, dents, and other imperfections.

J. Furnish materials in longest practical lengths and largest practical sizes to avoid all unnecessary jointing.

K. Make all joints secure, tightly fitted, and as inconspicuous as possible by the best accepted practice in joinery and fabrication.

L. Consult Engineer for mounting height or position of any unit not specifically indicated or located on Drawings or specified in Specifications.

M. Job mixed multi-component materials used in the work shall be mixed in such regulated and properly sized batches that material can be used before it begins to “set”. Mixing of a partially “set” batch with another batch of fresh materials will not be accepted and entire batch shall be discarded and removed from site. Clean all mixing tools and appliances that can be contaminated prior to mixing of fresh materials.

N. In addition to the above refer to each Section of the Specifications for additional installation requirements for the proper completion of all work.

O. Piping or ductwork connected to equipment may require different size connection than indicated on the Drawings. The Contractor shall provide transition pieces as required at the equipment, at no additional cost.

1.20 SCAFFOLDING, RIGGING AND HOISTING

A. Provide all scaffolding, rigging, hoisting and services necessary for erection and delivery into the premises of all equipment and materials furnished under this Section of the Specifications, and remove same from premises when no longer required.

B. In the event that supplementary bracing of the basic building structure is required to assure a secure rigging procedure and a secure route for the equipment being handled, assume full responsibility for such supplementary bracing.

1.21 TOOLS

A. All specified tools for proper operation and maintenance of the equipment shall be delivered to the Owner’s representative and a receipt requested for the same at no additional cost to the Owner.

1.22 QUIET OPERATION

A. All equipment and material shall operate under all conditions of load without any sound or vibration which, in the opinion of the Architect, is objectionable. Where sound or vibration conditions arise which are considered objectionable by the Architect, eliminate same in a manner approved by the Architect.

1.23 RUBBISH REMOVAL

A. See to it that the Project is, at all times, maintained free of all rubbish, rubble, waste material, packaging materials, etc. accumulating as a result of this work. Assume responsibility for the cleaning up of packaging removed from materials and equipment furnished by other trades for the installation. Note that final acceptance of the work is contingent upon the project being free of all excess and waste materials resulting from the work.

1.24 DELIVERY OF MATERIAL

A. Deliver the material and store same in spaces indicated by the Architect and assume full responsibility for damage to structure caused by any overloading of the material or storage in spaces exposed to moisture, humidity, or other environmental conditions.

B. Hoods which will be duct-connected in the field shall be received and set in place by HVAC Contractor.

1.25 ALTERATIONS

A. All equipment, piping, ductwork, etc. to be removed shall be disposed of, turned over to the owner or salvaged as directed by the Owner. They shall not be removed from the premises without the Owner's approval.

B. When new work and alterations render equipment, piping and ductwork useless, such equipment, piping and ductwork shall be removed and connections thereof to lines or ducts remaining shall be properly capped or plugged and left in construction. If construction, such as hung ceiling, furred beams, chase, etc., is opened up and removed during the course of the construction, the useless pipe and ducts therein shall be completely removed

C. No dead ends shall be left on any piping or ductwork upon completion of job.

D. When existing piping and duct systems, at points of connection to new work or in rerouting are found defective, such defective portions shall be removed and replaced with new materials without cost to the Owner.

E. The existing system shall be left in perfect working order upon completion of all new work.

F. Locations and sizes of existing piping are approximate. Exact sizes and locations of all existing piping shall be verified at the site.

G. No removed existing piping, fittings, valves, ductwork, dampers, etc. shall be reused.

H. All existing to remain piping that is rendered inoperable or orphaned by demolition shall be reconnected to nearest active systems during the completion of work in a given space. See additional requirements for shut-down coordination.

I. In instances where the removal of existing wall finishes reveals piping or systems that are not indicated for demolition, but are located in an area that conflicts with the proposed floor plan, the existing piping or system shall be relocated to a position that does not conflict with future finishes.

J. Provide temporary supports where required.

K. Where alterations reveal piping, ductwork, conduit circuits, wiring, and accessories that must necessarily remain in service, same shall be rerouted, replaced or altered as required to make same completely concealed in the new work at no additional cost to the Owner.

L. Where existing piping or ductwork insulation is damaged by the requirements of the work, replace all damaged insulation to match existing.

M. This Contractor shall not interrupt any of the services of the existing facility, nor interfere with the services in any way without the express permission of the Owner. Such interruptions and interferences shall be made as brief as possible and only at the time stated by the Owner.

N. Under no circumstances shall this Contractor or his workmen be permitted to use any part of the facility as a shop, except parts designated by the owner for such purposes.

O. Provide branch shut-off valves as required to install new work without continuous shut-down of entire building chilled water, condenser water, hot water, and steam systems

1.26 PAINTING

A. Paint all unpainted, non-insulated, non-galvanized, ferrous metal surfaces of pipes, conduits, ducts, equipment, fixtures, hangers, supports and accessories as follows:

1. Exposed and Concealed - one prime coat of primer and one coat of oil varnish based paint, color selected by Architect.
2. Underground - two coats of black asphaltum paint.
3. The inside of all ductwork where visible through openings shall be painted with two prime coats of dull black paint.

B. Nameplates on all equipment shall be cleaned and left free of paint. One finish coat of enamel color to be identified by architects.

PART 2 – PRODUCTS

2.1 QUALITY CONTROL

A. Manufacturers of equipment or materials will fall into one of the following categories:

1. "Basis of Design" - The manufacturer of equipment or materials listed on the Drawings or first named in the Specifications. If the Drawings and Specifications are in conflict, the drawings shall take precedence.

2. "Approved Equal" - Manufacturers whose products are listed in the Specifications under "Approved Equal"

3. "Substitution" - Manufacturers whose products are not listed in the Specifications.

B. Requirements applicable to all submittals:

1. Refer to Section 230502 / 2.2 - General Submittal Requirements

2. Provide Specification Compliance with all Submittals:

a. Contractor/Manufacturer shall submit the all relevant specification sections within the submittal indicating that they comply with each line item of each of the relevant specification section(s). For any item that doesn't comply, the contractor/manufacture shall clearly indicate why not and how their product meets or exceeds the requirement of that line item.

C. Requirements applicable to submission of "Approved Equals":

1. The submittal shall include a cover sheet indicating the following, signed by the contractor:

a. The proposed product will not affect dimensions shown on Drawings.
b. The contractor will pay for changes to the building design, including engineering design, detailing, and construction costs caused by the submission.

c. The proposed product will have no adverse effect on other trades, the construction schedule, operation and maintenance, and specified warranty requirements.
d. Maintenance and service parts will be locally available for the proposed product.

2. The contractor shall be responsible for coordinating the required dimensions, clearances, access points and other service locations such that the submitted product properly fits in the available space allocated for the Basis of Design.

3. Provide all features which are standard on the Basis of Design, whether or not specifically specified or scheduled.

D. Requirements applicable to submission of "Substitutions":

1. Products by manufacturers not listed in the specifications may not be used as the basis of the bid price.

2. Substitution Request Form: Use Architect's Substitution Request Form, if one is not provided by the architect, utilize CSI Standard Form 13.1A.

3. Documentation: Show compliance with requirements for substitutions and the following, as applicable:

a. Statement indicating why specified material or product cannot be provided.
b. Coordination information, including a list of changes or modifications needed to other parts of the Work and to construction performed by Owner and separate contractors that will be necessary to accommodate proposed substitution.
c. Detailed comparison of significant qualities of proposed substitution with those of the Work specified. Significant qualities may include attributes such as performance, weight, dimension, durability, visual effect, and specific features and requirements indicated.
d. Product Data, including drawings and descriptions of products and fabrication and installation procedures.
e. Operation, maintenance, and efficiency difference.
f. Samples, where applicable or requested.
g. List of similar installations for completed projects with project names and addresses and names and addresses of architects and owners.
h. Material test reports from a qualified testing agency indicating and interpreting test results for compliance with requirements indicated.
i. Research/evaluation reports evidencing compliance with building code in effect.
j. Detailed comparison of Contractor's Construction Schedule using proposed substitution with products specified for the Work, including effect on the overall Contract Time. If specified product or method of construction cannot be provided within the Contract Time, include letter

from manufacturer, on manufacturer's letterhead, stating lack of availability or delays in delivery.

k. Cost information, including a proposal of change, if any, in the Contract Sum.

l. Contractor's certification that proposed substitution complies with requirements in the Contract Documents and is appropriate for applications indicated.

m. Contractor's waiver of rights to additional payment or time that may subsequently become necessary because of failure of proposed substitution to produce indicated results.

4. A/E will review Substitution Request and indicate one of the following actions:

a. Substitution Request Approved as Noted - Make submittals in accordance with "Approved Equal" Requirements.

b. Substitution Request Rejected - Use specified materials.

5. Under no circumstances should the substitution result in added cost to the project.

E. Shop drawings shall not be submitted prior to approval of all equipment submittals.

F. The materials, workmanship, design, and arrangement of all work installed under the Contract shall be subject to the approval of the Architect or Engineer.

G. If material or equipment is installed before it is approved, each trade installing same shall be liable for the removal and replacement at no extra charge to the Owner if, in the opinion of the Architect or Engineer, the material or equipment does not meet the intent of the Drawings and Specifications.

H. It is the intent of these Specifications that wherever a "Basis of Design" manufacturer of a product is specified, the submitted item must conform in all respects to the "Basis of Design" specified item. Consideration will not be given to claim that the substituted item meets the performance requirements with lesser construction (such as lesser heat exchange surface, reduced horsepower, etc.). Performance as delineated in schedules and in the Specifications shall be interpreted as minimum performance.

I. Being listed in the specifications as a "Basis of Design" or "Approved Equal" manufacturer does not permit the manufacturer to provide standard manufactured equipment which does not comply with the performance and/or physical characteristic requirements of the Contract Documents.

J. All equipment and materials required for installation under these Specifications shall be new and without blemish or defect. All electrical equipment shall bear labels attesting to Underwriter's Laboratories approval. Where no specific indication as to the type or quality of the material or equipment is indicated, a first class standard article shall be furnished.

K. Where it is proposed to use an item of equipment other than specified “Basis of Design” which requires any redesign of the structure, partitions, foundations, piping, wiring, or of any other part of the mechanical, electrical, or architectural layout, all such redesign, and all new drawings and detailing required therefore shall, with the approval of the Architect or Engineer, be prepared at no additional cost to the Owner. On multiple prime contracts the substituting contractor shall negotiate with other prime contractors to have alternate work performed without cost to the owner.

L. All equipment of one type (such as fan coil units, etc.) shall be the product of the same manufacturer.

M. Note that the approval of shop drawings or other information submitted in accordance with the requirements hereinbefore specified does not assure that the Engineer, Architect, or any other Owner's representative attests to the dimensional accuracy or dimensional suitability of the material or equipment involved or the mechanical performance of equipment. Approval of shop drawings does not invalidate the Plans and Specifications if the shop drawings are in conflict with the Plans and Specifications.

N. With regard to proprietary or partially proprietary systems, including but not limited to building automation, automatic temperature controls, fire alarm, signaling, monitoring, data center alarm systems, etc., the specification of system components by a single manufacturer shall not be questioned. No discussion about inter-operability or open protocols will be considered. Contractor shall assume that engineer has previously considered substitutions of non-proprietary systems or open protocols and rejected this option.

2.2 GENERAL SUBMITTAL REQUIREMENTS

A. Coordination and Sequencing:

1. Coordinate submittals 2 weeks (min.) prior to expected order date so that work will not be delayed by submittals.
2. No extension of time will be allowed because of failure to properly coordinate and sequence submittals.
3. Do not submit product data, or allow its use on the project until compliance with requirement of Contract Documents has been confirmed by Contractor.
4. Submittal is for information and record, unless otherwise indicated, and is not a change order request. Approval of alternate equipment or notations on shop drawings shall not be considered to be approval of additional cost.
5. Submitting contractor is responsible for routing reviewed submittals to all parties affected including but not limited to electrical, temperature control, and test and balance subcontractors.
6. All submittals requiring expedited review shall be made at the start of the project. Submittals requiring expedited review due to delay of submission will be reviewed on engineering premium time which will be back-charged to the contractor.

B. Preparation of Submittals:

1. Refer to Division 1 requirements.
2. Provide permanent marking on each submittal to identify project, date, Contractor, Subcontractor, Supplier, submittal name and similar information to distinguish it from other submittals.
3. Indicate any portions of work which deviate from the Contract Documents.
    a. Explain the reasons for the deviations.
    b. Show how such deviations coordinate with interfacing portions of other work.
4. Show Contractor's executed review and approval marking.
5. Provide space for Architect's/Engineer's "Action" marking.
6. Submittals which are received from sources other than through Contractor's office will be returned "Without Action".
7. Submittals shall be presented in a neat and legible fashion and shall be returned "Without Action" if presented in any other fashion.
8. Electronic submittals shall be subject to a minimum $50 document processing charge per submittal up to 50 letter size pages or 15 sq. ft. of wide format printing. Larger quantities will be subject to increased charges. Charges shall be deducted from payments to the Contractor by the owner.
9. Contractor is responsible for submission of shop drawings in accordance with plans and specifications for compliance with the system description and manufacturer. Shop drawings submitted, which are not in substantial compliance requires additional and unnecessary review time by the Engineer and Architect. Shop drawings submitted more than once, which are not in substantial compliance, shall be reviewed at a rate of $225 per hour and charged to the contractor. Charges shall be deducted from payment to the contractor by the owner.

C. Quantities: Unless otherwise indicated in Division 1, submit six copies.

1. Refer to Division 1 requirements.
2. Multiple System Items: Where a required submittal relates to an operation or item of equipment used in more than one system, increase the number of final copies as necessary to complete the Maintenance Manuals for each system.
3. Preliminary Submittal: Provide a preliminary, two-copy submittal for automatic temperature controls and when product data is required (or desired by Contractor) for selection of options by Architect/Engineer.
4. General Distribution:
    a. Provide additional distribution of submittals (not included in foregoing copy submittal requirements) to Subcontractors, Suppliers, Fabricators, Installers, Governing Authorities and others as necessary for proper performance of the work.
    b. Include such additional copies in transmittal to Architect/Engineer where required to receive "Action" marking before final distribution.
        1) Show such distributions on transmittal forms.

D. Response to Submittals: Where standard product data have been submitted, it is recognized:

1. That the Submitter has determined that the products fulfill the specified requirements.
2. That the submittal is for the Architect’s or Engineer’s information only, but will be returned with appropriate action where observed to be not in compliance with the requirements.

E. If more than two submissions (either for shop drawings, as-built drawings, or test and balance reports) are made by the contractor, the Owner reserves the right to charge the contractor for subsequent reviews by their consultants. Such extra fees shall be deducted from payments by the Owner to the contractor.

2.3 SPECIFIC CATEGORY SUBMITTAL REQUIREMENTS

A. Manufacturer’s Data:

1. Where pre-printed data covers more than one distinct product, size, type, material, trim, accessory group or other variation, mark submitted copy with black pen to indicate which of the variations is to be provided.
2. Delete or mark-out significant portions of pre-printed data which are not applicable.
3. Where operating ranges are shown, mark data to show portion of range required for project application.
4. For each product, include the following:
   a. Sizes
   b. Weights
   c. Speeds
   d. Capacities
   e. Piping and electrical connection sizes and locations.
   f. Statements of compliance with the required standards and regulations.
   g. Performance data.
   h. Manufacturer’s specifications and installation instructions.
   i. Certified performance curves for all pumping and fan equipment shall be submitted for approval.
   j. Samples of materials or equipment, when requested by the Architect, shall be submitted for approval.
   k. Samples, drawings, specifications, catalogs, etc., submitted for approval, shall be properly labeled indicating project name, specific service for which material or equipment is to be used, Section and Article number of Specifications.
   l. Catalogs, pamphlets, or other documents submitted to describe items on which approval is being requested, shall be specific and identification in catalog, pamphlet, etc., of item submitted shall be clearly made in ink. Data of a general nature will not be accepted.
   m. Approval rendered on shop drawings shall not be considered as a guarantee of measurements or building conditions. Where drawings are

approved, said approval does not in any was relieve responsibility, or necessity, of furnishing material or performing work as required by the Contract Drawings and Specifications.

n. Prior to submission of shop drawings, thoroughly check each shop drawing, reject those not conforming to the Specifications, and indicate (by signature) that the shop drawings submitted meet Contract Requirements.

o. All shop drawings showing routing of ductwork, piping and conduit, shall be not less than 3/8" = 1'0" scale.

B. Shop Drawings:

1. Prepare Mechanical Shop Drawings, except diagrams, to accurate scale.
   a. Show clearance dimensions at critical locations.
   b. Show dimensions of spaces required for operation and maintenance.
   c. Show interfaces with other work, including structural support.

C. Test Reports:

1. Submit test reports which have been signed and dated by the firm performing the test.
2. Prepare test reports in the manner specified in the standard or regulation governing the test procedure (if any) as indicated.

D. Required equipment and shop drawing submittals:

1. Provide a submittal schedule with bid.
2. Provide equipment submittals for each item of equipment specified or scheduled in the contract documents.
3. Submittal Schedule shall show each item of equipment, applicable Section of the specifications where it is described, applicable Drawing number and schedule name where it is scheduled, date of Contractor’s proposed submittal to Architect, required date to receive submittal from Architect and schedule order date.
4. Provide a Mechanical Shop Drawing Schedule for submission to the Architect with the Submittal Schedule.
5. Before request for acceptance and final payment for the work, write a letter to the Architect stating that all shop drawings are brought to a condition "Reviewed" or "Exception as Noted ". Any outstanding shop drawings must be cleared with the Engineer.

E. Submit shop drawings covering the following items:

1. Coordination drawings.
2. Brine and condenser water pumps, including pump curves.
3. Internal cleaning and treating of piping.
4. Sleeve and ductwork penetration drawings.
5. Identification schedule and samples.
6. Water Cooled Package equipment.

7. Air filters and draft gauges.
8. Coils.
9. Heat exchangers.
10. Expansion joints, anchors and guides, including details of installation.
11. Air diffusers, registers and grilles.
12. Schedule of ductwork, joints, gauges, supports, flexible connections, fire dampers, access doors, etc.
13. Centrifugal fans, and power roof ventilators and propeller fans.
14. Sheet metal fabrication drawings.
15. Schedule of steam traps.
16. Machinery guards and V-belt drives.
17. Roof vent fittings.
18. Steam safety relief valves.
19. Schedule of piping and fitting materials.
20. Piping shop drawings.
21. Schedule of valves, strainers, vacuum breakers.
22. Schedule of steam pressure reducing valves.
23. Flow metering device and systems.
24. Thermometers and pressure gauges.
25. Automatic stop-check valves.
26. Expansion tanks.
27. Schedule of pipe and ductwork supports, including inserts, escutcheons, etc.
28. Brine Ice Chiller(s).
29. Water pumps including pump curves.
30. All motor starters, motor control devices and motor control centers.
31. Cooling towers including sound criteria.
32. Water treatment equipment and systems.
33. Schedule of insulation types and samples of each type.
34. Vibration isolation schedule including inertia block details.
35. Templates for equipment bases.
36. Acoustic material (internal duct lining).
37. Building management system.
38. Air vents, air separators, water strainers, reducing safety valves for water systems.
39. Concrete pad location and size.
40. All air and water cooled condensers.
41. All water source heat pumps.

F. All shop drawings being submitted that include electrical work shall be submitted with all internal and external wiring diagrams.

G. The previously listed items are major equipment and do not limit this Division's responsibility to submit shop drawings for all equipment and accessories which are to be provided under this Division of the Specifications.

2.4 COMPATIBILITY

A. General: Provide products which are compatible with other products of the mechanical work, and with other work requiring interface with the mechanical work.

B. Altitude Ratings: Except where noted otherwise, all ratings and capacities stated in the Contract Documents are at the altitude of the project.

C. Power Characteristics:

1. For power characteristics of equipment supplied under Division 21, 22 and 23 Sections, refer to the Sections of Divisions 26, 27 and 28 and the Electrical Drawings for the power characteristics of each power driven item of mechanical equipment.
2. Coordinate available power with Electrical Contractor before ordering equipment. Mechanical Contractor shall be responsible for ordering equipment to meet the available power characteristics.
3. See also Division 23 05 01 of these specifications.
4. If there is a conflict between Divisions 21, 22 and 23 documents and Divisions 26, 27 and 28 documents, alert the engineer. Do not order equipment prior to determining the proper electrical service. No contract cost adjustment will be allowed for equipment ordered in conflict with the available power characteristics.

2.5 SAFETY PROVISIONS

A. Equipment Nameplates: Provide power-operated mechanical equipment with a permanent nameplate attached by the manufacturer, indicating:

1. The manufacturer
2. Product name
3. Model number
4. Serial number
5. Speed
6. Capacity
7. Power characteristics
8. Labels of testing, listing, or inspecting agencies
9. Other similar data

B. Where manufacturer affixed nameplate is not available, Mechanical Contractor shall fabricate and attach nameplate.

C. Guards:

1. Unless equivalent guards are provided integral with the equipment, enclose each belt drive (including sheaves) on both side in a galvanized, one inch, mesh screen of No. 18 gauge steel wire or expanded metal, fastened to an approved, structural steel frame, securely fastened to the equipment or floor.

2. Provide tachometer holes at shaft centers. Unless equivalent guards are provided integral with the equipment, install a solid guard of No. 20 gauge galvanized steel over the coupling of each item of direct-driven equipment.

D. Refrigerant

1. Any refrigeration system containing any refrigerants listed in the Clean Air Act as a Class I or Class II Ozone Depleting Compound shall comply with the Clean Air Act.
2. As a minimum all systems shall be equipped with refrigerant recovery service valves, relief valves capable of resetting after activation, and for system with more than 50 pounds of charge, and isolateable receiver and/or condenser capable of holding the complete charge.
3. Any refrigerant removed from systems shall be recovered in accordance with Clean Air Act.

PART 3 – EXECUTION

3.1 COORDINATION OF MECHANICAL INSTALLATION

A. Inspection and Preparation:

1. Examine the work interfacing with mechanical work, and the conditions under which the work will be performed, and notify the Architect/Engineer of conditions detrimental to the proper completion of the work at original contract price.
2. Do not proceed with the work until unsatisfactory conditions have been corrected.

B. Layout:

1. Layout the mechanical work in conformity with the Contract Drawings, Coordination Drawings and other Shop Drawings, product data and similar requirements so that the entire mechanical plant will perform as an integrated system, properly interfaced with other work, recognizing that portions of the work are shown only in diagrammatic form.
2. Where coordination requirements conflict with individual system requirements, comply with the Architect’s or Engineer’s decision on resolution of the conflict.
3. Take necessary field measurements to determine space and connection requirements.
4. Provide sizes and shapes of equipment so the final installation conforms to the intent of the Contract Documents.

C. Integrate mechanical work in ceiling spaces with suspension system, light fixtures and other work so that required performances of each will be achieved. Modification of duct work sizes from contract documents to sheet metal shop drawings for coordination purposes shall be included in the contractor's scope of work, confirm new ductwork dimensions with the engineer.

3.2 PRODUCT INSTALLATION

A. Manufacturer's Instructions:

1. Except where more stringent requirements are indicated, comply with the product manufacturer's instructions and recommendations.
2. Consult with manufacturer's technical representatives, who are recognized as technical experts, for specific instructions on special project conditions.
3. If a conflict exists, notify the Architect/Engineer in writing and obtain his instruction before proceeding with the work in question.

B. Movement of Equipment:

1. Wherever possible, arrange for the movement and positioning of equipment so that enclosing partitions, walls and roofs will not be delayed or need to be removed.
2. Otherwise, advise other Contractors of opening requirements to be maintained for the subsequent entry of equipment.

C. Heavy Equipment:

1. Coordinate the movement of heavy items with shoring and bracing so that the building structure will not be overloaded during the movement and installation.
2. Where mechanical products to be installed on an existing roof are too heavy to be hand-carried, do not transport across the existing roof deck; position by crane or other device so as to avoid overloading the roof deck.

D. Coordinate location of all floor mounted work (piping, ductwork, supports, etc.) in all areas (including mechanical rooms) to avoid obstruction of egress path.

E. Clearances:

1. Install piping and ductwork:
   a. Straight and true.
   b. Aligned with other work.
   c. Close to walls and overhead structure (allowing for insulation).
   d. Concealed, where possible, in finished spaces.
   e. Out-of-the-way with maximum passageway and headroom remaining in each space.
2. Except as otherwise indicated, arrange mechanical services and overhead equipment with a minimum of:
   a. 8'-0" headroom in storage spaces.
   b. 8'6" headroom in other spaces; where approved by Architect.
3. Do not obstruct windows, doors or other openings.

4. Give the right-of-way to piping systems required to slope for drainage (over other service lines and ductwork).

F. Access:

1. Provide for removal, without damage to other parts, of:
   a. Coils
   b. Tubes
   c. Shafts
   d. Fan wheels
   e. Drives
   f. Filters
   g. Strainers
   h. Bearings
   i. Control components
   j. Other parts requiring periodic replacement or maintenance
2. Connect equipment for ease of disconnecting with minimum of interference with other work.
3. Provide unions where required.
4. Locate operating and control equipment and devices for each access.
5. Provide access panels where units are concealed by non-accessible finishes and similar work.
6. Extend all grease fittings to an accessible location.

3.3 PROTECTION OF WORK

A. All pipe ends, valves, ducts, and equipment left unconnected shall be capped, plugged or otherwise properly protected to prevent damage or the intrusion of foreign matter.

B. Do not allow any fans in the HVAC system to operate before the area served by the fan has been cleaned and vacuumed of all debris and dust which might enter the system.

C. Any equipment, duct or piping systems found to have been damaged or contaminated above “MILL” or “SHOP” conditions shall be replaced or cleaned to the Engineer’s satisfaction.

D. Provide initial water seal fill for all waste P-traps, condensate traps, or similar traps.

3.4 PROTECTION OF POTABLE WATER SYSTEMS

A. All temporary water connections shall be made with an approved back flow preventer.

B. All hose bibs shall have as a minimum, a vacuum breaker, to prevent back flow.

C. Direct connections to hydronic systems shall only be made through a reduced pressure zone back flow preventer. Backflow drain shall be piped to drain to nearest floor drain or mopsink.

3.5 PROTECTION OF SYSTEMS SERVING OCCUPIED SPACES

A. Where work is being performed in occupied spaces, or occupancy is to be phased in with ongoing construction, contractor shall prevent contamination of all systems serving the occupants including but not limited to:

1. Supply Or Return Air
   a. Systems shall be capped or provided with adequate particulate and gas phase filtration to prevent dust, chemical, or biological contamination. Particulate filters shall be, as a minimum, equivalent to those specified for the completed system.
2. Domestic Water
   a. Isolate sterilized portions from non-sterilized portions.
3. Medical Gases
   a. Isolate certified portions from non-certified portions.

3.6 REFRIGERATION SYSTEMS

A. All techniques involved in the installation of refrigeration systems shall be by certified staff trained in accordance with the state and local requirements, and the applicable sections of the Clean Air Act.

B. No refrigerant shall be intentionally vented to the atmosphere. All refrigerant shall be recovered before opening a closed system for charging, evacuation or service. Equipment being demolished that contains R-170, R-290, R-600, R-600W, R-1150, R-1270 type refrigerants shall be subject to the approval of the commissioner of the Fire Department.

C. All refrigerant installed shall be new unless approved by the Engineer.

D. The Contractor shall be responsible and accountable for compliance with the EPA Clean Air Act (CAA) Section 608, 40 CFR Part 82 and any state or local codes for all refrigerant related work. In general, an EPA-certified technician shall perform any activity involving refrigerant-containing equipment that includes: (1) attaching and detaching hoses and gauges to and from refrigerant containing equipment to measure pressure; (2) adding refrigerant to, or removing refrigerant from equipment; or (3) any other activity that violates the integrity of a refrigerant containing circuit (for example any activity where a refrigerant containing circuit is ‘opened’ in any manner).

E. Refrigerant and oil shall be recovered from any equipment that does not meet the definition of a small appliance in 40CFR Part 82 Subpart F before removal and subsequent disposal. Small appliances (as defined in 40CFR Part 82 Subpart F) may be removed from the site with the charge (refrigerant) intact, provided it is properly labeled and handled in such a manner so as to prevent damage to coils. Small Appliances are defined in 40CFR Part 82 Subpart F as: Any appliance that is fully manufactured, charged, and hermetically sealed in a factory with five (5) pounds or less of a Class I or Class II substance used as a refrigerant, including, but not limited to, refrigerators and freezers (designed for home, commercial, or consumer use), medical or industrial research refrigeration equipment, room air conditioners (including window air conditioners and packaged terminal air heat pumps), dehumidifiers, under-the-counter ice makers, vending machines, and drinking water coolers.

F. All new equipment installed shall utilize non-CFC refrigerants.

G. Prior to starting construction, demolition, or service work Contractor shall provide to Owner a list of all service technicians with EPA certification numbers and level of certification. (Copies of EPA certification cards are acceptable for those who will be working on the site.)

H. Contractor shall provide to the Owners Representative all Service Invoices (or equivalent service documentation acceptable to owner) for all work performed by EPA-certified Technicians. Service Invoices (or equivalent documentation) shall include the following information at a minimum for each piece of refrigerant containing equipment serviced:

- Date of Service
- Name of EPA-Certified Technician
- Technicians Certification Level
- Type of Equipment Serviced
- Equipment Manufacture
- Equipment Model and Serial Number
- Description of Service Performed
- Date Leak Discovered (if applicable)
- Date Leak Repaired (if applicable)
- Date Follow-Up Leak Test Performed (if applicable)
- Type of Refrigerant
- Normal System Full Charge (in pounds)
- Amount of Initial Refrigerant Charge Recovered During Service
- Amount of Recovered Refrigerant Returned to System
- Type of Additional Refrigerant Added to System
- Amount of Additional Refrigerant Charged to System
- System Charge at End of Service

I. Contractor shall provide Owners Representative a copy of complete manifests, invoices, or other documentation showing any refrigerant removed from the project by the contractor was disposed of appropriately or reclaimed by an EPA-certified Reclaimer.

3.7 LEAK TESTING

A. All new equipment not meeting the definition of a small appliance, including packaged equipment, factory charged, field charged, split systems or field-constructed systems with field-installed refrigerant piping shall be leak tested prior to or during startup. Leak testing shall utilize appropriate electronic leak-testing equipment.

B. Leak testing shall be conducted by an EPA-certified technician. The contractor shall provide written verification of the leak testing and results.

C. If a leak is detected, the following procedure shall be followed:

1. Notify the Owner's Site Representative (who will notify the Refrigerant Compliance Coordinator).
2. Document the leak.
3. Repair the leak.
4. Document the procedures followed.
5. Leak test to verify the leak was repaired.
6. Schedule and provide a 30-day follow-up verification leak test witnessed by a designated HVAC technician.
7. Document follow-up leak testing.
8. Repeat the above process if follow-up leak is detected.

3.8 DEMOLITION PROCEDURE FOR EQUIPMENT REMOVED BY CONTRACTOR

A. The Contractor, in contractor-provided refrigerant recovery cylinders, shall take ownership of the recovered refrigerant and transport off site to a proper disposal company or certified reclaimer.

B. Service Invoices, as described in RECORD DOCUMENTS, shall be provided.

C. The Contractor technician shall tag the unit that the refrigerant was removed.

D. Once an EPA-certified technician has removed the refrigerant and tagged the unit, a noncertified person may perform the remainder of the demolition.

3.9 ASBESTOS

A. The identification and/or abatement of asbestos hazards is not part of this trade contract. If asbestos is encountered, contact Owner for instructions.

3.10 START-UP

A. Tests shall be performed to the satisfaction of the Architect. The Architect will be present at such test, when he deems necessary and such other parties as may have legal jurisdiction.

B. Pressure tests shall be applied to piping only before connection of equipment and installation of insulation. In no case shall piping, equipment, or accessories be subjected to pressure exceeding their rating.

C. All defective work shall be promptly repaired or replaced and the tests shall be repeated until the particular system and component parts thereof receive the approval of the Architect.

D. Any damages resulting from tests shall be repaired or replaced and the tests shall be repeated until the particular system and component parts thereof receive the approval of the Architect.

E. The duration of tests shall be as determined by all authorities having jurisdiction, but in no case less than the time prescribed in each Section of the Specification.

F. Equipment and systems which normally operate during certain seasons of the year shall be tested during the appropriate season. Tests shall be performed on individual equipment, systems, and their controls. Whenever the equipment or system under test is interrelated with and depends upon the operation of other equipment, systems and controls for proper operation, functioning, and performance, the latter shall be operated simultaneously with the equipment or system being tested.

G. The electrical work shall include providing any assistance (such as removal of switchboard and panelboard trims and covers, pull and junction box covers, etc.) deemed necessary by the Architect to check compliance with the Drawings and Specifications.

H. The Contractor shall assign a Plumbing, Fire Protection and HVAC Start-Up Coordinator to this project.

I. The Start-Up Coordinator shall develop detailed start-up procedures, equipment checkout procedures and data forms for recording compliance with contract document performance criteria, and will assist in developing schedules for checkout and Owner acceptance.

J. The Plumbing, Fire Protection and HVAC Contractors shall include as part of the work of this contract, manpower, equipment, tools, ladders, instruments, etc. necessary to confirm start-up of Plumbing, Fire Protection and HVAC systems.

K. The Test, Adjust and Balancing Contractor shall include as part of the work of his/her contract, labor and material to provide manpower, equipment, tools, ladders, instruments, etc. necessary to assist the Start-Up Coordinator in accomplishing his/her work.

L. The Start-Up Coordinator shall be responsible for maintaining documentation of Start-Up activities until final acceptance of the project.

M. The documentation shall be kept current by the Start-Up Coordinator and shall be available for inspection at all times. At the time of acceptance of the project, the Start-Up Coordinator shall surrender 3 completed copies of the documentation to the Owner's representative.

N. Before Testing, Adjusting, Calibration and Balancing, the Start-Up Coordinator shall confirm, in writing to the Owner, the following:

1. All equipment, components, and systems have been set, started-up, and adjusted.
2. Systems have been established at the appropriate temperatures and pressures for proper operation and performance.

3. All electric power connections, disconnects, fuses, circuit breakers, etc. are properly sized and installed.
4. The operation of all valves, dampers and sensors is positive (per the control sequences) and demonstrated.

O. Provide dated matrices for each item of equipment showing the date each of the start-up activities was witnessed or performed by the Start-Up Coordinator.

1. Start-up and operating performance test documentation shall include all Division 21, 22 and 23 equipment with scheduled or rated capacities.

P. At the completion of the start-up; and test and balance, Plumbing, HVAC and Fire Protection contractors shall conduct a 72 hour dynamic mode demonstration of the systems in the presence of the Owner and Architect/Engineer. Contractor shall be available during the period to adjust equipment operation or setpoints. The engineer may direct the contractor to implement new control sequences or alter system installation in response to data collected during start-up. Work that can be completed by staff assigned to start-up that can be completed in the time period assigned to the start-up shall be completed with out additional cost to the owner.

Q. The Owner may require operation of parts or all of the installation for the beneficial occupancy to final completion and acceptance of the building. The operation shall not be construed to mean acceptance of the work by the Engineer for the Owner. The Owner will furnish supervisory personnel to direct operation of the entire system and the Contractor shall continue to assume this responsibility until final acceptance.

3.11 DEMONSTRATION

A. Refer to Architectural sections of the specifications regarding requirements of Record Drawings and Operation and Maintenance Manual submittal and systems demonstration.

1. Demonstrate to the Architect/Engineer that each system operates in accordance with the contract documents.
2. Explain the operation of each system to the Owner's Representative. Explain use of O&M manual in operating and maintaining systems.

B. Date and time of demonstration will be determined by Owner.

C. Demonstration Requirements.

1. Provide a point-to-point check-out of 100% of BMS controlled points for all equipment.

3.12 PROJECT CLOSEOUT

A. Refer to the individual sections of the specifications for individual closeout requirements.

B. Provide a written schedule of when systems are to be started up, tested and demonstrated along with dates for completion of the temperature controls and balancing. This schedule shall be submitted no later than 30 days prior to starting up and testing equipment.

C. The contractor shall notify the Architect/Engineer no later than 2 weeks in advance of system testing or demonstration.

END OF SECTION

SECTION 23 05 03

BASIC MECHANICAL MATERIALS AND METHODS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. This Section supplements Division 1, General Requirements.

B. Where contradictions occur between this Section and Division 1, the most stringent of the two shall apply. The design team shall decide which is most stringent.

C. Provisions of this Section shall also apply to all Sections of Divisions 21, 22 and 23.

1.2 SUBMITTALS

A. Manufacturer's Data - Submit manufacturer's data for:

1. Access panels.
2. Fire stopping materials.

B. Application Data - Submit application data for firestopping materials showing UL required installation details for every combination of pipe material, penetrated structure, opening size and required fire rating within the scope of this project. Application data drawings shall include UL system number.

PART 2 – PRODUCTS

2.1 ACCESS PANELS

A. See Architectural specification for access panel types and finishes.

1. If panels are not specified in architectural specification, comply with the following:
    a. Manufacturers:
        1) Design Basis: Milcor Division, Inryco, Inc.
        2) Other Acceptable Manufacturers:
            a) Birmingham Ornamental Iron Co.
            b) Karp Associates, Inc.
            c) Wilkenson Co., Inc.

B. Construction:

1. Doors: 14 gauge steel.
2. Frames: 16 gauge steel.
3. Fire Rating: Equivalent to construction in which installed.

4. Latches: Flush or concealed, ¼ turn.
5. Finish: Selected by Architect.

2.2 FIRE STOPPING MATERIAL

A. Manufacturers:

1. Design Basis: 3M.
2. Other acceptable manufacturers:
    a. GE
    b. Metalines
    c. Hilti

B. General Requirements:

1. Products to be used shall have been tested in accordance with ASTM E 814-88, and be listed in the UL Fire Resistance Directory.

C. Bare Piping:

1. Model: FD 150, or CP-25.

D. Insulated Piping:

1. Model: CP-25 or FS-195, Intumescent.
2. “No-sag” or “self-leveling” as required.

E. Accessories:

1. Provide fasteners, restricting collars, backing materials, and protective coatings as required to comply with the UL system listing.

2.3 SPARE PARTS

A. Chilled water, condenser water, condensate return pumps and hot water pumps - For each pump listed, unless otherwise specified.

1. One set of wearing rings or seals.
2. One set of bearings.
3. One set of packing glands complete with rings, nuts and bolts.
4. Three gaskets for casing joint.
5. Sufficient stuffing box packing for four packings.

Where pump specifications do not require mechanical seals, packing glands or stuffing boxes, spares listed may be omitted. Spare set of seals shall be provided.

B. Filters

1. The Contractor shall furnish a minimum of 2 complete spare filter sets for the filters for all units.

C. Miscellaneous Spare Parts

1. Furnish one complete set of V-belts for each belt driven unit installed.
2. A full set of spare fuses for each VFD drive.

2.4 ESCUTCHEONS

A. Provide escutcheons on pipes wherever they pass through ceilings, walls, floors, or partitions.

B. Escutcheons or pipes passing through outside walls shall be Ritter Pattern and Casting Co., No. 1, solid, cast brass, flat type secured to pipe with set screw.

C. Escutcheons for pipes passing through floors shall be Ritter Pattern and Casting Co., No. 36A, split-hinged, cast brass type, designed to fit pipe on one end and cover sleeve projecting through floor on the other end.

D. Escutcheons for pipes passing through interior walls, partitions, and ceilings shall be Ritter Pattern and Casting Co., No. 3A, split-hinged, cast beams chromium plated type.

PART 3 – EXECUTION

3.1 CUTTING AND PATCHING

A. Refer to Architectural sections of the Specifications for additional requirements.

B. Provide measurements, drawings and layouts to installers of other work so that required openings may be provided as construction progresses. Any cutting and patching made necessary by failure to provide this information shall be done at no increase in the contract amount.

C. All cutting and patching of existing work required for Plumbing, HVAC and Fire Protection work is included in the scope of the plumbing, HVAC and Fire Protection contracts. Finish patching, painting and restoration of finishes outside of primary work area is the Plumbing, HVAC and Fire Protection contractor performing work. Finish patching, painting and restoration of finishes in primary work area is by others. Rough patching, finish patching, painting and/or restoration of finishes outside of the primary work area is by each trade contractor.

D. Where possible, mark openings to be cut on existing construction. Otherwise, provide measurements, drawings and layouts to the trade doing the cutting so that openings may be provided as construction progresses.

E. Cutting Concrete:

1. Where authorized, cut openings through concrete for pipe penetration and similar services by core drilling or sawing.
2. Do not cut by hammer-driven chisel or drill.

F. Cutting:

1. Cut openings in accordance with layouts, measurements or drawings of the Installer of work requiring openings. Cut openings in concrete by core drilling or sawing; not by hammer-driven chisel or drill.
2. Coordinate the location of all openings with structural drawings. Report any discrepancies to Architect. Do not proceed with work until discrepancies have been resolved.
3. Do not endanger or damage other work through the procedures and processes of cutting to accommodate mechanical work.
4. Review the proposed cutting with the Installer of the work to be cut, and comply with his recommendations to minimize damage.
5. Where necessary, engage the original Installer or other specialists to execute the cutting in the recommended manner.

G. Patching:

1. Where patching is required to restore other work because of either cutting or other damage inflicted during the installation of mechanical work, engage experienced craftsmen to complete the patching of the other work.
2. Restore the other work in every respect, including the elimination of visual defects in exposed finishes.
3. All openings in fire rated construction shall be patched and sealed with U.L. approved sealant to maintain the fire integrity of the structure.

H. Perform cutting, patching and restoration of finishes required to:

1. Uncover work to provide installation of ill-timed work.
2. Remove and replace defective work.
3. Remove and replace work not conforming to requirements of the Contract Documents.
4. Remove samples of installed work as specified for testing.
5. Install equipment and materials in existing structures.
6. Upon written instructions from the Architect/Engineer, uncover and restore work to provide for Architect/Engineers observation of concealed work.

I. Painting:

Paint all surfaces marred by cutting and/or patching to match existing.

1. Engage experienced painters.
2. Comply with requirements of Painting Sections of the Specification.

J. Structural Limitations:

1. Do not cut or drill into structural framing, walls, floors, decks, and other members intended to withstand stress, except with Engineer's written authorization.
   a. Provide lintels, columns, braces and other temporary and permanent supports made by cutting.
   b. Submit shop drawings of permanent supports.
   c. Do not penetrate legs of structural "T's" or any other location where pre-stressed structural chords are likely to be encountered when cutting or drilling.

K. Provide inspection via metal detector or x-ray to identify existing concealed utilities when existing conditions make it apparent that concealed utilities may exist.

3.2 ACCESS PANELS

A. Furnish access panels where indicated and at locations where required for access to:

1. Concealed valves
2. Dampers
3. Control devices
4. Equipment servicing
5. Shock arresters
6. Air vents
7. Flow measuring and balancing stations
8. Any other device or item equipment requiring maintenance, adjustment or service.

B. Deliver access panels for installation by the trade responsible for surface in which installed.

1. Provide instructions for location.
2. The minimum size for access doors shall be the larger of 24"x24" or to fit the size of equipment to be removed.
3. If calculation of required access doors under item A above identifies less than 1 access door per 200 square feet of ceiling and wall construction, the quantity of access doors shall be increased to 1 per 200 square feet of ceiling and wall construction.

C. See "mechanical and electrical coordination" for additional access door requirements if section has been included in this specification.

3.3 SLEEVES

A. Provide sleeves for piping passing through walls, floors and roofs.

B. Provide sleeves for existing-to-remain piping through new walls.

C. Set pipe sleeves and inserts in place before concrete is poured. Coordinate the placing of these items to avoid delaying concrete placing operations.

D. Locate chases, shafts, and openings required for the installation of the mechanical work during framing of the structure. Do any additional cutting and boring required due to improperly located or omitted openings without cost to the Owner under the supervision of the Owner's representative.

E. Size sleeves for below grade pipe a minimum of 2" beyond outside of pipe.

F. Coat surface of all sleeves in contact with concrete, masonry or soil with two coats of coal tar bitumastic paint.

G. Provide Sleeves as Follows:

Sleeve Location	Sleeve Material
Interior Stud Partition Walls	Adjustable galvanized sheet metal with wall flanges and plaster lip, 2" and smaller – 22 gauge, 3" through 6" – 20 gauge, 8" and larger – 18 gauge.
Membrane Waterproof Floor and Roof Construction	Galvanized cast iron body with flashing clamp, threaded for sleeve riser. (J.R. Smith 1760 or equivalent by Ancon, Zurn or Josam).
Nonmembrane Floor, Construction	Non-adjustable galvanized sheet metal with deck flange and end cap, 2" and smaller – 22 gauge, 3" – 20 gauge, 4" and larger – 16 gauge.
Floors of Mechanical Rooms, Concrete Walls or Masonry Walls Above Grade.	Standard weight galvanized steel pipe.

H. Length of Sleeves as Follows:

Location	Sleeve Length
Floors	Equal to depth of floor construction including finish. Extend minimum of 1" above finished floor level within partitions, mechanical rooms, pipe chases and finished areas.
Roofs	Equal to depth of roof construction including insulation. Extend to 2" above maximum flood depth where rooftop retention is provided.

Location	Sleeve Length
Walls	Equal to depth of construction.

3.4 FIRE STOPPING

A. Install firestopping materials in accordance with their UL and ASTM tested methods.

B. Coordinate required annular space with size of pipe and sleeve.

C. Requirements for specific systems:

1. Cold piping - includes chilled water, domestic water, storm water and refrigerant: Insulation and vapor barrier shall be continued through wall and firestopping for “insulated piping” shall be provided.
2. Hot piping - to 250ºF -includes domestic hot water, steam to 15 psig and heating hot water: The Contractor has the option of continuing the insulation through the penetration and providing firestopping for “insulated piping”, or stopping the insulation on either side of the penetration and using firestopping for “uninsulated piping”.
3. High temperature piping, over 250ºF or over 15 psig steam: Contractor shall stop insulation and provide firestopping for high temperature piping.

3.5 EQUIPMENT BASES AND SUPPORTS

A. Supporting Steel: Provide supporting steel not indicated on the Structural Drawings for equipment, pipe ductwork, and other pieces of this Division’s work requiring same.

1. Submit shop drawings and structural calculations to the Engineer for information and records.
2. Brace and fasten with flanges bolted to structure.
3. Paint supporting steel with one coat of primer paint in the shop after fabrication welding is complete. Paint completed field joints with one coat of matching primer.

B. Housekeeping Bases:

1. Concrete bases for pumps, boilers, tanks, fans, etc., including anchor bolts and inserts, will be provided in accordance with American Concrete Institute (ACI) and American Society for Testing and Materials (ASTM) Standards for housekeeping pads and equipment support bases.
2. The concrete shall be placed in accordance with setting diagrams and sizes furnished by the equipment installer.
3. The Section furnishing the equipment shall provide not less than 4" high concrete bases for all pumps, refrigeration machines, compressors, and rotating machinery. Bases shall extend six inches beyond machinery base in all directions, with top edge chamfered. Provide 1/2" x 6" steel dowels into floor to anchor bases. Provide anchor bolts set in pipe sleeves, two sizes larger than

anchor bolts for securing machinery. After anchor bolts are aligned with equipment bases, fill sleeves with concrete and allow to set.

3.6 RAILINGS

A. Where railings and guards are not provided in another section of the specification, each contractor shall provide protection as described below for all equipment installed by the contractor.

1. Guards shall be provided where appliances, equipment, fans or other components that require service are located within 10 feet of a roof edge or open side of a walking surface and such edge or open side is located more than 30 inches above the floor, roof, or grade below.
2. The guard shall extend not less than 30 inches beyond the end of such appliance, equipment, fan or component.
3. The top of the guard shall be located not less than 42 inches above the elevated surface.
4. The guard shall be constructed so as to prevent the passage of a 21-inch-diameter sphere and shall comply with the loading requirements for guards specified in the local Building Code.

3.7 DRIP PANS

A. Drip Pans:

Where possible to run mechanical piping elsewhere, do not run mechanical piping directly above electrical (or electronic) work which is sensitive to moisture. Otherwise, provide drip pans under mechanical piping, sufficient to protect electrical work from dripping.

1. Locate pan immediately below piping, and extend a minimum of 6” on each side of piping and lengthwise 18” beyond equipment being protected.
2. Fabricate pans 2” deep of reinforced 22 gauge galvanized sheet metal with rolled edges and welded seams.
3. Provide ¾” copper drainage piping from pan to nearest floor drain or similar suitable point of discharge, and terminate pipe as an open-sight drainage connection.
4. Provide permanent support and anchorage to prevent displacement of drip pans.
5. Insulate bottom of pan where pan is subject to the frequent discharge of water or materials less than 60˚F.

END OF SECTION

SECTION 23 05 03

BASIC MECHANICAL MATERIALS AND METHODS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. This Section supplements Division 1, General Requirements.

B. Where contradictions occur between this Section and Division 1, the most stringent of the two shall apply. The design team shall decide which is most stringent.

C. Provisions of this Section shall also apply to all Sections of Divisions 21, 22 and 23.

1.2 SUBMITTALS

A. Manufacturer's Data - Submit manufacturer's data for:

1. Access panels.
2. Fire stopping materials.

B. Application Data - Submit application data for firestopping materials showing UL required installation details for every combination of pipe material, penetrated structure, opening size and required fire rating within the scope of this project. Application data drawings shall include UL system number.

PART 2 – PRODUCTS

2.1 ACCESS PANELS

A. See Architectural specification for access panel types and finishes.

1. If panels are not specified in architectural specification, comply with the following:
    a. Manufacturers:
        1) Design Basis: Milcor Division, Inryco, Inc.
        2) Other Acceptable Manufacturers:
            a) Birmingham Ornamental Iron Co.
            b) Karp Associates, Inc.
            c) Wilkenson Co., Inc.

B. Construction:

1. Doors: 14 gauge steel.
2. Frames: 16 gauge steel.
3. Fire Rating: Equivalent to construction in which installed.

4. Latches: Flush or concealed, ¼ turn.
5. Finish: Selected by Architect.

2.2 FIRE STOPPING MATERIAL

A. Manufacturers:

1. Design Basis: 3M.
2. Other acceptable manufacturers:
   a. GE
   b. Metalines
   c. Hilti

B. General Requirements:

1. Products to be used shall have been tested in accordance with ASTM E 814-88, and be listed in the UL Fire Resistance Directory.

C. Bare Piping:

1. Model: FD 150, or CP-25.

D. Insulated Piping:

1. Model: CP-25 or FS-195, Intumescent.
2. "No-sag" or "self-leveling" as required.

E. Accessories:

1. Provide fasteners, restricting collars, backing materials, and protective coatings as required to comply with the UL system listing.

2.3 SPARE PARTS

A. Chilled water, condenser water, condensate return pumps and hot water pumps - For each pump listed, unless otherwise specified.

1. One set of wearing rings or seals.
2. One set of bearings.
3. One set of packing glands complete with rings, nuts and bolts.
4. Three gaskets for casing joint.
5. Sufficient stuffing box packing for four packings.

   Where pump specifications do not require mechanical seals, packing glands or stuffing boxes, spares listed may be omitted. Spare set of seals shall be provided.

B. Filters

1. The Contractor shall furnish a minimum of 2 complete spare filter sets for the filters for all units.

C. Miscellaneous Spare Parts

1. Furnish one complete set of V-belts for each belt driven unit installed.
2. A full set of spare fuses for each VFD drive.

2.4 ESCUTCHEONS

A. Provide escutcheons on pipes wherever they pass through ceilings, walls, floors, or partitions.

B. Escutcheons or pipes passing through outside walls shall be Ritter Pattern and Casting Co., No. 1, solid, cast brass, flat type secured to pipe with set screw.

C. Escutcheons for pipes passing through floors shall be Ritter Pattern and Casting Co., No. 36A, split-hinged, cast brass type, designed to fit pipe on one end and cover sleeve projecting through floor on the other end.

D. Escutcheons for pipes passing through interior walls, partitions, and ceilings shall be Ritter Pattern and Casting Co., No. 3A, split-hinged, cast beams chromium plated type.

PART 3 – EXECUTION

3.1 CUTTING AND PATCHING

A. Refer to Architectural sections of the Specifications for additional requirements.

B. Provide measurements, drawings and layouts to installers of other work so that required openings may be provided as construction progresses. Any cutting and patching made necessary by failure to provide this information shall be done at no increase in the contract amount.

C. All cutting and patching of existing work required for Plumbing, HVAC and Fire Protection work is included in the scope of the plumbing, HVAC and Fire Protection contracts. Finish patching, painting and restoration of finishes outside of primary work area is the Plumbing, HVAC and Fire Protection contractor performing work. Finish patching, painting and restoration of finishes in primary work area is by others. Rough patching, finish patching, painting and/or restoration of finishes outside of the primary work area is by each trade contractor.

D. Where possible, mark openings to be cut on existing construction. Otherwise, provide measurements, drawings and layouts to the trade doing the cutting so that openings may be provided as construction progresses.

E. Cutting Concrete:

1. Where authorized, cut openings through concrete for pipe penetration and similar services by core drilling or sawing.
2. Do not cut by hammer-driven chisel or drill.

F. Cutting:

1. Cut openings in accordance with layouts, measurements or drawings of the Installer of work requiring openings. Cut openings in concrete by core drilling or sawing; not by hammer-driven chisel or drill.
2. Coordinate the location of all openings with structural drawings. Report any discrepancies to Architect. Do not proceed with work until discrepancies have been resolved.
3. Do not endanger or damage other work through the procedures and processes of cutting to accommodate mechanical work.
4. Review the proposed cutting with the Installer of the work to be cut, and comply with his recommendations to minimize damage.
5. Where necessary, engage the original Installer or other specialists to execute the cutting in the recommended manner.

G. Patching:

1. Where patching is required to restore other work because of either cutting or other damage inflicted during the installation of mechanical work, engage experienced craftsmen to complete the patching of the other work.
2. Restore the other work in every respect, including the elimination of visual defects in exposed finishes.
3. All openings in fire rated construction shall be patched and sealed with U.L. approved sealant to maintain the fire integrity of the structure.

H. Perform cutting, patching and restoration of finishes required to:

1. Uncover work to provide installation of ill-timed work.
2. Remove and replace defective work.
3. Remove and replace work not conforming to requirements of the Contract Documents.
4. Remove samples of installed work as specified for testing.
5. Install equipment and materials in existing structures.
6. Upon written instructions from the Architect/Engineer, uncover and restore work to provide for Architect/Engineers observation of concealed work.

I. Painting:

Paint all surfaces marred by cutting and/or patching to match existing.

1. Engage experienced painters.
2. Comply with requirements of Painting Sections of the Specification.

J. Structural Limitations:

1. Do not cut or drill into structural framing, walls, floors, decks, and other members intended to withstand stress, except with Engineer's written authorization.
    a. Provide lintels, columns, braces and other temporary and permanent supports made by cutting.
    b. Submit shop drawings of permanent supports.
    c. Do not penetrate legs of structural "T's" or any other location where pre-stressed structural chords are likely to be encountered when cutting or drilling.

K. Provide inspection via metal detector or x-ray to identify existing concealed utilities when existing conditions make it apparent that concealed utilities may exist.

3.2 ACCESS PANELS

A. Furnish access panels where indicated and at locations where required for access to:

1. Concealed valves
2. Dampers
3. Control devices
4. Equipment servicing
5. Shock arresters
6. Air vents
7. Flow measuring and balancing stations
8. Any other device or item equipment requiring maintenance, adjustment or service.

B. Deliver access panels for installation by the trade responsible for surface in which installed.

1. Provide instructions for location.
2. The minimum size for access doors shall be the larger of 24"x24" or to fit the size of equipment to be removed.
3. If calculation of required access doors under item A above identifies less than 1 access door per 200 square feet of ceiling and wall construction, the quantity of access doors shall be increased to 1 per 200 square feet of ceiling and wall construction.

C. See “mechanical and electrical coordination” for additional access door requirements if section has been included in this specification.

3.3 SLEEVES

A. Provide sleeves for piping passing through walls, floors and roofs.

B. Provide sleeves for existing-to-remain piping through new walls.

C. Set pipe sleeves and inserts in place before concrete is poured. Coordinate the placing of these items to avoid delaying concrete placing operations.

D. Locate chases, shafts, and openings required for the installation of the mechanical work during framing of the structure. Do any additional cutting and boring required due to improperly located or omitted openings without cost to the Owner under the supervision of the Owner’s representative.

E. Size sleeves for below grade pipe a minimum of 2” beyond outside of pipe.

F. Coat surface of all sleeves in contact with concrete, masonry or soil with two coats of coal tar bitumastic paint.

G. Provide Sleeves as Follows:

Sleeve Location	Sleeve Material
Interior Stud Partition Walls	Adjustable galvanized sheet metal with wall flanges and plaster lip, 2” and smaller – 22 gauge, 3” through 6” – 20 gauge, 8” and larger – 18 gauge.
Membrane Waterproof Floor and Roof Construction	Galvanized cast iron body with flashing clamp, threaded for sleeve riser. (J.R. Smith 1760 or equivalent by Ancon, Zurn or Josam).
Nonmembrane Floor, Construction	Non-adjustable galvanized sheet metal with deck flange and end cap, 2” and smaller – 22 gauge, 3” – 20 gauge, 4” and larger – 16 gauge.
Floors of Mechanical Rooms, Concrete Walls or Masonry Walls Above Grade.	Standard weight galvanized steel pipe.

H. Length of Sleeves as Follows:

Location	Sleeve Length
Floors	Equal to depth of floor construction including finish. Extend minimum of 1” above finished floor level within partitions, mechanical rooms, pipe chases and finished areas.

Location	Sleeve Length
Roofs	Equal to depth of roof construction including insulation. Extend to 2” above maximum flood depth where rooftop retention is provided.
Walls	Equal to depth of construction.

3.4 FIRE STOPPING

A. Install firestopping materials in accordance with their UL and ASTM tested methods.

B. Coordinate required annular space with size of pipe and sleeve.

C. Requirements for specific systems:

1. Cold piping - includes chilled water, domestic water, storm water and refrigerant: Insulation and vapor barrier shall be continued through wall and firestopping for “insulated piping” shall be provided.
2. Hot piping - to 250ºF -includes domestic hot water, steam to 15 psig and heating hot water: The Contractor has the option of continuing the insulation through the penetration and providing firestopping for “insulated piping”, or stopping the insulation on either side of the penetration and using firestopping for “uninsulated piping”.
3. High temperature piping, over 250ºF or over 15 psig steam: Contractor shall stop insulation and provide firestopping for high temperature piping.

3.5 EQUIPMENT BASES AND SUPPORTS

A. Supporting Steel: Provide supporting steel not indicated on the Structural Drawings for equipment, pipe ductwork, and other pieces of this Division’s work requiring same.

1. Submit shop drawings and structural calculations to the Engineer for information and records.
2. Brace and fasten with flanges bolted to structure.
3. Paint supporting steel with one coat of primer paint in the shop after fabrication welding is complete. Paint completed field joints with one coat of matching primer.

B. Housekeeping Bases:

1. Concrete bases for pumps, boilers, tanks, fans, etc., including anchor bolts and inserts, will be provided in accordance with American Concrete Institute (ACI) and American Society for Testing and Materials (ASTM) Standards for housekeeping pads and equipment support bases.
2. The concrete shall be placed in accordance with setting diagrams and sizes furnished by the equipment installer.
3. The Section furnishing the equipment shall provide not less than 4" high concrete bases for all pumps, refrigeration machines, compressors, and rotating machinery. Bases shall extend six inches beyond machinery base in all

directions, with top edge chamfered. Provide 1/2" x 6" steel dowels into floor to anchor bases. Provide anchor bolts set in pipe sleeves, two sizes larger than anchor bolts for securing machinery. After anchor bolts are aligned with equipment bases, fill sleeves with concrete and allow to set.

3.6 RAILINGS

A. Where railings and guards are not provided in another section of the specification, each contractor shall provide protection as described below for all equipment installed by the contractor.

1. Guards shall be provided where appliances, equipment, fans or other components that require service are located within 10 feet of a roof edge or open side of a walking surface and such edge or open side is located more than 30 inches above the floor, roof, or grade below.
2. The guard shall extend not less than 30 inches beyond the end of such appliance, equipment, fan or component.
3. The top of the guard shall be located not less than 42 inches above the elevated surface.
4. The guard shall be constructed so as to prevent the passage of a 21-inch-diameter sphere and shall comply with the loading requirements for guards specified in the local Building Code.

3.7 DRIP PANS

A. Drip Pans:

Where possible to run mechanical piping elsewhere, do not run mechanical piping directly above electrical (or electronic) work which is sensitive to moisture. Otherwise, provide drip pans under mechanical piping, sufficient to protect electrical work from dripping.

1. Locate pan immediately below piping, and extend a minimum of 6” on each side of piping and lengthwise 18” beyond equipment being protected.
2. Fabricate pans 2” deep of reinforced 22 gauge galvanized sheet metal with rolled edges and welded seams.
3. Provide ¾” copper drainage piping from pan to nearest floor drain or similar suitable point of discharge, and terminate pipe as an open-sight drainage connection.
4. Provide permanent support and anchorage to prevent displacement of drip pans.
5. Insulate bottom of pan where pan is subject to the frequent discharge of water or materials less than 60˚F.

END OF SECTION

SECTION 23 05 13

MOTORS AND STARTERS

PART 1 - GENERAL

1.1 SUBMITTALS

A. Submit manufacturer’s product data.

1. Motors: Identify by unit served. Include:
    a. Voltage
    b. Phase
    c. Horsepower
    d. Frame
    e. Insulating class
    f. Efficiency
    g. Power factor
    h. Index number
    i. Speed
    j. Starting characteristics
2. Starters: Identify by motor served. Include:
    a. Enclosure, NEMA Type
    b. NEMA size
    c. Accessories, switches, transformers, etc.
    d. Wiring diagram
    e. Auxiliary contacts
    f. Thermal overload size
3. Submit as part of packaged unit submittals when purchased as part of item of equipment.

1.2 SINGLE MANUFACTURER

A. Provide all motors, except those factory mounted, by a single manufacturer.

B. Provide all starters, except those factory mounted, by a single manufacturer.

C. “Factory mounted” means “as part of a packaged unit” where the motor is not purchased separately from the driven equipment.

PART 2 - PRODUCTS

2.1 MOTORS (OTHER THAN FACTORY MOUNTED)

A. Manufacturers:

1. Design Basis: Reliance
2. Other Acceptable Manufacturers:
   a. General Electric
   b. Westinghouse
   c. U.S. Motor
   d. Magnetek
   e. Baldor
   f. U.S. Electric

3. Factory mounted motors may be by equipment manufacturer's standard supplier.

B. Bearings: Ball bearings, grease lubricated with grease fittings.

C. Enclosure: As required by location.

D. Service Factor: 1.15.

E. Full-Load Operation: At 105ºF and altitude of project.

F. Overload Protection:

1. Type: Trip-free thermal overload relay.
2. Location: Each ungrounded conductor.
3. Reset: Manual.
4. Ambient Temperature Compensation: Provide where required.
5. Overload protection to be sized for nameplate running amps.

G. Insulation:

1. Constant Speed: Class B.
2. Variable Frequency Controlled: Class F.

H. Efficiency Ratings:

1. All motors one horsepower and larger, except as noted, shall be premium efficiency motors, in accordance with NEMA Standard MGI-2003, Tables 12-12 and 12-13.

I. Electrical Characteristics:

1. Refer to sections 23 05 01, Mechanical and Electrical Coordination.
2. Motors less than ½ hp shall be 115-volt single phase.
3. Motors ½ hp and larger shall be three phase, of voltage shown in Electrical Section of Contract Documents.

J. Multi-speed Motors:

1. Type: Motors may be one of the following:

a. Two speed, two winding 1800/900 rpm.
b. Two speed, one winding 1800/900 rpm.

K. Variable Speed Drives:

1. All motors operated by a variable speed drive shall be rated for inverter duty.
2. Motor insulation shall be rated for 1600-volt peak.
3. All motors need to be NEMA MG-1, Part 31 compliant.
4. Refer to VFD specification for additional requirements if included in this specification.
5. Provide AEGIS shaft grounding rings for all motors operated by a VFD.

2.2 MOTORS (FACTORY MOUNTED)

A. Provide premium efficiency motors.

B. Variable Speed Drives:

1. All motors operated by a variable speed drive shall be rated for inverter duty.
2. Motor insulation shall be rated for 1600 volt peak.
3. All motors need to be NEMA MG-1, Part 31 compliant.
4. Refer to VFD specification for additional requirements if included in this specification.
5. Provide shaft grounding rings for all motors operated by a VFD.

2.3 STARTERS

A. Manufacturers:

1. Allen Bradley
2. Cutler-Hammer
3. General Electric
4. Square D

B. General:

1. Starters shall be standard NEMA sizes and UL listed.

C. Type: Across the line except where noted.

D. Enclosure: NEMA Type as required for location. Provide stainless steel enclosures in wash down areas, kitchens, dishwasher areas, exterior spaces, and any other areas where equipment will be exposed to moisture. Provide space heater and any necessary transformer within the enclosure as required to maintain the minimum internal temperature required by the manufacturer.

E. Overload Protection:

1. Type: Trip-free thermal overload relay for each ungrounded conductor.
2. Reset: Manual.
3. Ambient Temperature Compensation: Provide where required.
4. Overload protection to be sized for nameplate running amps.

F. Auxiliary Contacts:

1. Number: Provide three per starter as required for control sequence, and one (1) auxiliary contact.
2. Switchable type, easily changed from N.O. to N.C. without removing from its mounting.

G. Switches in Cover:

1. Manually Controlled: Three wire start-stop.
2. Automatically Controlled: Hand-off-automatic.
3. Start and stop indicating lights.
4. Equipment used for life safety (smoke exhaust, etc.): Hand-Automatic.
5. Equipment not designed to run continuously: Off-Automatic.

H. Control Transformer:

1. Provide when line voltage exceeds 208 volts.
2. Secondary wiring shall have one leg fused and the other grounded.
3. Secondary voltage not to exceed 120 volts.

I. Provide starters for all motors as follows:

1. Single phase motors less than ½ hp.
   a. With internal overload protection: None.
   b. Without internal overload protection:
      1) Manually Controlled: Manual starter.
      2) Automatically Controlled: Magnetic starter.
2. Single phase motors ½ hp and larger:
   a. Manually Controlled: Manual starter.
   b. Automatically Controlled: Magnetic starter.
3. Three Phase Motors: Magnetic starter.

J. Soft Start Starters:

1. Provide Y-Delta or solid state reduced voltage starters for all motors 50hp and larger.
2. Starter shall limit starting voltage to 200% of full load voltage.

K. Multi-Speed Starters:

1. Starters shall be suitable for the type multi-speed motor selected.
2. Provide time delay for automatic transfer from high to low speed.

L. Housing coils to be 120V.

M. Motor Protection: (above 20 hp)

1. Provide Single-phase protection.
2. Provide under-voltage protection.

N. Disconnecting Means

1. Provide combination starters-disconnects for all starters unless specifically stated otherwise.

PART 3 - EXECUTION

3.1 MOTORS

A. Install motors on motor mounting systems so coupling or belt drive is properly aligned. Provide proper belt tension. Dowel direct coupled motors.

B. Field quality control: Fun each motor to demonstrate rotation, speed, current draw meets nameplate, etc.

C. Requirements for storage, handling and protection: Keep motor windings protected and clear of dust.

3.2 STARTERS

A. Deliver to installer of electrical work.

B. All safety devices shall be wired so that they will stop the motor with a hand-off-automatic switch in the hand as well as the automatic position.

END OF SECTION

SECTION 23 05 19

ENERGY METERING DEVICES

PART 1 - GENERAL

1.1 DESCRIPTION

A. In addition to the work covered under this section, comply with description of individual systems under other sections of the Specifications.

PART 2 - PRODUCTS

2.1 BTU METERING STATIONS

A. Provide BTU demand and consumption metering stations indicated on the drawings. Meters shall be of either rotating disc, propeller type, turbine type, low pressure drop orifice type, ultrasonic type, vortex type, or sonic type. Meter shall be capable of accurate measurement while operating under design water flow turndown ratios as shown on the drawings, as specifically approved by the Architect, and under actual water flow conditions. For non-Ultrasonic Type meters provide isolation shutoff values for maintenance purposes and line size spool pieces at metering.

B. Flow Sensor-Condenser Water and Brine Chilled Water

1. Ultrasonic Type: Piping location for meter must meet the manufacturer's recommendation for minimum specified length of straight pipe.
2. The metering of the energy is based on the total BTU (British Thermal Units) delivered to the building.
    a. Determination of BTUs of energy requires a minimum of two temperature sensors (one on the supply line, one on the return line) and a flow sensor/transmitter, preferably on the supply line for chilled water.
3. Meter data communication must be coordinated with Building Automation System (BAS) – interface requirements. The BTU meter will perform BTU calculations, which shall be made available through analog inputs to the BAS, as well as available for manual reading from a remote mounted display terminal at eye level near the BTU meter. Remote display for flow and BTU meters shall be furnished by the manufacturer.
4. Product Details
    a. Transit time flow and energy meter.
    b. High precision clamp-on flow transducers.
    c. Insertion (wetted) type RTDs w/ 4 wire output (balanced) individually accurate to within 0.1 degree F and provided as a matched pair.
    d. NEMA 4X enclosure.
    e. Alphanumeric LCD display with user selectable display options.
    f. Totalizer with reset possible only with security code or non-resettable.

g. Pulsed BTU totalizer output signal sent to the BAS panel for interpretation.
h. High/low limit alarm relays.
i. Mounting hardware.
j. RTD and flow transducer cables.
k. Calibration certification.

5. Acceptable Manufacturers: Onicon, Controlotron and Panametric

C. Refer to detail drawings for metering arrangement.

D. Chilled water meter shall record peak demand in tons and consumption in ton-hours times 10 or other appropriate factor corresponding to the daily consumption at each meter.

E. Demand meters shall be capable of transmitting a remote signal to the BMS.

F. All metering devices shall be of the type required by the billing agent and must be approved by the billing agent prior to installation.

G. Metering devices shall be calibrated to meter the specific system fluid being measured at the anticipated system temperatures.

H. Device mounting method shall allow for removal of device from a filled system without significant fluid loss.

I. All elements of the metering equipment exposed to fluid shall be rated for service at 300 PSI and constructed of a stainless steel alloy compatible with fluid being measured.

J. Provide thermal wells and electronic temperature probes in supply and return piping to allow for a calculation of differential temperature in system being metered.

K. Flow sensor shall be provided with electronic metering equipment to produce a signal proportional to flow that can be output to the BMS. Coordinate with control specification.

L. Measuring devices shall not require moving parts and shall sample across the full diameter of the pipe being measured.

M. Provide all tools and software required for proper operation and maintenance of metering equipment.

N. System shall measure with an accuracy of +/- 1%.

O. The mounting coupling shall be made of a material that is compatible with the process pipe material.

P. Chilled water system shall operate in a temperature range from -40 to 185° F with fluid temperatures ranging from 20 to 200° F.

Q. Electronic control module shall sample 20 times per seconds and convert collected data to a signal suitable for collection by the building management system. The building management system shall log data and maintain a running sum of daily, weekly and monthly consumption.

R. Chilled water BTU metering includes a flow meter, two temperature sensors, and a BTU processor, which is connected to the University EMCS. Basis of design shall use an electromagnetic meter. Contact Cornell for special conditions requiring the use of an ultrasonic meter. Acceptable manufacturers and models shall be as follows:

1. Basis of Design: Siemens Sitrans MAG 3100 (electromagnetic).
2. Alternate: Flexim FLUXUS ADM 7407 (ultrasonic).

S. Temperature sensors associated with the chilled water meter shall be Resistance Temperature Device (RTD) as manufactured by JMS Southeast, Inc. Model 3X(X=3TF3)SBK6BZZ312ZWZ2AX(X=Fully Potted). Probe shall have date of manufacture stamped on the surface. Thermowells shall be JMS model 51AT2CUK ½ inch step shank, 316 stainless steel, 0.260 bore sized to insert a minimum of 1/3 pipe diameter into flow stream. The junction box shall be a 2 x 4 handy box connected to the thermowell with CPVC nipples from the well to the head. Terminal connections shall be to a termination strip on the back of the handy box so probe can be removed through the front with the handy box cover removed. Provide a spare test well (identical to the sensing well) with brass cap and chain at all sensor locations.

T. The flow meter and temperature sensors shall be coupled to a BTU meter flow processor "FP93" as manufactured by EMCO. The flow processor shall be connected to the University EMCS via Ethernet.

U. Install meter as shown on Cornell Standard Detail 3.1.7 – Electromagnetic Chilled Water Meter Installation Detail, or Cornell Standard Detail 3.1.8 – Ultrasonic Chilled Water Meter Installation Detail.

V. If more than one building loop, or sub meters are required in a single building, multiple FP93 meters shall be connected to the University EMCS via Ethernet. Contact Cornell for metering needs beyond one total building meter.

W. Do not disconnect existing chilled water metering until new metering or communications are in place.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install in accordance with manufacturers recommendations. For clearance, upstream straight pipe length, downstream straight pipe length and support. Where manufacturer's requirement for straight pipe is less than 16 pipe diameters a minimum of 16 pipe diameters shall be provided. Provide straightening vanes where required pipe lengths cannot be maintained.

B. Provide all labor and materials required to deliver a signal compatible with the BMS system. Contractor to connect, start-up and calibrate meter.

C. Entire system shall be covered by a 5 year parts and labor warranty.

END OF SECTION

SECTION 23 05 23

VALVES

PART 1 - GENERAL

1.1 SUBMITTALS

A. Manufacturer's Data: Submit manufacturer's product data including:

1. Dimensions
2. Sizes
3. End Connections
4. Weights
5. Installation instructions
6. Instructions on repacking and repairing valves.
7. Range of flow for balancing valves and plug valves.

B. Valve Tag List: See requirements in this Specification.

PART 2 - PRODUCTS

2.1 GENERAL

A. In addition to valves specified herein, provide products meeting the pressure requirements of the system.

B. Where type or body material is not indicated, provide valve with pressure class selected from MSS or ANSI standards, based on the maximum pressure and temperature in the piping system. Valve body material shall be coordinated with the piping system material.

C. Except for balancing or otherwise indicated, provide valve of same size as connecting pipe size.

D. All valves shall be gate valves. If ball, butterfly, globe, plug, or balancing valves are called out by note or symbol, only that type of valve is acceptable.

E. Ball valves or butterfly valves may be used in lieu of gate valves in non-balancing applications when pressure and temperature ratings are adequate.

F. Where pipe sizes overlap, contractor has the option of threaded or flanged valves.

G. All valves shall be domestically manufactured unless approved for use by Engineer.

H. All components in hydronic systems shall be compatible with ethylene glycol and water solution.

I. All valves shall be of a design which the manufacturer lists for the service and shall be of materials allowed by the latest edition of the ASME Code for pressure piping for the pressure and temperature contemplated, unless a higher grade or quality is herein specified.

J. Valve packing compression is to be independent of the stem, ball or handle systems. All valve stems are to be blowout proof. Packing shall be accessible without disturbing the insulation.

K. All valves used for vent or drain service on water systems shall have a brass hose connection with cap and chain.

L. Unless otherwise noted, all valves for shut-off and bypass service shall be ball valves, 2" and below, and butterfly valves 2-1/2" and above. Ball valves are acceptable in 2-1/2" and 3" copper only.

M. End connections for NPS 2” and below shall be the same as is used for fittings. Use flanged valves for NPS two and one half inches (2-1/2") and above. Solder joints are also acceptable in 2-1/2" and 3" copper piping systems.

N. Install valves after welding adjacent to valve is completed to protect seat and disk.

O. All valves used for vent or drain service on water systems shall have a brass hose connection with cap and chain.

P. Non-electric radiator control valves with valve mounted heads are not acceptable, except on cast iron radiators, where they shall be side mounted. Where used, thermostatic radiator valves shall be remote bulb and remote control head design. The control head shall be mounted on the radiation enclosure, if possible.

2.2 GLOBE VALVES (Water)

A. Manufacturers:

1. Design Basis: Milwaukee
2. Other Acceptable Manufacturers:
   a. Crane
   b. Nibco
   c. Powell
   d. Gruvlok
   e. Stockham

2" AND SMALLER	UNDER 300 PSI	Milwaukee Model 591A Bronze, 150 SWP at 406 deg. F., 300 WOG at 150 deg. F., Non-Shock, Heavy Duty Service, Special Hardened Stainless Steel Seat Ring and Disc, Union Bonnet, Gland Packed, Threaded Ends
2 ½" AND LARGER	UNDER 200 PSI	Milwaukee Model F-2981 Iron, 125 SWP, 200 WOG, Non-Shock, Solid Disc, Bolted Bonnet, Gland Packed, Flanged Ends
	OVER 200 PSI	Milwaukee Model F-2983 Iron, 250 SWP, 500 WOG, Non-Shock, Solid Disc, Bolted Bonnet, Gland Packed, Flanged Ends.
3" AND SMALLER (for use with copper tubing)	UNDER 300 PSI	Milwaukee Model 590T Bronze, 150 SWP, 300 WOG, Heavy Duty Service, Teflon Disc, Union Bonnet, Gland Packed

2.3 GLOBE VALVES (Steam)

A. Manufacturers:

1. Design Basis: Milwaukee
2. Other Acceptable Manufacturers:
   a. Crane
   b. Nibco
   c. Stockham
   d. Hammond
   e. Gruvlok

2" AND SMALLER	UNDER 300 PSI	Milwaukee Model No. 593A Bronze, 300 lb. WSP, Threaded
2 ½" AND LARGER	UNDER 250 PSI	Milwaukee Model F2983 Iron body, 250 lb. WSP, OS&Y, Flanged ends - Bronze Trim

2.4 ANGLE VALVES

A. Manufacturers:

1. Design Basis: Milwaukee
2. Other Acceptable Manufacturers:
   a. Crane
   b. Nibco
   c. Stockham
   d. Hammond
   e. Gruvlok

2" AND SMALLER	UNDER 300 PSI	Milwaukee Model 595T Bronze Body, 150 WSP, 300 WOG, Threaded, Union Bonnet, Angle Bronze Disc
2½ " AND LARGER	UNDER 300 PSI	Milwaukee Model 595T Bronze, 150 SWP, 300 WOG, Heavy Duty Service, Teflon Disc, Union Bonnet, Gland Packed.

2.5 SILENT/WAFER CHECK VALVES

A. Manufacturers:

1. Design Basis: Milwaukee
2. Other Acceptable Manufacturers:
   a. Metra Flex
   b. Hammond
   c. GA Industries
   d. Nibco
   e. Tyco
   f. Victaulic (for Grooved Pipe Systems)
   g. Gruvlok
   h. Stockham

2" – 6"	UNDER 200 PSI @ 150 °F	Milwaukee Model 1400 Cast Iron body, Bronze trim, Center guided single disc, 200 PSI rating.
8" -10"	UNDER 400 PSI @ 150 °F	Milwaukee Model 1400 Cast Iron body, Bronze trim, Center guided single disc, 400 PSI rating.
11" – 42"	UNDER 300 PSI @ 150 ˚F	Milwaukee Model 1400 Cast Iron Body, Bronze trim, Center guided single disc, 250 lb. class, 300 PSI Test

B. Hydronic piping system grooved end spring-loaded check valves shall be suitable for pressures up to 365 psi and operating temperatures up to 230 deg F.

1. 2" through 3": Ductile iron body, stainless steel disc and spring, nickel-plated seat, 365 psi CWP.
2. 4" through 12": Ductile iron body, EPDM coated ductile iron disc, stainless steel spring and shaft, welded-in nickel seat, 300 psi CWP.
3. 14" through 24": Ductile iron body, stainless steel disc, spring, and shaft, EPDM seat bonded to the valve body, 230 psi CWP.

2.6 SWING CHECK VALVES

A. Manufacturers:

1. Design Basis: Milwaukee
2. Other Acceptable Manufacturers;
   a. Crane
   b. Nibco
   c. Hammond
   d. Stockham
   e. Victaulic (for Grooved Pipe Systems)
   f. Gruvlok

2" and Smaller	Under 400 PSI	Milwaukee Model 508 Bronze body, 200 PSI SWP, 400 PSI WOG, Straight through pattern, bronze disc
2½" and Larger	Under 200 PSI	Milwaukee Model F2974 Iron Body, 125 PSI SWP, 200 PSI WOG, bolted cap

B. Hydronic piping system grooved end horizontal swing check valves shall be suitable for pressures up to 300 psi and operating temperatures up to 230 deg F. Ductile iron body, type 316 stainless steel clapper, EPDM seat.

C. Two inches (2") and under: 45˚ swing check, screwed end.

D. Two and one half inches (2 1/2") and over: Non-slam type globe style lift check, non-slam type tilting disc or wafer body non-slam type lift check. Double disc or bi-folding disc type valves are not acceptable.

2.7 BUTTERFLY VALVES (Water)

A. Manufacturers:

1. Design Basis: Bray
2. Other Acceptable Manufacturers:
   a. Jamesbury
   b. Victaulic (for Grooved piping systems)

½" – 1 ½"	USE BALL VALVE	
2" – 12"	UNDER 250 PSI	Bray Model 40/41 Cast Iron body, Stainless Steel stem, Aluminum-bronze disc (316 stainless steel disc)

B. Butterfly valves in size 2" - 12" shall be of the single flange, lug body style. Bodies shall be ductile iron. Valves shall provide drip-tight shutoff at differentials up to 300 psi.

C. Lug body valves shall have a retained seat and shall provide tight shutoff up to the full valve rating on dead end or isolation service without the use of downstream flanges.

D. All valves shall be furnished with self lubricated bearings of TFE coated stainless steel. Shaft seals shall be provided to prevent leakage and to protect bearings from internal or external corrosion.

E. Body:

1. Shall be one-piece wafer, lug or double flanged design with extended neck to allow for 2” of piping insulation.
2. Flange hole drilling per international flange standard as specified.
3. Provided with top and bottom stem bearings consisting of a 316 stainless steel shell with a TFE/glass fabric liner bearing surface.
4. Equipped with an externally adjustable stem packing system that allows packing adjustment without removing the actuator.
5. Internal over-travel stop shall be provided to prevent over-travel of the disc and minimize possible seat damage.

F. Seats:

1. Design shall consist of a resilient energizer totally encapsulated by the seat.
2. Seat retainer shall be full-faced and firmly attached by bolts located outside the sealing area to protect them from corrosion.
3. The seat assembly shall be locked in the body recess by the full-faced retainer.
4. The seat shall be self-adjusting for wear and temperature changes.
5. The seat shall be easily field replaceable.

G. Stem:

1. Shall be one-piece design
2. Stem shall be provided with blow-out proof stem retention system to assure full retention of the stem in the unlikely event of an internal stem failure.
3. Disc-to-stem connection shall be an internal connection design with no possible leak paths in the disc-to-stem connection. External disc-to-stem connections such as disc screws or pins are not allowed.
4. Stem shall be provided with blow-out proof stem retention system to assure full retention of the stem in the unlikely event of an internal stem failure.

H. Disc edge shall be hand polished for minimum torque and maximum sealing capability.

I. Valve shall be tested for tight shut-off per API 598 requirements.

J. Latch lock levers shall provide automatic, positive latching in the open, closed or eight intermediate positions. These valves shall allow locking in any position with a standard padlock. Infinite position levers shall allow manual throttling and locking in any position from open to close. External disc position indicators shall be provided.

K. All manually actuated valves 8" and larger shall be operated using a cast iron housed handwheel actuator available in standard, weatherproof, or buriable constructions - as required - with optional chainwheel, crank, or 2" square nut input. All units to have adjustable open and closed position stops with provision to prevent accidental adjustment changes. Operating shaft to be supported axially and radially at input end by permanently lubricated bronze thrust and sleeve bearings.

L. Butterfly valves equipped with gear or automatic operators shall have operator factory mounted and the stops factory adjusted. Loose gear operators shall not be permitted to be installed in the field. Gear operators on steam valves shall be spaced a minimum of 4” above packing assembly.

M. All automatic butterfly valves intended for exterior use shall be furnished with and wired for crankcase heaters.

2.8 BUTTERFLY VALVES (STEAM)

A. Provide high performance butterfly valve suitable for maximum operating pressure.

2” - 20”	UNDER 300 PSI	Milwaukee HP1LCS4212/4213 and HP3LCS4212/4213 Suitable for mating between Class 150/300 flanges (flat or raised face). Conforms to MSS SP68.

B. Body: Carbon Steel

C. Body Style: Tapped Lug (full flange)

D. Trim: 316 Stainless Steel Double Offset Stem

E. Disc: 316 Stainless Steel

F. Seat: High temperature RTFE, fully bi-directional, dead-endable

G. Seat Working P/T Rating: 100 psig @ 450˚F Minimum

H. Body Working P/T Rating: ANSI 150

I. Actuator: Handwheel Gear Operator

J. Provide external disc position indicators.

2.9 GATE VALVES (Water)

A. Manufacturers:

1. Design Basis: Milwaukee
2. Other Acceptable Manufacturers:
   a. Crane
   b. Nibco
   c. Stockham
   d. Gruvlok
   e. Hammond

2” AND SMALLER	UNDER 400 PSI	Milwaukee Model 1151/1182 Bronze Gate Valve, 300/1000 PSI WOG Non-Shock, Heavy Duty Service, Solid Wedge Disc, Rising Stem, Stainless Seat, Union Bonnet, Threaded Ends
2 ½” AND LARGER	UNDER 200 PSI	Milwaukee Model F-2885 Cast Iron Body, 125 PSI Fluid Pressure to 450 deg. F. 200 PSI Non-Shock Cold Water, Oil or Gas. -200 deg. F. to 150 deg. F, or -29 deg. C to 66 deg. C, Bronze Trim, OS & Y, Bolted Bonnet, Solid Wedge, Flanged Ends
	OVER 200 PSI	Milwaukee Model F-2894 Iron Gate Valve, 250 SWP – 450 deg. F., 500 WOG Non-Shock, Solid Wedge Disc, OS&Y, Bolted Bonnet, Gland Packed. Flanged Ends

B. Gate valves shall not be used for refrigerant systems.

C. All gate valves within the building shall be wedge gate valves with painted iron wheels handles, shall have gland followers in stuffing boxes, and shall be constructed that they may be repacked while open and under pressure. All valves shall have the name of the manufacturer and working pressure cast or stamped thereon.

D. Select and install valves with outside screw and yoke stems, except provide inside screw non-rising stem valves where headroom prevents full opening of OS&Y valves.

2.10 GATE VALVES (Steam)

A. Manufacturers:

1. Design Basis: Milwaukee
2. Other Acceptable Manufacturers:
   a. Crane
   b. Nibco
   c. Stockham
   d. Victaulic (for Grooved Pipe Systems)
   e. Gruvlok
   f. Hammond

2" AND SMALLER	UNDER 200 PSI	Milwaukee Model 115/1182 Bronze Gate Valve, 300/1000 PSI WOG Non-Shock, Heavy Duty Service, Solid Wedge Disc, Rising Stem, Stainless Seat, Union Bonnet, Threaded Ends
2 ½" AND LARGER	UNDER 125 PSI	Milwaukee Model F-2885 Cast Iron Body, 125 PSI Fluid Pressure to 450 deg. F, Stainless Steel Trim, OS & Y, Bolted Bonnet, Solid Wedge, Flanged Ends

2.11 BALL VALVES (Water, *Low Pressure Steam, Low Pressure Condensate)*

A. Manufacturers:

1. Design Basis: Milwaukee
2. Other Acceptable Manufacturers:

   a. Apollo
   b. Dyna Quip
   c. Hammond
   d. Victaulic (for Grooved Pipe Systems)
   e. Watts
   f. Bray
   g. Gruvlok
   h. Stockham

3" and above	UNDER 300 PSI	Milwaukee BA400 Bronze body, Threaded, Full Port, SST Trim, Blowout-Proof Stem, 300 lb. WOG 150 PSI Non-Shock Cold Working Pressure, 150 PSI/Saturated Steam. Conforms to MSS SP-110 Reinforced Teflon seat
2½" and below	UNDER 300 PSI	Bronze body, standard port, 316 SST ball, 316 SST stem, Stem extension for insulated applications, RTFE seat, 15% glass filled double seal, Seat working rating 300 PSIG, 250°F minimum, Body working rating 300 PSIG 300°F minimum. 300 PSI WOG. 150 PSI steam

B. Options: Provide the following where required:

1. Extended stems for insulated valves.
2. Memory stop device for balancing applications.
3. Tee handle for tighter areas.
4. Hose end and cap for drain.
5. Mounting pads for actuator.
6. Provide “stop and drain” for compressed air.

C. Hydronic piping grooved end ball valves, 1-1/2” through 6”, shall be ductile iron, chrome-plated carbon steel ball and stem, TFE seats, fluoroelastomer seals, lever handle or gear operator with hand wheel. Valve shall be suitable for shutoff service at 800 psi CWP and NACE compliant for fuel oil service. Victaulic Series 726.

2.12 BALANCING VALVES

A. Manufacturer, variable orifice type circuit setter:

1. Armstrong
2. Victaulic/Tour and Andersson
3. Nibco
4. Oventrop

2” AND SMALLER	UNDER 300 PSI	Armstrong CBV-VS/VT Brass alloy body/stem and disk, 300 PSI Max. Working Pressure, -4°F to 300°F Operating Temperature Range, Threaded or Solder Connections Victaulic/Tour & Andersson Series 786, 787, 78K A metal brass copper alloy body, EPDM o-rings, 4-turn digital hand wheel for balancing, soldered or threaded end connections, 250°F temperature rating.
	UP TO 350 PSI	Oventrop Hydrocontrol R Bronze alloy body/ brass alloy stem and disk, 7-turn minimum veneer/digital hand wheel, threaded or solder end connections, 300°F rated operating temperature
2 ½” AND LARGER	UNDER 125 PSI	Armstrong CBV-FS/FA 125 PSI rating, Cast Iron valve body, Bronze disc, Brass stem, Stainless Steel spring, Straight or Angle
	UP TO 350 PSI	Victaulic/Tour & Andersson Series 789. Ductile iron body, EPDM o-rings, multiple-turn digital readout handwheel for balancing, flanged or grooved end connections, 250 deg F temperature rating. Oventrop Hydrocontrol G Cast iron body / brass alloy stem and disk, 8-turn minimum veneer/digital hand wheel, grooved end connections, 300°F rated operating temperature.

B. Manufacturers, valve and venturi type:
   1. Flowset
   2. Gerand
   3. Griswold
   4. HCI
   5. Nexus
   6. Oventrop
   7. Preso

C. Connections: Threaded, soldered, grooved, or flanged.

D. Pressure Reading Ports:

   1. "P/T" Ports, Shraeder valves, or Hansen type quick connect. No "refrigeration" fittings.

E. Design, variable orifice type:

   1. Globe-type valve.
   2. Multiple turns of handwheel from full closed to full open.
   3. Bubble-tight shut-off.
   4. Taps upstream and downstream.
   5. Memory stop device to allow valve to be returned to balanced position after being closed.

F. Design, valve and venturi type:

   1. Ball valve complying with the above requirements for ball valves.
   2. Fixed orifice or venturi, upstream of valve.
   3. Taps on venturi, upstream and downstream.
   4. Memory stop device to allow valve to be returned to balanced position after being closed.
   5. Regardless of the manufacturer's claims, these valves shall not be considered as tight shut off for service. Provide additional valves for equipment isolation.

G. Insulation: Provide premolded insulation conforming to the valve body. Material shall have a flame spread of 25 and a smoke development of 50.

H. Where application or building height causes working pressure to exceed 150 psi. Provide 2" and smaller: Crane No. 80E, 250 lb. WSP, bronze; 2 ½" and larger: use globe.

I. Balancing Cocks: Up to 2"

   1. Bronze.
   2. Screwed 120 psi WSP Class; similar to Fig. 554.
   3. 250 psi WSP Class; similar to Fig. 576.

J. Balancing Cocks 2½ and 3”

1. Iron body similar to Walworth Co.
2. Screwed.
3. 120 psi WSP Class; similar to Fig. 651.
4. 250 psi WSP Class; similar to Fig. 671.

K. Balancing cocks 4” and above

1. Provide flanged lubricated plug valve.

2.13 COMBINATION THROTTLING/CHECK/SHUTOFF VALVES

A. Manufacturers:

1. Basis of Design: Armstrong Flo-Trex Valve.
2. Other Acceptable Manufacturers:
   a. Bell and Gossett
   b. Taco
   c. Victaulic (for Grooved Pipe Systems)
   d. Watts

B. Features:

1. 150 psi, 230ºF water working pressure.
2. Globe style valve with stainless steel spring loaded brass disk guided and limited by a brass or stainless steel stem.
3. Resilient seat.
4. Able to be re-packed under pressure.

C. Tri-Duty Valve Assembly: Combination shutoff, throttling, and non-slam check service in one unit, with pressure rating up to 300 psig at 230 deg F. Victaulic Vic-300 MasterSeal™ butterfly valve and Series 716H/716 check or 779 venturi check valve with flow measurement capabilities assembled with Victaulic couplings (style to be determined by system requirements). For sizes 14” through 24”, assembly shall consist of Vic-300 AGS butterfly valve and Series W715 dual disc design check valve with pressure rating up to 250 psig at 230 deg F.

2.14 SUCTION DIFFUSERS

A. Manufacturers:

1. Basis of Design: Armstrong
   a. Bell & Gossett
   b. Taco
   c. Victaulic (for grooved pipe systems)
   d. Watts

B. Features:

1. 150 psi, 230ºF water working temperature.
2. Strainer shall be 1/8” perforated stainless steel.
3. Provide a removable cover for easy access to the strainer.
4. Ductile iron body.

C. Pump suction diffuser with grooved inlet and straight, single, or double reduction flanged outlet, ASTM A395 ductile iron body, Type 304 stainless steel frame and perforated sheet diffuser with 5/32” diameter holes, Type 304 stainless steel 20-mesh startup pre-filter, pipe plug for system drainage, and bosses for support. Victaulic Series 731-D rated to the working pressure of the mating flange.

D. Pump suction diffuser 14” through 24” shall have an AGS grooved inlet and Class 150 flanged outlet connection. ASTM A536 ductile iron body, Type 304 stainless steel frame and perforated sheet diffuser with 5/32” diameter holes. Type 304 stainless steel 20-mesh startup pre-filter, pipe plug for system drainage, and bosses for support. Victaulic Series W731-I rated for 300 psig CWP.

2.15 DRAIN VALVES

A. Gate or ball valve with hose end adapter and cap. Milwaukee BA100H or approved equal.

B. Drain valves: 2” and smaller: Crane No. 451, 300 lb. WOG, non-rising stem, Hose end, bronze with bronze cap and chain.

C. Where application or building height cause working pressure to exceed 150 psi provide Crane No. 453, 300 lb. WOG, non-rising stem, hose for valves 2” and smaller.

2.16 PLUG VALVES

A. Manufacturers:

1. Design Basis: Homestead
2. Other Acceptable Manufacturers:
   a. DeZURIK
   b. Victaulic (For grooved pipe systems)

B. Model: Series 600 (ANSI class 125) cast-iron, full port body; EPDM coated plug; welded nickel seat; stainless steel bearings; integral memory stop device.

C. Lubricated Plug Valves:

1. Full port opening tapered plug suitable for lubrication under service pressure with plug in any direction.

2. Lubricating Guns:
   a. One for every 10 valves.

b. Extra heavy, lever type, hydraulic hand gun.
c. 15,000 psi gauge and 12" long connection hose.
d. Similar to Walworth #1699 or approved equal.

3. Lubricant:
a. Manufacturer's recommendations.
b. One year supply, each valve.

4. Operators:
a. 4" to 6", wrench, except as noted. Provide wrench set for each size valve, one wrench for every 10 valves, each size.
b. 8" and larger: Gear operated with permanently installed handwheel.

5. Valve Construction

a. Piping less than 100 psi: 200# WOG Class, cast iron body.
b. Piping 100 psi to 250 psi: 500# WOG Class, cast iron body.
c. Piping over 250 psi: 720# WOG Class, carbon steel body.
d. Up to 2": screwed. 2½ " and larger: flanged, USAS 250#.
e. Similar to the following Walworth figure numbers:

Class	4"	5" & 6"	8" & 12"
200#	1700F	1705F	1727F
500#	2720F	2721F	2721F
720#	1760F	1761F	1764F

6. In lieu of lubricated plug valves use DeZURIK BOS-US for piping up to 250 psi. For piping above 275 psi use DeZURIK BHP high performance butterfly valve.

D. Non-Lubricated, Eccentric Type Plug Valves:

1. 175 psi CWP, ductile iron body and plug, EPDM plug coating, welded-in nickel seat, grooved ends, lever handle or gear operator with hand wheel. Victaulic Series 377.

PART 3 - EXECUTION

3.1 GENERAL

A. Furnish all valves as indicated on the plans, and as may be required for the proper control of the pipe lines installed under this Specification, so that any fixture, line or piece of apparatus may be cut out for repair without interference or interruption of the service to the rest of the Building.

B. Install valves where required for proper operation of piping and equipment including valves in branch lines necessary to isolate sections of piping. Whether they are shown on the drawings or not, provide isolation valves at the following locations:

1. All branch piping connections to risers
2. All branch piping connections to piping mains
3. Branch piping at each mechanical room
4. Each piece of equipment, fixture, and appliance so that the supply and return services can be shut off to remove the item without draining the remainder of the piping system

C. Provide drain valves at main shut-off valves, all low points of piping and apparatus.

D. Install check and globe valves on downstream side of the shutoff valve on hot water circulating riser and branch lines.

E. Provide shut-off valves and check valves on each pump discharge line.

F. Locate all valves so as to be accessible.

G. All valves shall be installed as per manufacturer's recommendations.

H. Combination balancing and shut-off valves may be used instead of a separate balancing valve and shut-off valve if the valve has a memory stop and the manufacturer lists its use as a leak-proof service valve

I. Valves, where exposed and used in connection with finished piping, shall be same finish as the pipe.

J. Install valves with bodies of metal other than cast iron where thermal or mechanical shock is indicated or can be expected to occur.

K. Do not install bronze valves and valve components in direct contact with steel, unless bronze and steel are separated by dielectric insulator. Install bronze valves where corrosion is indicated or can be expected to occur.

L. Limit selection and installation of valves with non-metallic discs to locations indicated and where foreign material in piping system can be expected to prevent tight shutoff of metal seated valves.

M. Select and install valves with renewable seats, except where otherwise indicated.

N. All valves shall have the trademark of the manufacturer and the guaranteed working pressure cast or stamped on the body of the valve.

O. Provide separate support for weight of valve where necessary.

P. Install all valves except butterfly with stems pointing up, and as close to vertical as possible. Butterfly valves to be offset at least 10° from vertical. All steam butterfly valves shall be installed at least 30° off vertical to protect the bottom bearing from debris. Do not allow meter connections of balancing valves to point downward.

1. Exception: All butterfly valves 12” and larger shall be installed with stems pointing straight up in the vertical position.

Q. Except as otherwise indicated, install gate, ball, globe, and butterfly valves to comply with ANSI B31.1.

R. All valves of a given type shall be of one manufacturer.

S. Provide extended stems on insulated system to prevent interference of operator with insulation.

T. Provide chain wheel operators for valves more than 7’ – 0” AFF in mechanical rooms and wherever shown on drawings.

U. Provide ball valves for shut-off on all pressure gauges at the gauge and separate 1/2" (one half inch) ball valves for the various taps to the gauge on a manifold gauge.

3.2 CHECK VALVE INSTALLATION

A. Swing and Check Valves:

1. Install only in horizontal lines unless absolutely impractical. If installed vertically, flow shall be upwards.
2. Do not install in pump discharge piping.

B. Silent Check Valves:

1. Install in all pump discharge lines.
2. Silent check valves may be installed in vertical pipes with flow down upon Engineer’s review for each instance.

C. Installation of Check Valves:

1. Wafer Check Valves: Install between 2 flanges in horizontal or vertical position.
2. Horizontal Lift Check Valve: Install in horizontal piping line with stem vertically upward.
3. Vertical Lift Check Valve: Install in vertical piping line with upward flow with stem vertically upward.
4. Air Compressor Lift Check Valve: Install in air compressor discharge line.
5. Spring Loaded Horizontal Lift Check Valve: Install in horizontal piping line with stem vertically upward.

3.3 VALVES USED FOR THROTTLING/BALANCING

A. Balancing valves shall not be used for flow indication in pipes 2½” and larger, or in pump discharge piping.

B. Flow indication in piping 2½” and larger and in pump discharge piping, shall be by a venturi with a plug, butterfly, or globe valve for throttling.

C. Throttling/Balancing Valves shall be selected so that the maximum design flow causes between 1’ and 10’ W.G. pressure drop or meter reading with the valve wide open.

D. Install balancing valves (excluding flow limiters) used for flow indication with a minimum of ten times pipe diameters downstream of a pump, five times the pipe diameter downstream and two times the pipe diameter upstream of a fitting or valve, unless otherwise specified by the valve manufacturer.

E. Circuit setters or plug valves may be used for throttling/balancing. Provide an infinitely variable, lockable memory stop device to allow the valve to be returned to the “balanced” position after closing, and to prevent movement of the disk or plug during operation. When ball valves are used for throttling, provide an additional valve for equipment isolation.

3.4 COMBINATION THROTTLING/CHECK VALVES

A. Combination throttling/check valves may be used in lieu of separate throttling and check valves on pump discharge piping. However, they may not be used for flow measurement.

END OF SECTION

SECTION 23 05 29

PIPE SUPPORTS AND ANCHORS

PART 1 - GENERAL

1.1 STANDARDS

A. Comply with MSS Standard Practice SP-58, SP-69 and SP-89, published by Manufacturer's Standardization Society of the Valve and Fitting Industry for type and size.

1.2 SUBMITTALS

A. Submit manufacturer's product data on the following:

1. Hangers other than clevis type.
2. Anchors.

B. Submit structural calculations for trapeze type supports.

PART 2 – PRODUCTS

2.1 PIPE HANGERS

A. General:

1. Use adjustable pipe hangers on suspended pipe. Trapeze hangers may be used at the Contractor's option. Contractor shall be responsible for sizing supports.
2. Chain, wire or perforated strap hangers will not be permitted.
3. Isolate hangers in contact with dissimilar materials with dielectric hanger liners. Tape is not acceptable.
4. Provide supports between piping and building structure where necessary to prevent swaying.

B. Hanger Rods:

1. Exposed in public areas: Zinc electroplated steel.
2. Concealed or in service areas: Black threaded steel.
3. Outside, exposed to weather: Hot dipped galvanized.

C. Spot Concrete Inserts: Steel case and expander plug for threaded connection with lateral adjustment, top slot for reinforcing rods and lugs for attaching to forms.

1. Size inserts to match size of threaded hanger rods.
2. Inserts to be UL and FM listed.
3. Minimum 1000 lb. Capacity with ½" rod.

D. Channel Type Inserts:

1. Standard channel support with anchor tabs on 4" centers, and nail holes for attaching to forms.
2. Styrofoam inserts to prevent wet concrete seepage.
3. Minimum 2000 pounds/foot capacity.

E. Expansion Anchors:

1. For use only in renovations or where modifications to piping layouts require installation away from pre-installed insert locations.
2. Inserts shall be of the drill, insert, and expand type. Power driven fasteners are not acceptable for piping.
3. Contractor shall select the appropriate type based on the following:

Rod Size	Maximum Working Load
3/8	600 pounds
½	1100 pounds
5/8	1800 pounds
¾	2700 pounds
7/8	3700 pounds
1	5300 pounds

F. Steel Structure Attachments:

1. Contractor may select welded or mechanically attached. All mechanically attached supports shall have jam nuts or other means to prevent loosening. Maximum loading requirements are as follows:

Rod Size	Maximum Working Load
3/8	600 pounds
½	1100 pounds
5/8	1800 pounds
¾	2700 pounds
7/8	3700 pounds
1	5300 pounds

G. Single Hangers:

1. Piping 2" and smaller: MSS type 1, Clevis hanger or type 7 adjustable swivel ring hanger. Minimum 180 pounds design load.
2. Piping 2" and smaller (steel): Clevis hanger, Anvil Fig. No. 260, F & M Fig. No. 239, Paterson Fig. No. 100.
3. Piping 2" and smaller (copper): Adjustable wrought iron, Anvil Fig. No. CT-65, F & M Fig. No. 364, Paterson Fig. No. 100 CT
4. Piping 2½" and larger: MSS type 1 Clevis hanger.
5. Piping 2½" to 4" (steel): Adjustable swivel pipe roll, Anvil Fig. No. 181, F & M Fig. No. 2729, Paterson Fig. No., 16.

6. Piping 2½” to 4” (copper): Adjustable wrought ring, Anvil Fig. No. CT-69.
7. Piping 5” and above: Two rod roller hanger, Anvil Fig. No. 171, F & M Fig. No. 170, Paterson Fig. No., 142.
8. Bare copper pipe: Above hangers, plastic or Neoprene coating, sized for copper pipe O.D. and copper coated for identification.
9. Insulated pipe: Hangers to be sized for O.D. of insulation. Hangers shall not penetrate any insulation.
10. Cast iron pipe above hangers sized for O.D. of cast iron pipe.
11. Hanger wire, cable or perforated metal strapping are not acceptable.

H. Trapeze hangers and wall supports:

1. Channel strut or structural steel shapes. Contractor shall follow channel strut manufacturers guidelines for loading or provide structural steel supports designed by a professional Engineer, licensed in the state where the project is located.
2. All piping shall be attached to the support by means of a channel strut clamp, U-bolt, or pipe rollers which will maintain lateral position of the pipe but allow longitudinal movement. Provide dielectric isolation between all dissimilar metals.
3. All insulation shall be continuous at supports. Do not notch or penetrate insulation or vapor barrier.
4. Kindorf or similar materials used for support of small piping shall not be used for piping 3” or larger.
5. ½” through 3”: Unistrut type channel and steel clamp.
    a. Use Hydrosorb cushions on copper pipe.
6. 4” and Over: Welded steel bracket and wrought steel clamp.

I. Vertical Supports: Provide steel riser clamp at each floor penetration or every 14 foot supported from wall bracket. Do not anchor riser clamps.

J. Hangers:

1. General: Adjustable wrought steel clevis with locking nut attachment.
2. Multiple or Trapeze: Steel channels with welded spacers and hanger rods.
3. Hanger Sizes and Spacing:
    a. For drain piping, conform to the code requirements for spacing, and the following table for hanger rod sizes.
    b. For steam and hydronic piping, conform to the following table:

PIPE TYPE	PIPE SIZE	MAXIMUM HORIZONTAL SPACING	MAXIMUM VERTICAL SPACING	MINIMUM HANGER ROD SIZE
Steel and	½”	6’-0”	15’-0”	3/8”
Stainless Steel	¾” thru 1¼”	8’-0”	15’-0”	3/8”
Pipe	1½” and 2”	10’-0”	15’-0”	3/8”
	2½” thru 3½”	12’-0”	15’-0”	½”
	4” and 5”	12’-0”	15’-0”	5/8”
	6”	12’-0”	15’-0	¾”
*	8” thru 12”			7/8”
Copper Pipe	½” thru 1”	8’-0”	10’-0”	3/8”
	1¼” thru 2”	10’-0”	10’-0”	3/8”
	2½” thru 3”	10’-0”	10’-0”	½”
	4”	10’-0”	10’-0”	5/8”
	6”	10”-0”	10’-0”	¾”
Copper Tubing	1¼ “ and below	6’-0”	10’-0”	3/8”

* Submit routing and support plans to Architect/Engineer for review.

K. Insulated Pipe Supports:

1. Size pipe supports for outside diameter of pipe insulation.
2. It is not acceptable to notch insulation or vapor barrier at supports.

L. Pipes over five inches and over 120ºF: Provide cast iron roller supports.

M. Beam clamps - Hangers supported from floor steel shall be approved I beam clamps. I beam clamps for hangers supporting piping 2 inches and smaller shall be C & P Fig. No. 148 adjustable beam clamps. For piping 2-1/2 inches and larger, I beam clamps shall be wrought steel. C & P Fig. No. 268 or equal.

N. Hangers for copper piping shall be copper plated.

2.2 INSULATION INSERTS

A. Pipe shall be protected at the point of support by an insert of high density, foam glass insulation, encased in a sheet metal shield. Insert to be same thickness as adjoining pipe insulation. Insulation insert to extend one inch beyond sheet metal shield on all “cold” lines. If pipe hanger spacing exceeds ten feet and for all pipe roller applications, utilize double layer shield on bearing surface.

B. Provide 180º insulation inserts when utilizing clevis hangers. Provide 360º insulation inserts at all trapeze and wall supports.

2.3 PIPE ANCHORS

A. Manufacturers:

1. Design Basis: Flexonics
2. Other Acceptable Manufacturers:
    a. Adsco
    b. Keflex
    c. Hilti

B. Model AC with threaded ends and welded angle brackets for steel pipe.

C. Model AC copper tube with solder ends and steel angle brackets brazed to tubing for copper tube.

D. Anchors may be field fabricated similar to manufactured products specified.

2.4 PIPE GUIDES

A. Manufacturers:

1. Basis of Design: B-line.
2. Other Acceptable Manufacturers:
    a. Fee & Mason
    b. Anvil
    c. M-Co
    d. PHD

B. Any of the Following:

1. Spider Type: B3281-7.
2. Roller Type: 2 sets of roller son opposite sides of pipe.
3. Slide Type: B3893 with hold down lugs.
    a. Not for use with cold piping.
4. Light duty, 1½” and smaller copper: U bolt or channel strut clamp (B2417) allowing clearance from O.D. of pipe or insulation.

2.5 ROOF MOUNTED PIPING

A. Manufacturers:

1. Miro Industries, Inc.
2. Portable Pipe Hangers, Inc.
3. Approved Equivalent.

B. Where roofing is not being replaced piping on roof shall be supported by an engineered prefabricated portable pipe system specifically designed to be installed on the roof without roof penetrations, flashing or damage to the roofing material. The system shall consist of recycled rubber or plastic bases, hot dipped galvanized or stainless steel frame with threaded rods and suitable pipe hangers and supports. The system shall be custom designed to fit the piping and conduits to be installed and the actual conditions of service.

C. Provide seismic restraints as required for seismic zone.

D. Piping on areas of roof being replaced shall be installed on pipe curbs bearing on roof structure and flashed into roofing material.

PART 3 – EXECUTION

3.1 INSTALLATION OF PIPE SUPPORTS

A. Adequately support piping from the building structure with adjustable hangers to maintain uniform grading where required and to prevent sagging and pocketing.

1. Provide supports between piping and building structure where necessary to prevent swaying.
2. Do not support pipe from other pipe or equipment.

B. Install hangers to provide minimum ½” clear space between finished covering and adjacent work.

1. Place a hanger within one foot of each horizontal elbow.
2. Space hangers generally as called for in Table in Part 2, Products.

C. Use hangers, which are vertically adjustable 1-½” minimum after piping is erected.

D. Use inserts for suspending hangers from reinforced concrete slabs and sides of reinforced concrete beams wherever practicable.

1. Set inserts in position in advance of concrete work.
2. Where concrete slabs form finished ceiling, finish inserts flush with slab surface.
3. Do not penetrate concrete “TT” legs for piping inserts. Do not penetrate the stressed (i.e. lower) chords of any structural member.

E. Provisions for Movement: Install hangers and supports:

1. To allow controlled movement of piping systems.
2. To permit proper movement between pipe anchors.
3. To facilitate the action of expansion joints, expansion loops, bends and offsets.
4. To isolate force due to weight or expansion from equipment connections.

F. In general, attach hangers to upper chord of roof trusses and floor joists, using long rods to facilitate pipe movement.

G. Anchors:

1. Use no pipe anchors. Arrange piping such that pipe expansion and contraction is accommodated by controlled movement of the pipe within the pipe supports. Provide sufficient offsets in branch piping to accommodate movement of main piping due to expansion and contraction. Where this is not possible due to building geometry or other reasons, securely anchor piping where indicated or where required for a proper installation and to force the pipe expansion in the proper direction.
2. Anchors shall be suitable for the location of installation and shall be designed to withstand not less than five times the anchor load.
3. Anchor vertical pipes by means of clamps welded around pipes and secured to wall or floor construction. Anchor at bottom of riser only but provide guides for vertical thermal movement.
4. All anchors shall be separate and independent of all hangers, guides, and supports. Anchors shall be of heavy blacksmith construction suitable in every way for the work approved by the Architect. Anchors shall be welded to the pipe and fastened to the structure with bolts.
5. Anchors shall be fabricated and assembled in such a form as to secure the piping in a fixed position. They shall permit the line to take up its expansion and contraction freely in opposite directions away from the anchored points: and shall be so arranged as to be structurally suitable for particular location, and line loading. Submit details for approval.

H. All heavy piping, such as individual pipes having a nominal diameter greater than 12 inches, groups of pipes consisting of more than three 8 inch, or more than two 10 inch pipes and any combination of closely spaced pipes weighing more than the equivalent of above or 15 lb. per linear foot shall be supported at all cross points with overhead floor beams by fastening to the flanges of such beams with steel clamps or other suitable means.

I. Where such heavy piping runs parallel with the floor beams properly designed auxiliary steel must be provided. The spacing of such auxiliary steel supports shall in no case be greater than the spacing of the floor beams running perpendicular to the corrugations of the permanent slab steel forms. The Contractor shall be responsible for designing such system.

J. Assume the responsibility for the proper transfer of the loads to the piping systems to the structure. No additional cost to the owner should be expected for any corrective work during construction.

K. Provide necessary structural members, hangers, and supports of approved design to keep piping in proper alignment and prevent transmission of injurious thrusts and vibrations. In all cases where hangers, brackets, etc., are supported from metal decking and/or concrete construction, care shall be taken not to weaken decking and/or concrete or penetrate waterproofing. Hangers supporting piping expanding into loops, bends and offsets shall be secured to the building structure in such a manner that horizontal adjustment perpendicular to the run of piping supported may be made to accommodate displacement due to expansion. All such hangers shall be finally adjusted, both in the vertical and horizontal direction, when the supported piping is hot, or chilled, as required.

L. Provide supplemental bolted steel in all locations where drilling of slab will create unacceptable noise in adjacent spaces.

M. Where piping is run near the floor and not hung from the ceiling construction but is supported from the floor, such supports shall be of pipe standards with base flange and adjustable top yoke similar to C & P Fig. 247 or equal.

N. All vertical piping shall be anchored by means of heavy steel clamps securely bolted or welded to the piping, and with end extension bearing on the building.

O. Vertical runs of pipe not over 15 feet long shall be supported by hangers placed not over one foot from the elbows on the connecting horizontal runs.

P. Vertical runs of pipe over 15 feet long but not over 60 feet long and not over 6 inches in size, or not over 30 feet long and not over 12 inches in size, shall be supported on heavy steel clamps. Clamps shall be bolted tightly around the pipes and shall reset securely on the building structure without blocking. Clamps shall be welded to the pipes or placed below couplings. Clamps shall be type 8, Federal Specification WW-H-171C, unless other types are approved.

Q. For all chilled water and makeup water and insulated refrigerant piping, provide "Insulshield" as made by Insulcoustic Corp. or pipe covering protection shield F & S Fig. 980 with steel shield, with vapor barrier jacket. For steam, condensate, hot fuel oil and hot-water heating piping 2 inches and smaller, same as above. For steam, condensate and hot-water heating piping 2-1/2 inches and larger, provide steel pipe covering protection saddles F & S Fig. 900 series. Sized to fit insulation as specified.

R. Piping in trenches shall hang from angle iron cross supports provided by the Contractor with two coatings of red led primer and final coat of black asphaltum paint.

S. Hanger rods shall be attached to preset concrete inserts with steel reinforcing rod through the insert and both ends hooked over the reinforcing mesh. For pipes 4 inches and larger, rods shall extend through concrete slab above where they shall be attached to steel bearing plates 6" x 6" x 1/4".

T. Piping shall not be hung from other piping, ducts, conduits or from equipment of other trades and no vertical expansion shields will be permitted. Hanger rods shall not pierce ducts.

U. All water piping connected to rotating equipment within all mechanical spaces shall be isolated from the building structure by means of vibration hangers inserted in the hanger rods. The vibration hangers shall consist of a steel spring in combination with a double deflection neoprene element within a rectangular steel housing. Combined static deflection shall be 1.375" minimum. Hangers shall have capability of supporting the piping at a fixed elevation during installation and shall incorporate an adjusting device to transfer the load to the spring. Deflection shall be indicated by means of scale. Vibration hangers shall be type PCDNHS made by Mason Industries.

V. All steam condensate piping within all mechanical spaces shall be isolated from the building structure by means of double deflection neoprene vibration hangers inserted in the hanger rods. The vibration hangers shall consist of a double deflection neoprene element within a rectangular steel housing. Minimum static deflection shall be 1.375". Vibration hangers shall be type PCDNHS as made by Mason Industries.

W. All piping running on walls shall be supported by means of hanger suspended from heavy angle iron wall brackets. No wall hooks will be permitted.

END OF SECTION

SECTION 23 05 30

ELECTRONIC SPEED CONTROLLERS

PART 1 – GENERAL

1.1 SUBMITTALS

A. Submit manufacturer's product data for each unit. Include:

1. Capacity:
    a. Horsepower
    b. Voltage
    c. Amps – both input and output
2. Wiring Diagrams:
    a. Include diagrams for basic unit and for all required accessories.
    b. Provide control wiring connections
3. Dimensions.
4. Installation instructions.
5. Description of diagnostic system.
6. Options provided.
7. BIM objects containing IFC parameters and associated data applicable to building system requirements.
8. Compliance to IEEE 519 – harmonic analysis for particular jobsite including total harmonic voltage distortion and total harmonic current distortion (TDD).
    a. The VFD manufacturer shall provide calculations; specific to this installation, showing total harmonic voltage distortion is less than 5%. Input filters shall be sized and provided as required by the VFD manufacturer to ensure compliance with IEEE standard 519. All VFD's shall include a minimum of 5% impedance, no exceptions.
    b. Notwithstanding the calculations specified above, provide harmonic filters on all drives with an input current rating higher than 78 amps.
9. Vendor shall program one drive of each type (pump, fan, etc.) and submit a complete listing of parameters to engineer for review with commissioning authority before proceeding with programming of all drives. Provide a complete listing of all parameters for each drive as both a hard copy and electronically in both text format and the format of the manufacturer's communication/service program.
10. The VFC manufacturer shall submit a list of all parameters with a suggested setting for each drive's specific application.
11. The VFD manufacturer shall submit documentation that the drive is capable of continuous operation at a minimum of 110% of motor nameplate rating, including the service factor.

1.2 QUALITY ASSURANCE

A. Referenced Standards:

1. Institute of Electrical and Electronic Engineers (IEEE) Standard 519-1992, IEEE Guide for Harmonic Content and Control.
2. Underwriters laboratories UL508C
3. National Electrical Manufacturer's Association (NEMA) ICS 7.0, AC Adjustable Speed Drives
4. IEC 16800 Parts 1 and 2
5. National Electric Code (NEC) NEC 430.120, Adjustable-Speed Drive Sys
6. International Building Code (IBC)
   a. IBC 2006 Seismic – referencing ASC 7-05 and ICC AC-156

PART 2 - PRODUCTS

2.1 GENERAL

A. Manufacturer:

1. Basis of Design:
   a. ABB ACH 550
2. Other Acceptable Manufacturers (provided the submitted model adheres to the spec.):
   a. Allen Bradley 700 Series
   b. Eaton SPX 9000
   c. Hitachi SJ700

B. Drive shall convert the constant frequency AC line voltage to a variable frequency, variable voltage AC output suitable for control of a standard NEMA design B induction motor over a 10:1 speed range and with full load amp rating between 65% and 130% of the drive full load current capability and without modification to the motor or the drive.

C. Variable frequency drives for all three phase motors shall have the following features:

1. Drive input: 208 or 480 volts +30% to -35%, 3 phase, 60 Hz.
2. Drive output: 0-208 or 0-460 volts, 3 phase, 0-80 Hz. For efficient operation of a variable torque load.
3. Operating conditions: Capable of continuous operation at 0 to 50^0 C (-10 to 122^0 F) ambient temperature
   a. Provide conformal coating on all printed circuit boards
4. Drive type: Pulse width modulation type, designed to minimize harmonic generated noise in the motor.
5. Enclosure type: UL type as required for location.
   a. Drives shall be UL listed as a plenum rated VFD
   b. See additional enclosure requirements herein.
6. AC line circuit breaker.
7. Input fuses for the VFD which shall ensure operation of the bypass in the event of the short circuit of the VFD
8. The input current rating of the VFD shall be no more than 3% greater than the output current rating.

9. Provide VFD one horsepower size higher than motor size for drives where input current rating of the VFD is more than 3% greater than the output current rating.
10. Coordinate additional costs with contractor, ensure no additional cost to engineer and/or owner.
11. Metal oxide varistors on incoming line for transient protection.
12. All VFD's shall include EMI/RFI filters. The onboard filters shall allow the VFD assembly to be CE Marked and the VFD shall meet product standard EN 61800-3 for the First Environment restricted level with up to 100 feet of motor cable. No Exceptions. Certified test reports shall be provided with the submittals confirming compliance to EN 61800-3, First Environment.
13. The VFD and Bypass shall be rated 100,000 SCCR for short circuit interrupt.
    a. The installation fuses is not an acceptable design for SCCR rating.
14. 120 volt Control power transformer with fused primary and fused secondary.
    a. Control power shall be fed from the DC bus.
    b. Control contactors shall be 120V; 24 V are not acceptable.
15. The Keypad shall include a backlit LCD display. The display shall be in complete English words for programming and fault diagnostics (alpha-numeric codes are not acceptable). All VFD faults shall be displayed in English words. The keypad shall include a minimum of 14 assistants including:
    a. Start-up assistant
    b. Parameter assistants
        1) PID assistant
        2) Reference assistant
        3) I/O assistant
        4) Serial communications assistant
        5) Option module assistant
        6) Panel display assistant
        7) Low noise set-up assistant
    c. Maintenance assistant
    d. Troubleshooting assistant
    e. Drive optimizer assistants
    f. All applicable operating values shall be capable of being displayed in engineering (user) units. A minimum of three operating values from the list below shall be capable of being displayed at all times. The display shall be in complete English words (alpha-numeric codes are not acceptable):

        Output Frequency
        Motor Speed (RPM, %, or Engineering units)
        Motor Current
        Motor Torque
        Motor Power (kW)
        DC Bus Voltage
        Output Voltage
16. Instantaneous overcurrent shutdown with indicator light when current exceeds 200%. Time-overcurrent overload protection for the motor.
17. There shall be a built-in time clock in the VFD keypad. The clock shall have a battery back up with 10 years minimum life span. The clock shall be used to date and time stamp faults and record operating parameters at the time of fault. If the

battery fails, the VFD shall automatically revert to hours of operation since initial power up. Capacitor back-up is not acceptable. The clock shall also be programmable to control start/stop functions, constant speeds, PID parameter sets and output Form-C relays.

18. Inverse characteristic time-overcurrent overload protection for the motor sized in accordance with NEC requirements.
19. Drive shall be capable of withstanding random application of an output short circuit without damage to drive components or fuses.
20. Input phase loss and undervoltage protection.
21. Torque/current limit control which will slow the motor without tripping when the motor is subjected to an overload, or slow the acceleration ramp when accelerating a high inertia load.
22. Drives shall be capable of “riding through” a momentary loss of power for up to 2 seconds.
23. Provide AC line reactors in the drive cabinet for each VFD with an input current rating above 78 Amps for protection against line notching and surges without requirement for an input isolation transformer. The VFD shall have internal 5% impedance reactors to reduce the harmonics to the power line and to add protection from AC line transients. The 5% impedance may be from dual (positive and negative DC bus) reactors, or 5% AC line reactors. VFD’s with only one DC reactor shall add an AC line reactor.
24. There shall be no VFD components shipped loose and / or mounted external to the VFD cabinet
25. Power factor shall be minimum 95% at all speeds and loads.
26. UL listed
27. Minimum and maximum speed adjustment.
28. Factory Tests: The VFD shall be tested with the system logic and given complete factory tests including simulated operation.
    a. Provide certification this test has been made for the particular units shipped for this job.
29. Field Adjustments: Independent acceleration/deceleration rates: 0.5 – 120 seconds.
30. Provide a maximum of 1000 volts at the motor terminals.

D. Control Interface Components

1. Provide every VFD complete with all control devices to accomplish each function described in the specification. Field installation of sensors, relays, terminal strips, etc. is not permitted. Provide all transducers, relays and interface devices factory installed and wired to a dedicated terminal strip to provide the following functions (described elsewhere in the specification) as follows:
    a. Proof of flow – current sensing
    b. Damper control
    c. Smoke control – all modes as described herein
    d. Broken belt
    e. Single phase protection
    f. Welded contactor

g. Amps – all phases
h. Volts – all phases

E. Serial Communications – addressable for drive and separately for the bypass

1. The VFD shall have an EIA-485 port as standard. The standard protocols shall be Modbus, Johnson Controls N2, Siemens Building Technologies FLN, and BACnet. [Optional protocols for LonWorks, Profibus, EtherNet, BACnet IP, and DeviceNet shall be available.] Each individual drive shall have the protocol in the base VFD. The use of third party gateways and multiplexers is not acceptable. All protocols shall be "certified" by the governing authority (i.e. BTL Listing for BACnet). Use of non-certified protocols is not allowed.
2. The BACnet connection shall be an EIA-485, MS/TP interface operating at 9.6, 19.2, 38.4, or 76.8 Kbps. The connection shall be tested by the BACnet Testing Labs (BTL) and be BTL Listed. The BACnet interface shall conform to the BACnet standard device type of an Applications Specific Controller (B-ASC). The interface shall support all BIBBs defined by the BACnet standard profile for a B-ASC including, but not limited to:
   a. Data Sharing – Read Property – B.
   b. Data Sharing – Write Property – B.
   c. Device Management – Dynamic Device Binding (Who-Is; I-Am).
   d. Device Management – Dynamic Object Binding (Who-Has; I-Have).
   e. Device Management – Communication Control – B.
3. If additional hardware is required to obtain the BACnet interface, the VFD manufacturer shall supply one BACnet gateway per drive. Multiple VFDs sharing one gateway shall not be acceptable.
4. Serial communication capabilities shall include, but not be limited to; run-stop control, speed set adjustment, proportional/integral/derivative PID control adjustments, current limit, accel/decel time adjustments, and lock and unlock the keypad. The drive shall have the capability of allowing the DDC to monitor feedback such as process variable feedback, output speed / frequency, current (in amps), % torque, power (kW), kilowatt hours (resettable), operating hours (resettable), and drive temperature. The DDC shall also be capable of monitoring the VFD relay output status, digital input status, and all analog input and analog output values. All diagnostic warning and fault information shall be transmitted over the serial communications bus. Remote VFD fault reset shall be possible.
5. Serial communication in bypass shall include, but not be limited to; bypass run-stop control, the ability to force the unit to bypass, and the ability to lock and unlock the keypad. The bypass shall have the capability of allowing the DDC to monitor feedback such as, current (in amps), kilowatt hours (resettable), operating hours (resettable), and bypass logic board temperature. The DDC shall also be capable of monitoring the bypass relay output status, and all digital input status. All bypass diagnostic warning and fault information shall be transmitted over the serial communications bus. Remote bypass fault reset shall be possible.
6. The VFD / bypass shall allow the DDC to control the drive and bypass digital and analog outputs via the serial interface. This control shall be independent of any VFD function. The analog outputs may be used for modulating chilled water valves or cooling tower bypass valves. The drive and bypass' digital (Form-C

relay) outputs may be used to actuate a damper, open a valve or control any other device that requires a maintained contact for operation. In addition, all of the drive and bypass' digital inputs shall be capable of being monitored by the DDC system. This allows for remote monitoring of which (of up to 4) safeties are open.

7. The VFD shall include an independent PID loop for customer use. The independent PID loop may be used for cooling tower bypass value control, chilled water value / hot water valve control, etc. Both the VFD PID control loop and the independent PID control loop shall continue functioning even if the serial communications connection is lost. As default, the VFD shall keep the last good set point command and last good DO & AO commands in memory in the event the serial communications connection is lost and continue controlling the process.

F. Harmonic Filter - provide integral harmonic filters as part of the factory assembled VFD package, completely wired including interface of all monitoring and control points to the VFD serial communications. The integral harmonic filter shall be provided as follows:

1. The harmonic filter shall be designed to filter all characteristic low frequency harmonics (5th, 7th, 11th, 13th, etc.) .
2. The filter shall consist of inductive element(s) in series with the load and an inductive-capacitive network in shunt with the load. The shunt circuit shall be tuned to 4.7 times the fundamental frequency.
3. The filter shunt circuit shall be protected by field replaceable fuses on each phase to ensure the VFD remains operational in the event of a capacitor over current or other condition causing the fuses to open. Fuses internal to the capacitor cell shall not be acceptable in lieu of field replaceable fuses.
4. The filter shall have a fuse status which is monitored by a digital input on the VFD and available to the serial communications interface.
5. The filter shall have a labeled SCCR rating of 100kA per UL 508A. An SCCR rating of EXEMPT will not be accepted as a valid alternative.
6. The Total Demand Distortion (TDD) of the current at the input terminals of the filter, in combination with the variable frequency drive, shall not exceed 5% THID at full rated load and given the filter is correctly applied.
7. The Total Harmonic Voltage Distortion (THVD) at the input terminals of the filter in combination with the variable frequency drive shall not exceed the limits defined in Table 10-2 of IEEE-519.
8. The full load efficiency of the filter shall not be less than 97% for filters larger than 5 HP or less than 98.5% for filters larger than 25 HP. The voltage regulation at the VFD terminals and attributable to the filter shall not exceed 5%. Filters with greater than 10% voltage drop, and/or filters that have capacitors in series with the VFD, are not acceptable.
9. The filter shall have a shunt capacitor in the circuit to control the capacitive VARS on the power system. The contactor shall be controlled by a digital output on the VFD. Both shunt circuit inductors and series line reactors shall be designed for harmonic filtering service and for slowing the rate of rapid current changes.

10. The inductors shall be UL component-recognized or listed and shall be built to comply to UL 508. Construction shall be of copper wire-wound on magnetic steel cores. Inductors shall be three-phase. Series line reactors shall be sized appropriately for the total connected load. Design maximum temperature rise for inductors shall be 115°C on bobbin wound and 155°C on form wound devices at rated current. Windings shall consist of copper wire or of copper foil. Terminations shall be copper alloy ring lugs, UL-recognized terminal blocks, or solid copper bus. Completed inductors shall be impregnated, using 100% solid epoxy resin. All insulation varnish systems shall be rated class H (180°C) or class R (220°C), 600V. Inductors shall be Hi-Pot tested (2,500V, 60 Hz, 1 minute) line-to-line and line-to-ground.

G. Bypass Controller - All variable frequency drives shall be equipped complete factory wired and tested bypass system consisting of a door interlocked, padlockable circuit breaker, output contactor, bypass contactor, and fast acting VFD input fuses are required. UL Listed motor overload protection shall be provided in both drive and bypass modes.

1. Drives with an INPUT Amp Rating equal to 114 Amps or greater must include a solid state soft starter in the bypass circuit. The soft starter must include a shunt contactor which will close when the motor reaches full speed.
2. The bypass enclosure door and VFD enclosure must be mechanically interlocked such that the disconnecting device must be in the “Off” position before either enclosure may be accessed.
3. The VFD and bypass package shall have a UL listed short circuit current rating (SCCR) of 100,000 amps and this rating shall be indicated on the UL data label.
4. The drive and bypass package shall be seismic certified and labeled to the IBC:
   a. Seismic importance factor of 1.5 rating is required, and shall be based upon actual shake table test data as defined by ICC AC-156.
5. Drive Isolation Fuses - To ensure maximum possible bypass operation, fast acting fuses, exclusive to the VFD, shall be provided to allow the VFD to disconnect from the line prior to clearing upstream branch circuit protection. This maintains bypass operation capability in the event of a VFD failure. Bypass designs which have no such fuses, or that incorporate fuses common to both the VFD and the bypass, will not be accepted.
6. The bypass shall include a minimum of two contactor (motor and bypass) and a lockable service switch to isolate the drive while in bypass mode. Designs that use a third contactor for drive isolation must also provide a lockable disconnect in series with the drive contactor for positive means of isolation avoiding the possibility of the drive contactor being welded closed.
7. The system (VFD and Bypass) tolerated voltage window shall allow the system to operate from a line of +30%, -35% nominal voltage range. The system shall incorporate circuitry that will allow the drive or bypass contactor to remain “sealed in” over this voltage tolerance at a minimum.
8. The bypass shall maintain positive contactor control through the voltage tolerance window of nominal voltage +30%, -35%. This feature is designed to avoid contactor coil failure during brown out / low line conditions and allow for

input single phase operation when in the VFD mode. Designs that will not allow input single phase operation in the VFD mode are not acceptable.

9. Motor protection from single phase power conditions - the bypass system must be able to detect a single phase input power condition while running in bypass, disengage the motor in a controlled fashion, and give a single phase input power indication. Bypass systems not incorporating single phase protection in bypass mode are not acceptable.
   a. All current sensing transducers to accomplish single phase detection must be factory mounted. Faults for single phase must be displayed on the keypad and communicated over serial interface.
10. The bypass system shall NOT depend on the VFD for bypass operation. The bypass system shall be designed for stand alone operation and shall be completely functional in both Hand and Automatic modes even if the VFD has been removed from the system for repair / replacement. Serial communications shall remain functional even with the VFD removed.
11. Serial communications – the bypass shall be capable of being monitored and / or controlled via serial communications. On-board communications protocols shall include ModBus; Johnson Controls N2; Siemens Building Technologies FLN (P1); and BACnet.
12. Serial communication capabilities shall include, but not be limited to; bypass run-stop control; the ability to force the unit to bypass; and the ability to lock and unlock the keypad. The bypass shall have the capability of allowing the DDC to monitor feedback such as, current (in amps), kilowatt hours (resettable), operating hours (resettable), and bypass logic board temperature. The DDC shall also be capable of monitoring the bypass relay output status, and all digital input status. All bypass diagnostic warning and fault information shall be transmitted over the serial communications bus. Remote bypass fault reset shall be possible. The following additional status indications and settings shall be transmitted over the serial communications bus and / or via a Form-C relay output – keypad "Hand" or "Auto" selected, bypass selected, and broken belt indication. The DDC system shall also be able to monitor if the motor is running in the VFD mode or bypass mode over serial communications. A minimum of 50 field serial communications points shall be capable of being monitored in the bypass mode.
13. The bypass serial communications shall allow control of the bypass' digital outputs via the serial interface. This control shall be independent of any bypass function or operating state. The bypass' digital (relay) outputs may be used to actuate a damper, open a valve or control any other device that requires a maintained contact for operation. In addition, all of the bypass' digital inputs shall be capable of being monitored by the DDC system.
14. There shall be an adjustable motor current sensing circuit for the bypass and VFD modes to provide proof of flow (broken belt) indication. The condition shall be indicated on the keypad display, transmitted over the building automation protocol and / or via a Form-C relay output contact closure. The broken belt indication shall be programmable to be a system (drive and bypass) indication. The broken belt condition sensing algorithm shall be programmable to cause only a warning or a fault and / or system shutdown.
15. The digital inputs for the system shall accept 24VAC or 24VDC. The bypass shall incorporate an internally sourced power supply and not require an external

control power source. The bypass power board shall supply 250 ma of 24 VDC for use by others to power external devices.

16. There shall be a run permissive circuit for damper or valve control. Regardless of the source of a run command (keypad command, time-clock control, digital input, or serial communications) the bypass shall provide a dry contact closure that will signal the damper to open (motor does not operate). When the damper is fully open, a normally open dry contact (end-switch) shall close. The closed end-switch is wired to a bypass system input and allows motor operation. Up to four separate safety interlock inputs shall be provided. When any safety is opened, the motor shall be commanded to coast to stop, and the damper shall be commanded to close. This feature will also operate in Fireman's override / smoke control mode.
17. The bypass control shall monitor the status of the VFD and bypass contactors and indicate when there is a welded contactor contact or open contactor coil. This failed contactor condition shall be indicated on the bypass LCD display, programmed to fire a Form-C relay output, and / or over the serial communications protocol.
18. The bypass control shall include a programmable time delay for bypass start and keypad indication that this time delay is in process. A Form C relay output provides a contact closure to signal the VAV boxes open. This will allow VAV boxes to be driven open before the motor operates at full speed in the bypass mode. The time delay shall be field programmable from 0 – 120 seconds.
19. There shall be a keypad adjustment to select manual or automatic transfer bypass. The user shall be able to select via keypad programming which drive faults will result in an automatic transfer to the bypass mode and which faults require a manual transfer to bypass. The user may select whether the system shall automatically transfer from drive to bypass mode on the following drive fault conditions:
    a. Over current
    b. Over voltage
    c. Under voltage
    d. Loss of analog input
    e. The following operators shall be provided:
        1) Bypass Hand-Off-Auto
        2) Drive mode selector
        3) Bypass mode selector
        4) Bypass fault reset
20. The bypass shall include a two line, 20 character LCD display. The display shall allow the user to access and view:
    a. Energy savings – in US dollars
    b. Bypass motor amps
    c. Bypass input voltage– average and individual phase voltage
    d. Bypass power (kW)
    e. Bypass faults and fault logs
    f. Bypass warnings
    g. Bypass operating time (resettable)
    h. Bypass energy (kilowatt hours – resettable)
    i. I/O status

j. Parameter settings / programming
k. Printed circuit board temperature

21. The following indicating lights (LED type) or keypad display indications shall be provided. A test mode or push to test feature shall be provided.
    a. Power-on (Ready)
    b. Run enable
    c. Drive mode selected
    d. Bypass mode selected
    e. Drive running
    f. Bypass running
    g. Drive fault
    h. Bypass fault
    i. Bypass H-O-A mode
    j. Automatic transfer to bypass selected
    k. Safety open
    l. Damper opening
    m. Damper end-switch made
22. The Bypass controller shall have six programmable digital inputs, and five programmable Form-C relay outputs. This I/O allows for a total System (VFD and Bypass) I/O count of 24 points as standard. The bypass I/O shall be available to the BAS / DDC system even with the VFD removed.
23. The on-board Form-C relay outputs in the bypass shall programmable for any of the following indications.
    a. System started
    b. System running
    c. Bypass override enabled
    d. Drive fault
    e. Bypass fault
    f. Bypass H-O-A position
    g. Motor proof-of-flow (broken belt)
    h. Overload
    i. Bypass selected
    j. Bypass run
    k. System started (damper opening)
    l. Bypass alarm
    m. Over temperature
24. The bypass shall provide a separate terminal strip for connection of freeze, fire, smoke contacts, and external start command. All external safety interlocks shall remain fully functional whether the system is in VFD or Bypass mode. The remote start/stop contact shall operate in VFD and bypass modes. The terminal strip shall allow for independent connection of up to four (4) unique safety inputs.
25. The bypass shall include a supervisory control mode. In this bypass mode, the bypass shall monitor the value of the VFD's analog input (feedback). This feedback value is used to control the bypass contactor on and off state. The supervisory mode shall allow the user to maintain hysteresis control over applications such as cooling towers and booster pumps even with the VFD out of service.

26. The user shall be able to select the text to be displayed on the keypad when an external safety opens. Example text display indications include “FireStat”, “FreezStat”, “Over pressure” and “Low suction”. The user shall also be able to determine which of the four (4) safety contacts is open over the serial communications connection.
27. Smoke Control Override Mode (Override 1) – The bypass shall include a dedicated digital input that will transfer the motor from VFD mode to Bypass mode upon receipt of a dry contact closure from the Fire / Smoke Control System. The Smoke Control Override Mode action is not programmable and will always function as described in the bypass User’s Manual documentation. In this mode, the system will ignore low priority safeties and acknowledge high priority safeties as required by UL 864/UUKL. All keypad control, serial communications control, and normal customer start / stop control inputs will be disregarded. This Smoke Control Mode shall be designed to meet the intent of UL864/UUKL.
28. Stair Pressurization Mode – the bypass shall include an option to control the speed of the motor based on an external pressure transmitter. In this mode the VFD shall modulate the speed of the motor to maintain a pressure setpoint and avoid over pressurization of the stairwell.
29. Preset speed mode – the bypass shall include an option to run the drive at a preset speed and follow the acceleration values programmed in the VFD. The preset speed can be any fixed value.
30. Fireman’s Override Mode (Override 2) – the bypass shall include a second, programmable override input which will allow the user to configure the unit to acknowledge some digital inputs, all digital inputs, ignore digital inputs or any combination of the above. This programmability allows the user to program the bypass unit to react in whatever manner the local Authority Having Jurisdiction (AHJ) requires. The Override 2 action may be programmed for “Run-to-Destruction”. The user may also force the unit into Override 2 via the serial communications link.
31. Class 10, 20, or 30 (programmable) electronic motor overload protection shall be included.

H. In addition to the above feature all drives shall have the following additional features:

1. Catch-a-spinning load capability.
2. Critical speed avoidance capability.
3. Where the building walls are not suitable for mounting drives a floor stand kit shall be provided.
4. Provide output isolator to provide VFD signal operation of frequency, and current to an isolated 4-20 mA signal for transmission to the building automation system for monitoring capability.

I. For variable frequency drives serving multiple motors, the following shall be provided:

1. Provide redundant drives, each drive sized for the aggregated load of all motors.
2. The system shall monitor drive performance and switch to the standby drive in the event of a drive failure.

3. The system shall balance run time between drives
4. Manual switchover will be required in an instance of electrical system deficiencies such as under voltage, ground fault, single phase input, etc.
5. Provide motor contactors for each motor for drives serving more than one motor, each contactor shall have auxiliary contacts to prevent drive damage if remote motor disconnect switch is open of closed.
6. Each drive shall have contactors for each motor it serves with individual thermal overload protection for each motor and H-O-A motor select switch.
7. All multiple motor variable speed controllers shall be capable of operating even if one of the motors is off.
8. Multiple motor protectors must be integral to the VFD enclosure.

J. Enclosure: NEMA Type as required for location.

1. Provide NEMA 4X stainless steel enclosures in wash down areas, kitchens, dishwasher areas, exterior spaces, and any other areas designated by the Engineer. Provide space heater/air conditioning as well as all necessary conditioning within the enclosure as required to maintain the minimum internal temperature required by the manufacturer. Air conditioning shall be powered by a single point of connection within the cabinet.
2. Provide NEMA 3r enclosures for drives exposed to weather. NEMA 3 r enclosures shall be fabricated from 304 SS with protected keypads. The enclosure shall be bottom entry and shall include heating and ventilation to maintain and operation environment during design conditions

K. For drive manufacturers who use portable test meter for diagnostics, provide not less than one test meter for each model or type used. Meters shall be supplied to the Owner upon completion of the project.

L. Provide one complete set of spare fuses for all variable speed controllers.

M. Interlock all disconnects with variable speed drive so variable speed drive opens before disconnect opens to prevent damage to the drive.

PART 3 – EXECUTION

3.1 Deliver units to installer of electrical work. Provide installation and wiring instruction and diagrams.

3.2 Certified factory start-up shall be provided for each drive by a factory authorized service center. A certified start-up form shall be filled out for each drive with a copy provided to the owner, and a copy kept on file at the manufacturer. The local service office shall be staffed by factory trained engineers within a 100-mile radius of the job site. Training shall be provided for the Owner's service personnel at the Owner's facility.

3.3 Provide wiring control diagrams and instructions to installer of automatic temperature controls.

3.4 Provide Two years warranty to cover parts and labor.

3.5 In applications where the drive will be more than 100 feet of cable from the motor, it is the responsibility of the contractor to have the manufacturer coordinated with the motor manufacturer to ensure that the motor is suitable for the application, or to provide a motor protecting DV/DT filter on the drive output to protect the motor. The manufacturer shall adjust the carrier frequency to minimize the audible noise of the connected motor.

3.6 An as-built drive control schematic (ladder diagram) shall be taped to the inside of the drive cabinet and sent to the Project Engineer and be included as part of the closeout document package.

END OF SECTION

SECTION 23 05 48

VIBRATION CONTROL

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Supplemental Conditions of the Construction Contract, and Specification Sections (General Requirements), apply to this Section.

1.2 DESCRIPTION

A. Furnish and install all vibration control devices, accessories, materials, and related items. Perform all work as shown on the drawings and as specified herein to provide complete vibration isolation systems in proper working order.

1.3 MATERIAL AND EQUIPMENT

A. Design Basis: Mason Industries

B. Alternate Manufacturers:

1. Vibration Eliminator Co.
2. Korfund Dynamics Corp.
3. Amber/Booth Co.
4. Vibration Mountings & Controls, Inc.

C. Unless otherwise specified, supply only new equipment, parts and materials.

1.4 QUALITY ASSURANCE

A. Firms regularly engaged in manufacture of this equipment with characteristics and capacities required, whose products have been in satisfactory use in similar service for not less than ten (10) years.

B. Coordinate the size, location, and special requirements of vibration isolation equipment and systems with other trades. Coordinate plan dimensions with size of housekeeping pads.

C. Provide vibration isolators of the appropriate sizes, with the proper loading to meet the specified deflection requirements.

D. Supply and install any incidental materials needed to meet the requirements stated herein, even if not expressly specified or shown on the drawings, without claim or additional payment.

E. Verify correctness of equipment model numbers and conformance of each component with manufacturer's specifications.

F. Should any rotating equipment cause excessive noise or vibration, the Contractor shall be responsible for rebalancing, realignment, or other remedial work required to reduce noise and vibration levels. Excessive is defined as exceeding the manufacturer's specifications for the unit in question.

1.5 SUBMITTALS

A. Prior to ordering any products, submit shop drawings and the items listed below. The shop drawings must be complete when submitted and must be presented in a clear, easily understood form. Incomplete or unclear presentation of shop drawings may be reason for rejection of the submittal. Contractor shall provide:

1. A complete description of products to be supplied, including product data, dimensions, specifications, and installation instructions.
2. Detailed selection data for each vibration isolator supporting equipment, including:
   a. The equipment identification mark;
   b. A cut sheet of the isolated equipment showing equipment support points and operating weight at each point.
   c. The isolator type;
   d. The actual load;
   e. The static deflection expected under the actual load;
   f. Specified minimum static deflection;
   g. The additional deflection-to-solid under load;
   h. The ratio of spring height under load to spring diameter.
3. Steel rails, steel base frames, and concrete inertia bases showing all steel work, reinforcing, vibration isolator mounting attachment method, and location of equipment attachment bolts.
4. Special details necessary to convey complete understanding of the work to be performed.

PART 2 - PRODUCTS

2.1 VIBRATION ISOLATION MOUNT TYPES

A. General:

1. All mechanical equipment shall be mounted in accordance with the specifications below and for the specific requirements shown in the equipment schedule.

2. The isolation manufacturer shall supply all unit isolators, complete rails, fan and motor bases and structural steel forms for concrete inertia blocks, where called for and shall be responsible for the selection of all vibration eliminators and shall guarantee to meet the requirements of these Specifications.
3. Wherever rotational speed is mentioned as the disturbing frequency, the lowest speed in the system shall be used. All isolation devices shall be selected for uniform static deflections according to distribution of weight. Lateral motion of all isolators shall be 1/4" maximum during start-up and shut-down.
4. All metal parts of vibration isolation units installed out-of-doors shall be cold-dip galvanized, cadmium plated, or neoprene coated after fabrication. Galvanizing shall meet ASTM Salt Spray Test Standards and Federal Test Standard No. 14. Isolators shall be equipped with limit stops to resist wind velocity.
5. All isolators installed out-of-doors shall have base plates with bolt holes for fastening the isolators to the support members.
6. Isolator types are scheduled to establish minimum standards. At the Contractor’s option, laborsaving accessories can be an integral part of isolators supplied to provide initial lift of equipment to operating height, hold piping at fixed elevations during installation and initial system filling operations, and similar installation advantages. Accessories must not degrade the vibration isolation system.
7. Static deflection of isolators shall be as provided in SECTION 3 - EXECUTION. All static deflections stated are the minimum acceptable deflection for the mounts under actual load. Isolators selected solely on the basis of rated deflections are not acceptable and will be disapproved.
8. All fan units and air handling units (except fans with wheels under 27") shall be isolated as follows:

1.	Up to 450 RPM:	75% efficiency (3-1/2" maximum deflection)
2.	450 RPM to 850 RPM:	90%
3.	850 RPM and over:	95%

   Submittals shall show disturbing frequency, required efficiency, designed deflection and outside diameter of springs, when pertinent.
9. All horizontal pipe connected to rotating equipment within the mechanical equipment room area, but not less than 50 feet from connected equipment shall be isolated from building structure by means of units designed for insertion in rods.

B. Type FSN (Floor Spring and Neoprene)

1. Spring isolators shall be freestanding and laterally stable without any housing. Spring diameter shall be not less than 0.8 of the compressed height of the spring at the rated load. Springs shall have a minimum additional travel-to-solid equal to 50% of the rated deflection. Springs shall be so designed that the ratio of horizontal stiffness to vertical stiffness is approximately one (1). All mounts shall have leveling bolts.

2. Either the spring element in the isolator shall be set in a neoprene cup and have a steel washer to distribute the load evenly over the neoprene, or each isolator shall be mounted on a Type NP isolator. If the NP isolator is used, provide a rectangular bearing plate of appropriate size to load the pad uniformly within the manufacturer’s recommended range.
3. If the basic spring isolator has a neoprene friction pad on its base and a NP isolator is to be added to the base, a galvanized steel, stainless steel or aluminum plate shall be used between the friction pad and the NP isolator. If the isolator is outdoors, the plate shall not be made of galvanized steel. The NP isolator, separator plate and friction pad shall be permanently adhered to one another and to the bottom of the bearing plate.
4. If the isolator is to be fastened to the building structure and Type NP isolator is used under the bearing plate, neoprene grommets shall be provided for each bolt hole in the base plate. Bolt holes shall be properly sized to allow for grommets. The hold down bolt assembly shall include washers to distribute load evenly over the grommets. Bolts and washers are to be galvanized.

   Type FSN isolators shall be Mason Type SLF with the appropriate neoprene pad (if used) selected from Type NP or approved equal.

C. Type FSNTL (Floor Spring and Neoprene Travel Limited)

1. Spring isolators shall be freestanding and laterally stable without any housing. Spring diameter shall not be less than 0.8 of the compressed height of the spring at the rate load. Spring shall have a minimum additional travel-to-solid equal to 50% of the rated deflection. Springs shall be so designed that the ratio of horizontal stiffness to vertical stiffness is approximately one (1). All mounts shall have leveling bolts. All mounts shall have vertical travel limit stops to control extension when weight is removed. The travel limit stops shall be capable of serving as blocking during erection of the equipment. A minimum clearance of ¼” shall be maintained around restraining bolts and between the limit stops and the spring to avoid interference with the spring action.
2. Either the spring element in the isolator shall be set in a neoprene cup and have a steel washer to distribute the load evenly over the neoprene, or each isolator shall be mounted on a Type NP isolator. If the NP isolator is used, provide a rectangular bearing plate of appropriate size to load the pad uniformly within the manufacturer’s recommended range. If the basic spring isolator has a neoprene friction pad on its base and a NP isolator is to be added to the base, a galvanized steel, stainless steel or aluminum plate shall be used between the friction pad and the NP isolator. If the isolator is outdoors, the plate shall not be made of galvanized steel. The NP isolator, separator plate, and friction pad shall be permanently adhered to one another and to the bottom of the bearing plate.
3. If the isolator is to be fastened to the building structure and Type NP isolator is used under the bearing plate, neoprene grommets shall be provided for each bolt hole in the base plate. Bolt holes shall be properly sized to allow for grommets. Hold down assembly shall include washers to distribute load evenly over the grommets. Bolts and washers are to be galvanized.

Type FSNTL isolators shall be Mason Type SLR with the appropriate neoprene pad (if used) selected from Type NP or approved equal.

D. Type FN (Floor Neoprene)

1. Neoprene isolators shall be neoprene-in-shear type with steel reinforced top and base. All metal surfaces shall be covered with neoprene. The top and bottom surfaces shall be ribbed. Bolt holes shall be provided in the base and the top shall have a threaded fastener. The mounts shall include leveling bolts that may be rigidly connected to the equipment.

   Type FN isolators shall be Mason Type ND or approved equal.

E. Type FNC (Floor Neoprene Chiller)

1. Neoprene isolators shall be double neoprene-in-shear type with steel reinforced top intermediate plates and base. Neoprene elements shall be ¾". Steel plates shall be ¼" and the top and bottom plates shall be ribbed. Bolt holes shall be provided in the base and the top shall have a threaded fastener. The mounts shall include leveling bolts that may be rigidly connected to the equipment.

   Type FNC isolators shall be Mason Type ND: Fabricate of type "Super W" pads, similar to Type ND otherwise.

F. Type NP (Neoprene Pad)

1. Neoprene pad isolators shall be one layer of ¼" to 3/8" thick ribbed or waffled neoprene. The pads shall be sized so that they will be loaded within the manufacturer's recommended range.

   Type NP isolators shall be Mason Type W or approved equal.

G. Type DNP (Double Neoprene Pad)

1. Neoprene pad isolators shall be formed by two layers of ¼" to 3/8" thick ribbed or waffled neoprene, separated by a galvanized steel, stainless steel or aluminum plate. If the isolator is outdoors, the plate shall not be made of galvanized steel. These layers shall be permanently adhered together. The pads shall be sized so that they will be loaded within the manufacturer's recommended range.

   Type DNP isolators shall be Mason Type WSW or approved equal.

H. Type HSN (Hanger Spring and Neoprene)

1. Vibration isolation hangers shall consist of a free standing and laterally stable steel spring and a neoprene element in series, contained within a steel housing. Spring diameters and hanger housing lower hole sizes shall be large enough to permit the hanger rod to swing through a 30º arc before contacting the housing.

Hangers shall provide a means to adjust hanger elevation under load. Spring diameter shall be not less than 0.8 of the compressed height of the spring at the rated load. Spring elements shall have a minimum additional travel-to-solid equal to 50% of the rated deflection. The neoprene element shall be designed to have a 0.3” minimum static deflection. The deflection of both the spring element and the neoprene element shall be included in determining the overall deflection of Type HSN isolators.

Type HSN isolators shall be Mason Type P30N or approved equal.

I. Type DSN (Double deflection spring and neoprene)

1. Vibration hangers shall contain a steel spring and a double deflection neoprene element in series. The neoprene element shall be molded with a rod isolation bushing that passes through the hanger box. Springs shall have a minimum additional travel to solid equal to 50% of the rated deflection and be seated in a neoprene cup with an integral molded bushing that passes through the lower hanger box.

   Type DSN isolators shall be Mason type DNHS or approved equal.

J. Type HN (Hanger Neoprene)

1. Vibration isolation hangers shall consist of a neoprene-in-shear element contained within a steel housing. A neoprene neck bushing shall be provided where the hanger rod passes through the hanger housing to prevent the rod from contacting the hanger housing. The diameter of the hole in the housing shall be sufficient to permit the hanger rod to swing through a 30º arc before contacting the hanger housing.

   Type HN isolators shall be Mason Type HD or approved equal.

2.2 EQUIPMENT BASES

A. Type BIB (Base - Inertia Base)

1. Concrete inertia bases shall be formed of stone-aggregate concrete (150 lbs./cu.ft.) and appropriate steel reinforcing cast between welded or bolted perimeter structural steel channels. Inertia bases shall be built to form a rigid base which will not twist, racks deform, deflect, or crack in any manner which would negatively affect the operation of the supported equipment or the vibration isolation mounts. Inertia bases shall be adequately sized to support basic equipment units and motors plus any associated pipe elbow supports, duct elbow supports, electrical control elements, or other components closely related and requiring resilient support in order to prevent vibration transfer to the building structure. Inertia base depth shall be at least 1/12 the longest dimension of the inertia base, but not less than 6” nor more than 12”. The base foot print shall be large enough to provide stability for supported equipment. Inertia bases shall

include side mounting brackets for attachment to vibration isolators. Mounting brackets shall be located on the sides of the base that are parallel to the axis of rotation of the supported equipment.

2. The steel frame and reinforcement shall be supplied by the vibration isolator manufacturer. Concrete may be provided by the General Contractors.

   Frame and reinforcement for Type BIB bases shall be Mason Type KSL or approved equal.

B. Type BC-1 (Base - Curb)

1. Curb type isolation bases shall be a prefabricated assembly consisting of an extruded aluminum frame and steel spring isolation system that fits over the roof curb and under the isolated equipment. The aluminum frame shall be sufficiently rigid to support the equipment load without detrimental twist or deflection. Spring isolators shall be selected and positioned along the curb to achieve the minimum static deflection called for in the schedule. The static deflection shall be constant around the entire periphery of the base. Springs shall be free standing, laterally stable with a diameter of not less than 0.8 times the compressed height, and have additional travel-to-solid that is at least 50% of the rated deflection. Resilient neoprene snubbers shall be provided at the corners of the base to limit the movement of the equipment under wind load to ¼”.
2. The isolation curb base shall be made weather tight by sealing all around the periphery with closed cell neoprene or flexible vinyl. This shall in no way inhibit the vibration isolation of the spring elements. A closed cell sponge gasket or field caulking shall be used between the equipment unit and the isolation curb base and between the isolation curb and roof curb to form a weather-tight seal. The isolation curb shall be designed to arrest and utilize outer placement of standard 2” roof insulation to act as a sound attenuation for inside of the curb.
3. Each spring isolator used in the curbs shall be weather protected. The entire assembly shall be dry galvanized or PUC coated.

   Type BC-1 vibration isolation curb bases shall be Mason Type CMAB or approved equal.

2.3 RESILIENT LATERAL GUIDES

A. These units shall either be a standard product of the vibration isolation mounting manufacturer, or be custom fabricated from standard components. These units shall incorporate neoprene isolation elements similar to Type FN which are specifically designed to provide resilient lateral bracing of duct or pipe risers.

Resilient lateral guides shall be Mason Type ADA.

2.4 FLEXIBLE DUCT CONNECTORS

A. Flexible duct connection shall be made from coated fabric (or leaded vinyl if called for on the drawings). The clear space between connected parts shall be a minimum of 3" and the connection shall have 5" minimum of slack material.

2.5 FLEXIBLE PIPE CONNECTIONS

A. Flexible pipe connection shall be fabricated of multiple plies of nylon cord, fabric, and neoprene; and shall be vulcanized so as to become inseparable and homogeneous. Flexible connections shall be formed in a double sphere shape, and shall be able to accept compressive, elongative, transverse, and angular movements.

B. The flexible connections shall be selected and specially fitted, if necessary, to suite the system temperature, pressure, and fluid type. In addition, suitable flexible connections should be selected which do not require rods or cables to control extension of the connector.

C. Connectors for pipe sizes 2" or smaller shall have threaded female union couplings on each end. Larger sizes shall be fitted with metallic flange couplings.

D. Provide Mason Industries Type MFTNC or MFTFU; Metraflex Twin Sphere; or Amber/Booth Type 2600 or 2655 for flexible pipe connections less than 220˚F and 150 psi.

E. Flexible pipe connections shall be mason Industries Type BSS braided stainless steel hose with carbon steel fittings for pressures above 150 psi or temperatures greater than 220˚F

2.6 RESTRAINTS

A. Snubber:

1. Snubbers shall be custom fabricated using Type FN isolators mounted to steel angle brackets. The steel angle shall be sufficiently rigid and the mounting sufficiently secure to resist excessive movement of equipment during on-off cycle.

B. Thrust Restraints:

1. Thrust restraints shall consist of a spring element in series with a neoprene pad. The unit shall be designed to have the same deflection due to thrust-generated loads as specified for the isolators supporting the equipment. The spring element shall be contained within a steel frame and be designed so it can be precompressed at the factory to allow for a maximum of ¼" movement during starting or stopping of the equipment. Allowable movement shall be field-adjustable.

2. The assembly shall be furnished complete with rods and angle brackets for attachment to both the equipment and the adjacent fixed structural anchor.
3. Thrust restraints shall be Mason Industries Type WB, Kinetics Noise Control Type HSR, Amber/Booth Type TRK or an equal product of the manufacturer supplying the isolators.

2.7 GROMMETS

A. Grommets shall either be custom made by combining a neoprene washer and sleeve, be Isogrommets as manufactured by MBIS, Inc. (Bedford Heights, Ohio), or be Series W by Barry Controls (Watertown, Mass.). Grommets shall be sized so that they will be loaded within the manufacturer's recommended load range. Grommets shall be specially formed to prevent both from directly contacting the isolator base plate.

2.8 ACOUSTICAL SEALANT

A. Sealants for acoustical purposes as described in this specification shall be silicone or one of the non-setting sealants indicated below:

Acoustical Sealant	D.A.P
BR-96	Pecora
Acoustical Sealant	Tremco
Acoustical Sealant	U.S.G.

PART 3 - EXECUTION

3.1 APPLICATION

A. General:

1. Refer to SECTION 2 - PRODUCTS of this specification for vibration isolation devices identified on the drawings or specified herein.
2. The static deflection of all isolators specified herein are the minimum acceptable deflections for the mounts under actual load. Isolators selected solely on the basis of rated deflection are not acceptable and will be disapproved.
3. Refer to Section 23 05 49 for seismic requirements.

B. Major Equipment:

1. Unless otherwise shown or specified, all floor-mounted major equipment shall be set on 4" high concrete housekeeping pads. Mount vibration isolating devices and related inertia blocks on concrete pads.
2. Types and minimum static deflections of vibration isolation devices for major equipment items shall be as scheduled on the drawings or specified hereunder.
3. Flexible duct connections shall be installed at all fan unit intakes, fan unit discharges, and wherever else shown on the drawings.

4. Flexible pipe connections shall be installed at all pipe connections to vibration-isolated equipment, refer to drawings for proper position.
5. Thrust restraints shall be installed on all floor-mounted fans developing 4” or more of static pressure, all suspended fans developing 2” or more static pressure, and wherever else called for on the drawings.
6. Snubbers shall be installed as called for on the drawings.
7. Brackets shall be provided to accommodate the isolator. The vertical position and size of the bracket shall be specified by the isolator manufacturer.

C. Miscellaneous Mechanical Equipment:

1. Miscellaneous pieces of mechanical equipment such as converters, pressure reducing stations, dryers, strainers, storage tanks, condensate receiver tanks, and expansion tanks which are connected to isolated piping system shall be vibration isolated from the building structure by Type NP or Type HN isolators (selected for 0.1” static deflection) unless their position in the piping system requires a higher degree of isolation as called for under Pipe Isolation.

D. Pipes:

1. All chilled water, condenser water, heating water, drain and engine exhaust piping that is connected to vibration-isolated equipment shall be isolated from the building structure within the following limits:
   a. Within mechanical rooms.
   b. And within 50’ total pipe length of connected vibration-isolation equipment (chillers, pumps, air handling units, pressure reducing stations, etc.):
2. Piping shall be isolated from the building structure by means of vibration isolation mounts, resilient pipe guides, and resilient penetration sleeve/seals.
3. Isolators for the first three support points adjacent to connected equipment shall achieve one half the specified static deflection of the isolators supporting the connected equipment. When the required static deflection of these isolators is greater than ½” Type FSN or HSN isolators shall be used. When the required static deflection is less than or equal to ½”, Type FN or HN isolators shall be used. All other pipe support isolators within the specified limits shall be either Type FN or HN achieving at least ¼” static deflection.
4. Where lateral support of pipe risers is required within the specified limits, this shall be accomplished by use of resilient lateral supports.
5. Pipes within the specified limits that penetrate the building construction shall be isolated from the building structure by use of resilient penetration sleeve/seals.
6. Provide flexible pipe connections on all piping connected to all isolated equipment, when required by manufacturer, and wherever shown on the drawings.

3.2 INSTALLATION OF VIBRATION ISOLATION EQUIPMENT

A. General:

1. Locations of all vibration isolation devices shall be selected for ease of inspection and adjustment as well as for proper operation.
2. Installation of vibration isolation equipment shall be in accordance with the manufacturer's instructions.

B. Isolation Mounts:

1. All vibration isolators shall be aligned squarely above or below mounting points of the supported equipment.
2. Isolators for equipment with bases shall be located on the sides of the bases, which are parallel to equipment shaft unless this is not possible because of physical constraints.
3. Locate isolators to provide stable support for equipment, without excess rocking. Consideration shall be given to the location of the center of gravity of the system and the location and spacing of the isolators. If necessary, a base with suitable footprint shall be provided to maintain stability of supported equipment, whether or not such a base is specifically called to herein.
4. If a housekeeping pad is provided, the isolators shall bear on the housekeeping pad and the isolator base plates shall rest entirely on the pad.
5. Hanger rods for vibration-isolated support shall be connected to structural beams or joists, not the floor slab between beam joists. Provide suitable intermediate support members as necessary.
6. Vibration isolation hanger elements shall be positioned as high as possible in the hanger rod assembly, but not in contact with the building structure, and so that the hanger housing may rotate a full 360º about the rod axis without contacting any object.
7. Parallel running pipes may be hung together on a trapeze, which is isolated from the building. Isolator deflections must be the greatest required by the provisions for pipe isolation for any single pipe on the trapeze. Do not mix isolated and non-isolated pipes on the same trapeze.
8. Pipes, ducts and equipment shall not be supported from other pipes, ducts and equipment.
9. Resiliently isolated pipes, ducts and equipment shall not come in rigid contact with the building construction or rigidly supported equipment.
10. The installed and operating heights of equipment vibration-isolated with Type FSNTL isolators shall be identical. Limit stops shall be out of contact during normal operation. Adjust isolators to provide ¼" clearance between the limit stop brackets and the isolator top plate, and between the travel limit nuts and travel limit brackets.
11. Adjust all leveling bolts and hanger rod bolts so that the isolated equipment is level and in proper alignment with connecting ducts or pipes.

C. Bases:

1. No equipment unit shall bear directly on vibration isolators unless its own frame is suitably rigid to span between isolators and such direct support is approved by the equipment manufacturer. This provision shall apply whether or not a base frame is called for on the schedule. In the case that a base frame is required for the unit because of the equipment manufacturer's requirements and is not specifically called for on the equipment schedule, a base frame recommended by the equipment manufacturer shall be provided at no additional expense.
2. Unless otherwise indicated, there is to be a minimum operating clearance of 2" between inertia bases or steel frame bases and the floor beneath the equipment. Position isolator mounting brackets and adjust isolators so that the required clearance is maintained. The clearance space shall be checked by the Contractor to ensure that no construction debris has been left to short circuit or restrict the proper operation of the vibration isolation system.

D. Flexible Duct Connections:

1. Sheet metal ducts and plenum opening shall be squarely aligned with the fan discharge, fan intake, or adjacent duct section prior to installation of the flexible connection, so the clear length is approximately equal all the way around the perimeter. Flexible duct connections shall not be installed until this provision is met. There shall be no metal-to-metal contact between connected sections, and the fabric shall not be stretched taut.

E. Flexible Pipe Connections:

1. Install flexible pipe connections in strict accordance with the manufacturer's instructions.

F. Restraints:

1. Snubbers shall be adjusted to clear the equipment base and to provide lateral restraint during on-off cycling, but be out of contact during normal operation of the equipment.
2. Thrust restraints shall be attached at the centerline of thrust and symmetrically on each side of the unit. The two rods of the thrust restraint shall be axially aligned. This may require modified brackets or standoffs. The body of the thrust restraint shall not come in contact with the connected elements. Thrust restraints shall be adjusted to constrain equipment movement to the specified limit.

G. Resilient Penetration Sleeve/Seals:

1. Maintain an airtight seal around the penetrating element and prevent rigid contact between the penetrating element and the building structure. Fit the sleeve tightly to the building construction and seal airtight on both sides of the construction penetrated with acoustical sealant.

a. At minimum, provide resilient penetration seals at all Mechanical, Equipment and Fan Room Penetrations.

3.3 ISOLATOR SCHEDULE

UNIT	ISOLATOR TYPE	MINIMUM STATIC DEFL.(IN.)	BASE TYPE	REMARKS
Inline Fans (Suspended)	HSN	2		
Chillers	FNC	0.35		Slab on Grade
Pumps (Basemount)	BIB (Note 3)	1.5		
Cooling Tower	FSNTL	2.5		
Self-Contained Air Conditioning Units	FSN (Note 1)	1.5		Thrust restraints if internally isolated.
Heat Pumps (Ceiling Mounted)	DSN	1.0		

Notes:

(1) External isolator may be omitted if units have internally isolated fans and no other rotating or reciprocating components.

(2) Isolators for fan coil units should be either HSN with 0.75” minimum static deflection or be equivalent to Mason Industries Type HN with 0.35” minimum static deflection.

(3) For slab-on-grade installations isolators are not required. Refer to section 23 21 23.

3.4 INSPECTION AND COORDINATION

A. Contractor shall examine location where this equipment is to be installed and determine space conditions and notify Architect in writing of conditions detrimental to proper and timely completion of the Work.

B. Do not proceed with the work until unsatisfactory conditions have been corrected.

C. Coordinate work with other trades to avoid rigid contact with the building. Inform other trades following work, such as plastering or electrical, to avoid any contact which would reduce the vibration isolation.

D. Bring to the Architect's attention, prior to installation, any conflicts with other trades which may result in unavoidable rigid contact with equipment or piping as described herein, duct to inadequate space or other unforeseen conditions. Corrective work necessitated by conflicts after installation shall be at the responsible Contractor's expense.

E. Bring to the Architect's attention, any discrepancies between the Specifications and field conditions or changes required due to specific equipment selection, prior to installation. Corrective work necessitated by discrepancies after installation shall be at the Contractor's expense.

3.5 FIELD QUALITY CONTROL

A. Obtain inspection and approval of any installation to be covered or enclosed, prior to such closure.

B. Upon completion of installation of all vibration isolation devices herein specified, the local representative of the isolation materials manufacturer shall inspect the completed system and report, in writing, any installation error, improperly selected isolation devices, or other faults in the system that could affect the performance of the system. Contractor shall submit a report to the Architect, including the manufacturer's representatives' final report, indicating all isolation reported as improperly installed or requiring correction, and include a report by the Contractor on steps taken to properly complete the isolation work.

END OF SECTION

SECTION 23 05 49

SEISMIC RESTRAINTS

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Locate, select, design, and install seismic restraints for all mechanical systems. Include restraints for ductwork, piping and equipment.

1.2 CODES, STANDARDS

A. Comply with the requirements of the “Guidelines for Seismic Restraints of Mechanical Systems and Plumbing Piping Systems”, first edition.

B. Design seismic restraint systems for seismic Zone 2 with an effective peak velocity - related acceleration coefficient (A_v) of 0.10 to 0.19.

<table>
<tr><td colspan="4">DESIGN LEVEL OF ACCELERATION AT EQUIPMENT CENTER OF GRAVITY</td></tr>
<tr><td colspan="4">SEISMIC ZONE 2, A_V = 0.10 TO 0.19</td></tr>
<tr><td>ELEVATION ABOVE GRADE</td><td>RIGIDLY FLOOR OR WALL MOUNTED EQUIPMENT</td><td>RESILIENTLY MOUNTED AND/OR SUPPORTED FROM CEILING OR STRUCTURE ABOVE</td><td>LIFE SAFETY EQUIPMENT (FIRE ALARM, EMERGENCY)</td></tr>
<tr><td>BELOW GRADE UP TO 20 FEET ABOVE GRADE</td><td>0.100 “G”
0.125 “G”</td><td>0.500 “G”</td><td rowspan="2">1.000 “G”</td></tr>
<tr><td>21 FEET to 300 FEET</td><td>0.500 “G”</td><td>0.750 “G”</td></tr>
</table>

1.3 SUBMITTALS

A. Submit manufacturer’s data for all manufactured restraints.

B. Submit shop drawings for all fabricated restraints.

C. Show restraint type and location on the sheet metal and piping shop drawings.

D. Provide an affidavit signed by a registered New York State licensed structural engineer certifying that all mechanical systems requiring such have been properly engineered and designed for seismic Zone 2.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Design Basis: Mason

1. Other Acceptable Manufacturers:
    a. M.W. Sausse and Company, Inc.
    b. Vibration Mounting and Controls, Inc.
    c. California Dynamics Corporation
    d. By prior approval

PART 3 - EXECUTION

3.1 GENERAL NOTES FOR BRACING OF DUCTS

A. Details shown in the Guidelines provide a lateral bracing system. A typical vertical support system conforming to the standards must also be used. However, where bracing occurs, the required vertical angle may replace a typical vertical support. This includes a trapeze vertical supporting system.

B. Brace all rectangular ducts 6 sq. ft. of area and larger. Brace all round ducts 38" in diameter and larger.

C. Transverse bracing to occur 30' - 9" o.c. maximum. (Except rectangular ducts 61" and larger in either direction may be braced at 32' - 0" o.c.) Transverse bracing shall be installed at each duct turn and at each end of a duct run.

D. Longitudinal bracing shall occur at 60' - 9" o.c. maximum. Transverse bracing for one duct section may also act as longitudinal bracing for a duct section connected perpendicular to it, if the bracing is installed within four feet of the intersection of both ducts and bracing is sized for the larger duct. Duct joints shall conform to SMACNA duct construction standard. All joints in duct sections shall provide a positive fastening together of the section.

E. No bracing is required if the top of duct is suspended 12" or less from the supporting structural member.

F. A group of ducts may be combined in a larger size frame using the overall dimensions.

G. Walls (including gyp-board non-bearing partitions) which have ducts running throughout them may replace a typical transverse brace. Provide solid blockings around duct penetration at stud wall construction.

H. Ducts and pipes not braced shall be installed with a 6" minimum clearance to vertical ceiling hanger wires.

I. All sheet metal for bracing to be F(y) = 33 ksi.

J. Minimum U.S. Standards gauge for sheet metal for bracing to be as follows:

16 gauge (0.0598 inch)
14 gauge (0.0747 inch)
12 gauge (0.1046 inch)

K. It is the responsibility of the Contractor to ascertain that an appropriate size device be selected for each individual piece of equipment. Submit signed and sealed drawings from a New York State licensed professional engineer confirming seismic design.

3.2 GENERAL NOTES FOR BRACING OF PIPES

A. These Guidelines are not intended for the seismic design of the piping. Piping shall be designed with consideration given to the dynamic properties of the piping and the structure.

B. Bracing details, support details, schedules and notes listed in the Guidelines apply to all types of pipe and all type of joints.

1. Bracing
   a. Brace all pipes 2½" diameter and larger.
   b. Brace all piping 1¼" and larger located in boiler rooms, mechanical equipment rooms and refrigeration machinery rooms. Bracing requirements for pipes less than 2½" in diameter shall be the same as for 2½" pipes in all other locations.
   c. Seismic braces may be omitted:
      1) When the top of the pipe is suspended 12" or less from the supporting structure member and the pipe is suspended by an individual hanger.
      2) On all piping ¾" and smaller.
2. Details shown in the Guidelines provide a lateral bracing system. A typical vertical support system conforming to the above standard must also be used.
   a. Vertical Piping
      1) Attachment - Vertical piping shall be secured at sufficiently close intervals to keep the pipe in alignment and carry the weight of the pipe and contents. Stacks shall be supported at their bases and if over 2 stories in height at each floor by approved metal floor clamps.
      2) Screwed pipe (I.P.S.) shall be supported at not less than every other story height.
      3) Copper tubing - copper tubing shall be supported at each story for piping 1½" and smaller in diameter.
      4) Pipes of other approved material shall be supported in accordance with their approved installation standards.

b. Horizontal Piping
   1) Supports - Horizontal piping shall be supported at sufficiently close intervals to keep it in alignment and prevent sagging.
   2) Screwed pipe - Screwed pipe (I.P.S.) or flanged pipe shall be supported at approximately 10 foot intervals.
   3) Copper tubing - Copper tubing shall be supported at approximately 6 foot intervals for tubing 1½" and smaller in diameter and 10 foot intervals for tubing 2" and larger in diameter.
   4) Pipes of other approved materials shall be supported in accordance with their approved installation standards.

3. Provide transverse bracings at 40' - 0" o.c. maximum unless otherwise noted in the Guidelines.
4. Provide longitudinal bracings at 80' - 0" o.c. maximum unless otherwise noted in the Guidelines. When thermal expansion or contraction is involved, provide longitudinal bracings at anchor points. The longitudinal braces and the connections must be capable of resisting the force induced by expansion and contraction.
5. Transverse bracing for one pipe section may also act as longitudinal bracing for the pipe section connected perpendicular to it, if the bracing is installed within 24" of the elbow or tee of similar size.
6. For threaded piping the flexibility may be provided by the installation of swing joints. In welded or solder joint piping the flexibility shall be provided by expansion loops or manufactured flexible connectors. For piping with manufactured ball joints select length of piping offset using "Seismic Drift" in place of "Expansion Per Joint Manufacturers" selection table. Seismic Drift = 0.015 ft. per foot of height.
7. Do not use branch lines to brace main lines.
8. Trapeze hangers may be used. Provide flexibility in joints where pipes pass through building seismic or expansion joints, or where pipes pass through building seismic or expansion joints, or where rigidly supported pipes connect to equipment with vibration isolators.
9. A rigid piping system shall not be braced to dissimilar parts of a building or two dissimilar building systems that may respond in a different mode during an earthquake. Examples: Wall and a roof; solid concrete wall and a metal deck with Lightweight concrete fill.
10. Provide large enough pipe sleeves through walls or floors to allow for anticipated differential movements.
11. At vertical pipe risers, wherever possible, support the weight of the riser at a point or points above the center of gravity of the riser. Provide lateral guides at the top and bottom of the riser, and at intermediate points not to exceed 30' - 0" on center.
12. Cast iron pipe of all types, glass pipe and any other pipe joined with a shield and clamp assembly where the top of the pipe is 12" or more from supporting structure shall be braced on each side of a change in direction of 90^0 or more. Riser joints shall be braced or stabilized between floors.

C. Essential facilities or life safety equipment. "Essential facilities" mentioned in the Guidelines are those structures or buildings which must be safe and useable for emergency purposes after an earthquake in order to preserve the health and safety of the general public.

3.3 GENERAL NOTES FOR EQUIPMENT RESTRAINTS

A. Mechanical Equipment Anchorages such as bolts, expansion anchors, screws, etc., shall comply with the force level requirements of the above standards as well as the Connecticut Building Code.

B. Restraining Devices shall be designed to conform with the force level requirements of A above.

C. Restraining Devices must be placed on all sides of the equipment base.

D. It is the entire responsibility of the Equipment Manufacturer to design his equipment so that the strength and anchorage of the internal components of the equipment exceeds the force level used to restrain and anchor the unit itself to the supporting structure.

E. It is the responsibility of the Mechanical Contractor to ascertain and assure that an appropriate size device be selected for each piece of equipment (including whole unit restraints for internally braced equipment).

END OF SECTION

SECTION 23 05 53

MECHANICAL IDENTIFICATION

PART 1 - GENERAL

1.1 SUBMITTALS

A. Submit manufacturer's product data on the following:

1. Plastic Pipe Markers and method of application.
2. Engraved Plastic Laminate Sign.
3. Equipment label and valve tag schedules shall be submitted to review as an MS Excel digital file.

PART 2 - PRODUCTS

2.1 GENERAL

A. Except as otherwise indicated, provide manufacturer's standard products.

B. Where more than a single type is specified for an application, selection is Installer's option, but provide a single selection for each application.

2.2 PLASTIC PIPE MARKERS (TYPE A)

A. Provide manufacturer's standard pre-printed, flexible or semi-rigid, permanent, color-coded, plastic-sheet pipe markers, complying with ANSI A13.1.

B. For Pipes Less Than Six Inches (including insulation if any): Provide full-band pipe markers, extending 360º around pipe at each location, fastened by one of the following methods:

1. Snap-on application of pre-tensioned semi-rigid plastic pipe marker.
2. Adhesive lap joint in pipe marker overlap.
3. Taped to pipe (or insulation) with color-coded plastic adhesive tape, not less than ¾" wide; full circle at both ends of pipe marker, tape lapped 1-½".

C. For Pipes Six Inches and Larger (including insulation if any): Provide either full-band or strip-type markers, but not narrower than 3 x letter height, taped to pipe (or insulation) with color-coded plastic adhesive tape, not less than 1-½" wide; full circle at both ends of pipe marker, tape lapped 3".

D. Lettering: Manufacturer's pre-printed wording which conforms to contract document system descriptions.

E. Where work is an extension or alteration of an existing system, new markers shall match existing terminology for systems which are modified or added by this work.

F. Arrows: Print each pipe marker with arrows indicating direction of flow, either integrally with piping system service lettering or as a separate unit of plastic (to accommodate both directions).

G. Pipe Size: All insulated pipes shall be labeled to indicate pipe size.

2.3 STENCILING (TYPE B)

A. Using a color contrasting to the surface to identify, spray or brush paint through neatly cut stencils.

B. Lettering shall conform to wording on contract documents. Size shall be in accordance with ANSI A13.1.

2.4 BACKGROUND COLOR AND STENCILING (TYPE C)

A. In addition to the requirements above, paint a background color band in accordance with ANSI A13.1.

2.5 VALVES TAGS

A. Brass Valve Tags: Provide manufacturer’s standard 19 ga brass tag; approximately 1-½” round wit ½” high black filled numbers and 3/16” top hole.

1. Numbers shall be sequential in accordance with schedule below.
2. Provide separate numbering for each legend sequence. Provide separate sequences for the following:
    a. Low Pressure Steam (LPS)
    b. Low Pressure Steam Condensate Return (LPR)
    c. Brine Chilled Water (BCW)
    d. Condenser Water (CW)
    e. All other systems (No legend)

B. Valve Tag Fasteners: Manufacturer’s standard chain (wire link or beaded type), or S-hooks.

2.6 VALVE SCHEDULE

A. Provide schedule for each piping system, as defined on the drawings, and below, typewritten and reproduced on 8-½” x 11” bond paper.

B. Tabulate valve number, piping system, system legend (as shown on tag), location of valve (room or space), and variations for identification (if any).

C. Provide piping schematic for each system as defined below in Part 3.

D. In addition to mounted copies, furnish extra copies for maintenance manuals as specified.

E. Valve Schedule Frames: For each page of the valve schedule, provide a glazed frame, with screws for removable mounting on masonry walls.

2.7 ENGRAVED PLASTIC-LAMINATE SIGNS

A. General: Provide engraving stock melamine plastic laminate, 1/16" thick, black with white core (letter color).

B. Fastening:

1. Screws
2. Rivets
3. Permanent Adhesive

C. Lettering and Graphics:

1. Coordinate names, abbreviations and other designations used in the mechanical identification work, with the corresponding designations shown, specified or scheduled in the construction documents.
2. In addition, for heating or cooling units and exhaust fans, identify area served.

PART 3 - EXECUTION

3.1 GENERAL

A. Where identification is to be applied to surfaces which require insulation, painting or other covering or finish, install identification after completion of covering and painting.

B. Install identification prior to installation of acoustical ceilings and similar removable concealment.

3.2 DUCTWORK IDENTIFICATION

A. General: Identify air supply, return, exhaust, intake and relief ductwork with stenciled signs and arrows, showing ductwork service and direction of flow, in black or white, whichever provides most contrast with ductwork color.

B. Location: In each space where ductwork is exposed, or concealed only by removable ceiling system, locate signs near points where ductwork originates or continues into concealed enclosures (shaft, underground or similar concealment), and at 50' spacing along exposed runs.

C. Access Doors: Provide stenciled or plastic laminate type signs on each duct or equipment mounted access door in ductwork and housings, indicating the purpose of the access (to what equipment) and other maintenance and operating instructions, and appropriate safety and procedural information.

3.3 PIPING SYSTEM IDENTIFICATION

A. General: Install pipe markers on piping of the following systems and include arrows to show normal direction of flow.

1. Low Pressure Steam (supply and return).
2. Brine Chilled water piping (supply and return).
3. Condenser water (supply and return).
4. Any other piping system as indicated on the drawings, or as required to match existing.

B. Locate pipe markers and color bands as follows wherever piping is exposed to view in occupied spaces above accessible ceilings, in accessible maintenance spaces, including chases, and above ceiling:

1. Near each valve and control device.
2. Near each branch, excluding short take-offs for fixtures and terminal units. Mark each pipe at branch, where there could be a question of flow pattern.
3. Near locations where pipes pass through walls, floors, or ceilings, or enter non-accessible enclosures.
4. Near major equipment items and other points of origination and termination.
5. Spaced intermediately at maximum spacing of 25’ along each piping run.
6. Within 6’ of access doors above otherwise non-accessible ceilings and chases.

C. Type:

1. Normally exposed to view - Type A or C.
2. Normally concealed from view - Type B.

3.4 VALVE IDENTIFICATION

A. Provide valve tag on every valve, cock and control device in each piping system; exclude check valves, valves within factory fabricated equipment units, hose bibs, HVAC terminal devices and similar rough-in connections of end-use fixtures and units. List each tagged valve in valve schedule for each piping system.

B. Mount framed valve schedules with piping schematics in each MER.

C. Identify each valve tagged on as-built drawings.

3.5 MECHANICAL EQUIPMENT IDENTIFICATION

A. Install an engraved plastic laminate sign on or near each major item of mechanical equipment.

1. Provide signs for the following general categories of equipment and operational devices:

a. Fans
b. Water Source Heat Pumps
c. Water Cooled Package units
d. Motor Starters and Variable Frequency Drives (Mount near starter)
e. Expansion Tanks
f. Heating Coils
g. Pumps
h. Chillers
i. Cooling Towers
j. Heat Exchangers

B. Provide engraved plastic laminate nameplate on every new piece of equipment not already provided with one in accordance with Section 23 05 02 of the specifications.

C. Identify area served, if applicable.

3.6 NON-POTABLE WATER IDENTIFICATION

A. Provide an engraved plastic laminate sign.

1. Legend: “Non-Potable Water”.
2. Location: At each outlet of piping downstream of backflow preventer, (e.g. Boiler Room hose bibb).

END OF SECTION

SECTION 23 05 93

TEST-ADJUST-BALANCE

PART 1 - GENERAL

1.1 RESPONSIBILITY

A. Work of this section shall be completed by a sub-contractor of the HVAC contractor.

B. The Balancing Contractor shall not be a sub-contractor of any other Division 21, 22 or 23 Contractor.

1.2 QUALITY ASSURANCE

A. Qualification:

1. Work shall be done by a firm certified by the National Environmental Balancing Bureau (NEBB), or the Associated Air Balance Council (AABC), or the firm shall have technicians certified by the "National Training Fund Sheet Metal & Air Conditioning Industry".
2. The firm shall be an independent testing and balancing firm specializing in testing and balancing of environmental systems.
3. The firm shall have an experience record of not less than five (5) years experience in the TAB industry.

B. Industry Standards: Comply with the following:

1. HVAC Systems-Testing, Adjusting, Balancing published by Sheetmetal and Air Conditioning Contractors National Association, Inc. (SMACNA).
2. Procedural Standards for Testing, Adjusting, Balancing of Environmental Systems published by National Environmental Balancing Bureau. (NEBB).
3. ASHRAE Systems Handbook. Testing, Adjusting and Balancing.

C. Registration: Work shall be done under the supervision of a professional engineer registered in the jurisdiction of the work. Engineer shall be available for all meetings and interpretation of all materials in the report.

D. Pre-qualification of TAB Contractor.

1. The firm must have experience and qualifications satisfactory to the consulting mechanical engineer and must be accepted by him prior to bidding.
2. Firms desiring approval to provide work under this section shall submit a booklet indicating procedures and data forms that they would use in the performance of the work.
3. Submittals shall be in accordance with Section 23 05 02.

4. Only firms which have been approved by the mechanical engineer may provide work under this section.

PART 2 – PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.1 GENERAL

A. Sequence work to commence after completion of system and start-up procedures and schedule completion of work before Substantial Completion of Project.

B. The project will be completed in phases and it will be necessary to balance new and existing equipment at the end of each phase.

1. Assume that any equipment installed in a phase must be balanced in its installation phase.
2. Assume that any equipment serving more than a single space will need to be rebalanced at the turnover of each phase after installation.
3. Assume that all equipment will require final balancing after the completion of the final phase.
4. Submit preliminary balancing reports at the end of each phase. Submit final balancing report at the completion of final phase.

C. Examine the installed work and conditions under which testing is to be done to ensure that work has been completed, cleaned and is operable.

D. Notify the Contractor in writing of conditions detrimental to the proper completion of the test-adjust-balance work.

1. Do not proceed with the work until unsatisfactory conditions have been corrected.
2. Provide Engineer/Architect with a copy of the notification.

E. Adjust flows to within 10% of values shown. If design flows cannot be obtained within specified limits the Balancing Contractor will perform the following (at the minimum):

1. Measure and record major pressure drops in the system.
2. Consult with the Engineer and Installer as required.
3. Upon receiving written directions to proceed and after any corrections are performed, re-balance affected portion of system.

F. Optimization: Work closely with the controls contractor to optimize setpoints.

1. Establish the minimum air static pressure or water differential pressure for variable or bypass flow system.

2. Establish the position of minimum outside air dampers, damper/valve and sequencing relays.

G. Calibration: Be responsible for calibration of flow measurement devices used as input to the temperature control system. All air systems flow measurement stations including VAV terminals shall be calibrated against a pitot tube traverse or air diffuser capture hood. Balancing contractor shall assure accuracy of all flow measurement devices or shall report on their failure to be accurate.

H. Patch holes in insulation, ductwork and housings, which have been cut or drilled for test purposes, in a manner recommended by the original Installer.

I. Make all final readings for each system at the same time, and after all adjustments have been made.

J. Mark equipment settings, including damper control positions, balancing cocks, circuit setters, valve indicators, fan speed control settings and similar controls and devices, to show final settings at completion of test-adjust-balance work.

1. Mark with paint or other suitable permanent identification material.

K. Check all new thermal overloads.

1. Identify improperly protected equipment in report.

L. All piping and equipment shall be tested; labor including standby electrician, materials, instruments and power required for testing shall be furnished unless otherwise indicated under the particular section of the Specification.

M. Tests shall be performed in the presence and to the satisfaction of the Architect and such other parties as may have legal jurisdiction.

N. In no case shall piping, equipment, or accessories be subjected to pressure exceeding their ratings.

O. All defective work shall be promptly repaired or replaced and the tests shall be repeated until the particular system and component parts thereof receive the approval of the Architects.

P. Any damage resulting from tests to any and all trades shall be repaired and damaged materials replaced, all to the satisfaction of the Architect.

Q. The duration of tests shall be as determined by all authorities having jurisdiction, but in no case less than the time prescribed below.

R. Equipment and systems which normally operate during certain seasons of the year shall be tested during the appropriate season. Tests shall be performed on individual equipment, systems, and their controls. Whenever the equipment or system under test is interrelated and depends upon the operation of other equipment, systems and controls for proper operation, functioning and performance, and latter shall be operated simultaneously with the equipment or system being tested.

S. All fans and duct systems shall be completely balanced by the adjustment of sheaves, dampers, registers and other volume and diverting control devices, to obtain the air quantities indicated on the design drawings. Replace sheaves if required to meet design conditions.

T. All pumps and piping systems shall be completely balanced by the adjustment of the plug cocks, globe valves or other control devices, to obtain the flow quantities indicated on the design drawings.

3.2 EXAMINATION

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

B. Examine systems for installed balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers. Note the locations of devices that are not accessible for testing and balancing.

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

D. Examine ceiling plenums and underfloor air plenums used for supply, return, or relief air to verify that are properly separated from adjacent areas. Verify that penetrations in plenum walls are sealed and fire-stopped if required.

E. Examine equipment performance data including fan and pump curves.

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

G. Examine terminal units, such as variable-air-volume boxes, and verify that they are accessible and their controls are connected, configured by the controls contractor, and functioning.

H. Examine strainers to verify that mechanical contractor has replaced startup screens with permanent screens and that all strainers have been cleaned.

I. Examine two-way valves for proper installation and function.

J. Examine three-way valves for proper installation for their intended function of diverting or mixing fluid flows.

K. Examine heat-transfer coils for correct piping connections and for clean and straight fins.

L. Examine air vents to verify that mechanical contractor has removed all air from all hydronic systems.

3.3 PREPARATION

A. Prepare a TAB plan that includes the following:

1. Equipment and systems to be tested.
2. Strategies and step-by-step procedures for balancing the systems.
3. Instrumentation to be used.
4. Sample forms with specific identification for all equipment.

B. Prepare system-readiness checklists, as described in the "AABC National Standards for Total System Balance," for use by systems installers in verifying system readiness for TAB. These shall include, at a minimum, the following:

1. Airside:
   a. Ductwork is complete with terminals installed.
   b. Volume, smoke and fire dampers are open and functional.
   c. Clean filters are installed.
   d. Fans are operating, free of vibration, and rotating in correct direction.
   e. Variable-frequency controllers' start-up is complete and safeties are verified.
   f. Automatic temperature-control systems are operational.
   g. Ceilings are installed.
   h. Windows and doors are installed.
   i. Suitable access to balancing devices and equipment is provided.

2. Hydronics:
   a. Piping is complete with terminals installed.
   b. Water treatment is complete.
   c. Systems are flushed, filled and air purged.
   d. Strainers are pulled and cleaned.
   e. Control valves are functioning per the sequence of operation.
   f. Shutoff and balance valves have been verified to be 100 percent open.
   g. Pumps are started and proper rotation is verified.
   h. Pump gage connections are installed directly at pump inlet and outlet flanges or in discharge and suction pipe prior to valves or strainers.
   i. Variable-frequency controllers' start-up is complete and safeties are verified.
   j. Suitable access to balancing devices and equipment is provided.

3.4 GENERAL REQUIREMENTS

A. At a minimum, measure, adjust and report the following:

1. Fans:
   a. Inlet and outlet pressure
   b. Air flow
   c. Fan speed
   d. Motor amps and KW
2. Ductwork Systems:
   a. Air flow at each inlet and outlet.
   b. Blade angles at all adjustable diffusers.
   c. Filter pressure drop.
   d. Outside air percentage at minimum and maximum setting.
   e. Air flow at supply, return, outside air and exhaust mains to determine total air flow.
3. Coils (Water):
   a. Air flow.
   b. Inlet and outlet air static pressure.
   c. Inlet and outlet air temperature.
   d. Water flow.
   e. Inlet and outlet water pressure.
   f. Inlet and outlet water temperature.
4. Coils (Steam):
   a. Air flow.
   b. Inlet steam pressure.
   c. Inlet and outlet air temperature.
5. Pumps:
   a. Water flow
   b. Inlet and outlet pressure
   c. Motor amps and KW
6. Water Cooled Packaged Air Conditioning Units:
   a. Perform tests for individual components present in units in accordance with specific requirements above.
   b. Inlet and outlet condenser water pressure.
   c. Inlet and outlet condenser water temperature.
   d. At full heat: (Check at minimum outside air):
      1) EAT
      2) LAT
   e. At full cooling: (Check at minimum outside air):
      1) EAT (DB/WB)
      2) LAT (DB/WB)
      3) Ambient temperature
      4) Suction and discharge pressures
      5) Oil pressure
      6) Compressor amps and KW
      7) Minimum air flow rate.

7. Chillers:
   a. Inlet and outlet water temperature and pressure
   b. Water flow
   c. Suction pressure
   d. Compressor amps and KW
   e. Inlet and outlet brine chilled water pressure.
   f. Inlet and outlet brine chilled water temperature.
   g. Inlet and outlet condenser water pressure.
   h. Inlet and outlet condenser water temperature.
8. Cooling tower:
   a. Inlet air wet bulb
   b. Entering and leaving water temperatures
   c. Water flow
   d. Fan amps and voltage
   e. Inlet and outlet condenser water pressure.
   f. Inlet and outlet condenser water temperature.
9. Heat Exchangers:
   a. Cooler fluid inlet and outlet temperatures
   b. Cooler fluid inlet and outlet water pressure.
   c. .Inlet steam pessure
   d. Cooler fluid flow

B. Refer to other sections of these specifications for additional requirements.

3.5 GENERAL PROCEDURES FOR BALANCING AIR SYSTEMS

A. Scope: All air systems are to be balanced.

B. Before any adjustments are made, check for:

1. Dirty filters, coils, or air intakes
2. Duct leakage
3. Filter leakage
4. Damper leakage, or blockage
5. Equipment vibrations
6. Correct damper operation

C. Simulate a pressure drop across filters equal to that when 50% loaded with dust.

1. Check fan motor amps with clean filters and simulated loaded filters, and report.

D. Procedure:

1. Measure and report all supply, return, exhaust, and outside air systems by means of (4) four methods:
   a. Individual air inlets and outlets.
   b. Pitot traverses of main supply, return, exhaust and outside air ducts.
   c. Rotating valve or velocity grid traverse of coils or filters.

d. Plot operating point on fan curve. Include compensation for effects of altitude and inlet vanes.

2. Above measurements shall be made with system in normal, full load condition.
   a. Systems with economizers shall be measured at minimum outside air and 100% outside air.
   b. Systems with 100% outside air capability or evaporative cooling sections shall be measured at maximum outside air.
   c. VAV systems shall be measured at the zone level at maximum air condition, and at the main at the system diversity condition.
3. Make main duct traverses or coil/filter traverses and report operation at all other operating conditions (as applicable).
   a. Economizer operation
   b. Unoccupied mode
   c. Smoke evacuation mode
   d. Pre-cool mode
   e. Fail over mode
   f. Two-speed fans
   g. All VAV terminals driven to maximum position
4. Set fan speed such that under no condition will the motor exceed the service factor rating when operating in any of the above possible modes.
5. Measure fan motor amps in each of the above possible operating modes (clean filters).

E. Adjust Air Systems to provided proper air pressure relationships as shown by relative air quantities or as indicated on the drawings.

1. Review drawings for room by room pressure relationships and use a smoke candle to prove proper relative air flow.

F. Adjust distribution system for uniform space temperatures free from objectionable drafts and noise.

G. Exchange sheaves and belts as required to adjust the RPM of all fans so they handle specified air quantity.

H. Set minimum outside air quantities.

I. Prepare test reports for both fans and outlets. Obtain approved submittals and recommended testing procedures. Crosscheck the summation of required outlet volumes with required fan volumes.

J. Prepare single-line schematic diagram of systems for the purpose of identifying HVAC components.

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

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

M. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.

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

O. Check condensate drains for proper connections and functioning.

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

Q. Refer to other sections of these specifications for additional requirements

3.6 PROCEDURES FOR CONSTANT-VOLUME AIR SYSTEMS

A. Retain this article if using constant-volume air systems.

B. Adjust fans to deliver total indicated airflows within the maximum allowable fan speed listed by fan manufacturer.

C. Measure total airflow.

1. Set outside air, return air and relief air dampers for proper position that simulates minimum outdoor air conditions.
2. Where duct conditions allow, measure airflow by Pitot-tube traverse. If necessary, perform multiple Pitot-tube traverses to obtain total airflow.
3. Where duct conditions are not suitable for Pitot-tube traverse measurements, a coil traverse may be acceptable.
4. If a reliable Pitot-tube traverse or coil traverse is not possible, measure airflow at terminals and calculate the total airflow.

D. Measure fan static pressures as follows:

1. Measure static pressure directly at the fan outlet or through the flexible connection.
2. Measure static pressure directly at the fan inlet or through the flexible connection.
3. Measure static pressure across each component that makes up the air-handling system.
4. Report any artificial loading of filters at the time static pressures are measured.

E. Do not make fan-speed adjustments that result in motor overload. Consult equipment manufacturers about fan-speed safety factors. Modulate dampers and measure fan-motor amperage to ensure that no overload will occur. Measure amperage in full-cooling, full-heating, economizer, and any other operating mode to determine the maximum required brake horsepower.

F. Adjust volume dampers for main duct, submain ducts, and major branch ducts to indicated airflows.

1. Measure airflow of submain and branch ducts.

2. Adjust sub-main and branch duct volume dampers for specified airflow.
3. Re-measure each sub-main and branch duct after all have been adjusted.

G. Adjust air inlets and outlets for each space to indicated airflows.

1. Set airflow patterns of adjustable outlets for proper distribution without drafts.
2. Measure airflow at all inlets and outlets.
3. Adjust each inlet and outlet for specified airflow.
4. Re-measure each inlet and outlet after all have been adjusted.

H. Verify final system conditions.

1. Re-measure and confirm minimum outdoor air, return and relief airflows are within design. Readjust to design if necessary.
2. Re-measure and confirm total airflow is within design.
3. Re-measure all final fan operating data, rpms, volts, amps, static profile.
4. Mark all final settings.
5. Test system in economizer mode. Verify proper operation and adjust, if necessary.
6. Measure and record all operating data.
7. Record final fan-performance data.

3.7 GENERAL PROCEDURES FOR HYDRONIC SYSTEMS

A. Scope: Balance all hydronic systems.

B. Prepare test reports for pumps, coils, heat exchangers and other equipment. Obtain approved submittals and any manufacturer-recommended testing procedures. Crosscheck the summation of required coil and heat exchanger flow rates with pump design flow rate.

C. Verify that hydronic systems are ready for testing and balancing:

1. Check liquid level in expansion tank.
2. Check that makeup water-has adequate pressure to highest vent.
3. Check that control valves are in their proper position.
4. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.
5. Verify that motor starters are equipped with properly sized thermal protection.
6. Check that air has been purged from the system.

D. Before any adjustments are made:

1. Check temperature control valve operation.
2. Check pump rotation.
3. Adjust pressure reducing valve.
4. Remove any roughing strainer screens in systems.

E. Using system flow meters, adjust the quantity of fluid handled by each pump and supplied to each coil, heat exchanger, cross-over bridge, bypass, etc., to meet design requirements.

F. Procedure:

1. Measure and report all hydronic and domestic water recirculation systems by all of the below means which are applicable.
   a. System, pump, branch, or terminal flow measuring stations.
   b. Terminal or heat exchanger pressure drop, compare to submittal data.
   c. Plot operating point on pump curve. Include compensation for effects of temperature, viscosity and density.
2. Above measurements to be made and reported at full heating/cooling load.
   a. For 3-way valve terminals/heat exchangers set bypass flow to equal coil flow.
   b. For primary/secondary systems, set crossover/bridle to have constant flow at all conditions.

G. Refer to other sections of these specifications for additional requirements

3.8 FIELD TESTING OF HYDRONIC SYSTEMS

A. During construction properly cap or plug all lines so as to prevent the entrance of sand, dirt, etc. The system of piping shall be blown through wherever necessary after completion (for the purpose of removing grit, dirt, sand, etc., from all equipment and piping), for as long a time as is required to thoroughly clean the apparatus.

B. Use anti-freeze solution for piping to be tested in winter.

C. All piping shall be tested as hereinafter specified. Tests shall be made after erection and before covering is applied or piping painted or concealed and as sections of mains and groups of risers are completed. The extent of the work completed before pressure tests are made shall be determined by the Architect.

D. All piping shall be tested to a hydrostatic pressure at least 1-1/2 times the maximum designed working pressure unless a higher pressure is required elsewhere (but not less than 50 psi) for a sufficiently long time to detect all leaks and defects; and after testing shall be made tight in the most approved manner. Tests shall be repeated once after leaks and defects have been repaired. When automatic-control valves and similar devices are incapable of withstanding test pressures applied to piping, such devices shall be removed, or otherwise protected during tests. After completion of such tests, devices shall be installed and tested with the operating medium to operating pressures.

E. The following systems shall be tested for four consecutive hours and proved tight. Leaks shall be remedied by replacing defective work. Test shall be performed at 1-1/2 times working pressure unless a higher pressure is required elsewhere; minimum pressures listed in table below.

Item	Hydrostatic Field Test
Low pressure steam and condensate piping	100 psi
Cold Water (domestic)	100 psi
Chilled water / Brine Chilled Water	100 psi
Condenser water	100 psi
Chemical Treatment	
- Condenser water	100 psi
- Chilled water	100 psi

F. Leaks appearing during the various pressure tests shall be corrected by replacing all defective materials or welds and subsequent tests shall be made until the piping is found perfect. Caulking of screwed joints or peening of welds is prohibited. Wherever it is necessary to cut out a weld and the ends of the pipe cannot be conveniently brought together, then a short piece of pipe shall be fitted in and welded as approved by the Architect.

G. Provide all other tests required by Building Department, Fire Department and other Authorities having jurisdiction.

H. Running Test of Piping Systems:

1. When directed, any section of the work, after it has been completed and otherwise satisfactorily tested, shall be put in actual operation and operated for a period of two days of 24 hours each, during which time any defects which may appear shall be remedied and any adjustment which may be necessary shall be made.
2. During the time of the tests, repack all valves, make all adjustments and otherwise put the apparatus in perfect condition for operation, and instruct the Owner's representative in the use and management of the apparatus.

3.9 PROCEDURES FOR CONSTANT-FLOW HYDRONIC SYSTEMS

A. Adjust pumps to deliver total design gpm.

B. Measure total water flow.

1. Position valves for full flow through coils.
2. Measure flow by main flow meter, if installed.
3. If main flow meter is not installed determine flow by pump total dynamic head (TDH) or exchanger pressure drop.

C. Measure pump TDH as follows:

1. Measure discharge pressure directly at the pump outlet flange or in discharge pipe prior to any valves.

2. Measure inlet pressure directly at the pump inlet flange or in suction pipe prior to any valves or strainers.
3. Convert pressure to head and correct for differences in gauge heights.
4. Verify pump impeller size by measuring the TDH with the discharge valve closed. Note the point on manufacturer's pump curve at zero flow and verify that the pump has the intended impeller size.
5. With all valves open, read pump TDH. Adjust pump discharge valve until design water flow is achieved.

D. Monitor motor performance during procedures and do not operate motor in an overloaded condition.

E. Adjust flow measuring devices installed in mains and branches to design water flows.

F. Measure flow in main and branch pipes.

G. Adjust main and branch balance valves for design flow.

H. Re-measure each main and branch after all have been adjusted.

I. Adjust flow measuring devices installed at terminals for each space to design water flows.

J. Measure flow at all terminals.

K. Adjust each terminal to design flow.

L. Re-measure each terminal after all have been adjusted.

M. Position control valves to bypass the coil and adjust the bypass valve to maintain design flow.

N. Perform temperature tests after all flows have been balanced.

O. For systems with pressure-independent valves at the terminals:

1. Measure differential pressure and verify that it is within manufacturer’s specified range.
2. Perform temperature tests after all flows have been verified.

P. For systems without pressure-independent valves or flow measuring devices at the terminals:

1. Measure and balance coils by either coil pressure drop or temperature method.
2. If balanced by coil pressure drop, perform temperature tests after all flows have been verified.

Q. Verify final system conditions as follows:

1. Re-measure and confirm that total water flow is within design.
2. Re-measure all final pumps' operating data, TDH, volts, amps, static profile.
3. Mark all final settings.
4. Verify that all memory stops have been set.

3.10 PROCEDURES FOR VARIABLE-FLOW HYDRONIC SYSTEMS

A. Balance systems with automatic two- and three-way control valves by setting systems at maximum flow through heat-exchange terminals and proceed as specified above for hydronic systems.

B. Adjust the variable-flow hydronic system as follows:

C. Verify that the differential-pressure sensor is located per the contract documents.

D. Determine if there is diversity in the system.

E. For systems with no diversity:

F. Follow procedures outlined in "Procedures for Constant-Flow Hydronic Systems" Article.

G. Prior to verifying final system conditions, determine the system differential-pressure set point.

H. If the pump discharge valve was used to set total system flow with variable-frequency controller at 60 Hz, at completion open discharge valve 100 percent and allow variable-frequency controller to control system differential-pressure set point. Record pump data under both conditions.

I. Mark all final settings and verify that all memory stops have been set.

J. For systems with diversity:

K. Determine diversity factor.

L. Simulate system diversity by closing required number of control valves, as approved by the design engineer.

M. Follow procedures outlined in "Procedures for Constant-Flow Hydronic Systems" Article.

N. Open control valves that were shut. Close a sufficient number of control valves that were previously open to maintain diversity, and balance the terminals that were just opened.

O. Prior to verifying final system conditions, determine the system differential-pressure set point.

P. If the pump discharge valve was used to set total system flow with variable-frequency controller at 60 Hz, at completion open discharge valve 100 percent and allow variable-frequency controller to control system differential-pressure set point. Record pump data under both conditions.

Q. Mark all final settings and verify that all memory stops have been set.

3.11 PROCEDURES FOR STEAM SYSTEMS

A. Check settings and operation of automatic temperature-control valves, self-contained control valves, and pressure-reducing valves. Record final settings.

B. Check settings and operation of each safety valve. Record settings.

C. Verify the operation of each steam trap.

3.12 PROCEDURES FOR HEAT EXCHANGERS

A. Balance water flow to within specified tolerances.

B. Measure inlet and outlet water temperatures.

C. Check settings and operation of safety and relief valves. Record settings.

3.13 PROCEDURES FOR MOTORS

A. Motors, 1/2 HP and Larger: Test at final balanced conditions and record the following data:

1. Manufacturer's name, model number, and serial number.
2. Motor horsepower rating.
3. Motor rpm.
4. Phase/Hertz (Hz)
5. Nameplate and measured voltage, each phase.
6. Nameplate and measured amperage, each phase.
7. Starter size and thermal-protection-element rating.
8. Service factor and frame size.

B. Motors Driven by Variable-Frequency Controllers: Test the manual bypass of the controller to prove proper operation.

3.14 PROCEDURES FOR CHILLERS

A. Balance water flow through each evaporator and condenser to within specified tolerances with all pumps operating per design sequence. Record the following data with each chiller operating at design conditions:

1. Evaporator-water entering and leaving temperatures, pressure drop, and water flow.
2. For water-cooled chillers, condenser-water entering and leaving temperatures, pressure drop, and water flow.
3. Power factor if shown on the chiller display panel.
4. Kilowatt input if shown on the chiller display panel.
5. Capacity: Calculate in tons of cooling.

B. For air-cooled chillers, verify condenser-fan rotation and record fan and motor data including number of fans and entering- and leaving-air temperatures.

3.15 PROCEDURES FOR COOLING TOWERS

A. Comply with CTI STD-105, "Acceptance Test Code."

B. Balance total condenser-water flows to the towers. Measure and record the following data:

1. Condenser-water flow to each cell of the cooling tower.
2. Entering- and leaving-water temperatures.
3. Wet- and dry-bulb temperatures of entering air.
4. Wet- and dry-bulb temperatures of leaving air.
5. Condenser-water flow through bypass.
6. Fan and motor operating data.

3.16 PROCEDURES FOR COILS

A. Measure, adjust, and record the following data for each water coil:

1. Entering- and leaving-water temperature.
2. Water flow rate.
3. Water pressure drop for major (more than 20 gpm) equipment coils, excluding unitary equipment such as reheat coils, unit heaters, fan-coil units, etc.
4. Dry-bulb temperature of entering and leaving air.
5. Wet-bulb temperature of entering and leaving air for cooling coils.
6. Airflow.

B. Measure, adjust, and record the following data for each steam coil:

1. Dry-bulb temperature of entering and leaving air.
2. Airflow.
3. Inlet steam pressure.

3.17 EXISTING TO REMAIN DUCTWORK

A. Prior to the start of any demolition work that alters the duct configuration of an air handler or fan the HVAC contractor shall take flow and pressure readings on all duct branches and\or diffusers that will remain in service after alterations. Readings shall measure the existing air flow and static pressure at each location so that flow and pressure in branch can be restored after completion of work. All flow and pressure readings shall be provided to the engineer and made available to future balancing contractors for use on this project to reduce the need to re-balance all diffusers\registers\grilles on systems not being altered. Any contractor removing existing ductwork prior to the completion of the pre-demolition flow and pressure readings shall be responsible for re-balancing all diffusers and branch ductwork downstream of the point of the alteration.

B. New balancing dampers will be required at all locations where a new duct main serves an existing to remain branch, main or diffuser. In locations where an existing and functional volume damper is being removed or does not exist at the point of the connection of the new duct to the existing duct a new balancing damper shall be provided at the point of the new connection.

C. After the completion of the duct alterations the new and existing damper(s) and fan(s) shall be balanced to provide indicated flow at all new diffusers and match pre-demolition flow measurements at all existing to remain distribution systems.

3.18 ADDITIONAL TESTS

A. Seasonal Periods: If initial TAB procedures were not performed during near-peak conditions, the engineer may request a temperature recheck to further verify performance at near-peak conditions.

B. Duct Leakage Testing:

1. Witness the duct pressure testing performed by the mechanical/installing contractor.
2. Verify that proper test methods are used and that leakage rates are within specified tolerances.
3. Report any deficiencies observed.

C. Controls Verification

1. In conjunction with system balancing perform the following:
    a. Work with the temperature control contractor to ensure the system is operating within the design limitations, and gain a mutual understanding of intended control performance.
    b. Confirm that the sequences of operation are in compliance with the approved drawings.
    c. Verify that controllers are calibrated and function as intended.
    d. Verify that controller setpoints are as specified.

e. Verify the operation of lockout or interlock systems.
f. Verify the operation of all valve and damper actuators.
g. Verify that all controlled devices are properly installed and connected to the correct controller.
h. Verify that all controlled devices travel freely and are in the position indicated by the controller: open, closed, or modulating.
i. Verify the location and installation of all sensors to ensure they will sense only the intended temperatures, humidity, or pressures.

3.19 FINAL TEST AND BALANCE REPORT

A. Provide a general information sheet listing:

1. Instruments used:
   a. Most recent calibration date.
2. Method of balancing.
3. Altitude correction.
4. Manufacturer's performance data for all air devices used.

B. Provide data sheets for all equipment, including motors and drives, listing:

1. Make
2. Size
3. Serial number
4. Capacity Rating
5. Amperage
6. Voltage input
7. Thermal heater size for each motor
8. Operating speed of driver and driven devices
9. Any additional pertinent performance data

C. Include design and final values for all items listed in Detailed Requirements, and totals for each system.

D. Provide data sheets showing:

1. Air flow at each inlet and outlet
2. Instrument used
3. Velocity reading
4. Manufacturer's free area factors

E. Provide recap sheet with explanation for each device not meeting specified performance. Contractor shall be responsible for correcting all deficiencies noted in the TAB report. Upon completion of correction of deficiencies, the TAB contractor shall retest all devices and provide an updated report.

F. Provide a set of prints with equipment, inlets and outlets marked to correspond to data sheets.

END OF SECTION

SECTION 23 07 00

MECHANICAL INSULATION

PART 1 - GENERAL

1.1 SUBMITTALS

A. Submit manufacturer's product data on the following:

1. Insulation.
2. Jackets, coatings and protective finishes.
3. Sealers, mastics and adhesives.
4. Fitting covers.
5. Manufacturer's installation details for fire rated duct wrap.

1.2 FLAME AND SMOKE RATINGS

A. Provide insulation tested on a composite basis (insulation, jacket, covering, sealer, mastic and adhesive) complying with the following for:

1. Flame Spread: 25 or Less
2. Smoke Developed: 50 or Less
3. Method: ASTM E84 (NFPA 255), UL 723

B. Accessories such as adhesives, mastics, cements, tapes and cloths for fittings shall have component ratings as listed above. All products shall bear UL labels indicating the above are not exceeded.

1.3 PRODUCT DELIVERY

A. Deliver insulation products in factory containers bearing manufacturer's label showing fire and smoke hazard rating, density and thickness.

B. Protect insulation against, dirt, water, chemical and mechanical damage. Do not install damaged insulation; remove from project site.

C. Store insulation in original wrappings and protect from weather and construction traffic.

1.4 DEFINITIONS

A. Exposed Location: Located in mechanical rooms or other areas exposed to view.

B. Concealed Location: Locations not exposed to view, such as pipe chases, furred spaces, attics, crawl-spaces and above wall to wall suspended ceilings.

1.5 STANDARDS

A. Comply with the latest edition of National Commercial and Industrial Insulation Standards.

B. Provide certifications or other data as necessary to show compliance with these Specifications and governing regulations. Include proof of compliance for test of products for fire rating, corrosiveness, and compressive strength.

PART 2 - PRODUCTS

2.1 PIPE INSULATION

A. Manufacturers:

1. Design Basis: Johns-Manville
2. Other Acceptable Manufacturers:
    a. Armacell
    b. Foster
    c. Childers
    d. Owens-Corning
    e. Knauf
    f. KFlex USA
    g. Imcoa
    h. Pittsburgh Corning

B. Materials:

1. Fiberglass Pipe Insulation with Vapor Barrier: Johns-Manville Micro-Lok heavy density pipe insulation with AP-T jacket or Owens-Corning Fiberglass Corp. ASJ/SSL-II.
2. Fiberglass Pipe Fitting Insulation: Johns-Manville "Zeston" fitting covers with factory-cut fiberglass insulation insert. Insulation blanket with foil tape and tie-wire will not be acceptable.
3. Flexible Unicellular Pipe Insulation: Armstrong Armaflex, II or Therma-cel By Nomaco.
4. Cellular glass with vapor barrier coating: Pittsburgh Corning FoamGlass.
5. Rigid Closed Cell Insulation: ITW Insulation Trymer 2000 XP (not for use indoors).
6. Vapor Barrier Mastic: Foster 30-65 or Childers CP-34; permeance shall be 0.03 perms or less per ASTM E96. Mastic must meet California Dept of Public Health (CDPH) Standard Method Ver. 1.1, 2010 Small Scale Environmental Chamber Test for VOCs for CA Specification 01350 and LEED IEQ 4.2.
7. Weather Barrier Mastic: Foster 46-50 or Childers CP-10/11. For use on hot service pipe and ducts.
8. Lagging Adhesive: Foster 30-36 or Childers CP-50AMV1.
9. Fiberglass Adhesive: Foster 85-60 or Childers CP-127.

10. For hot pipe insulation material shall be rated at 650˚F.

C. Thickness: (Thickness listed below are minimum required. Provide thickness required by Local Building or Energy Codes).

1. Hydronic Piping and Steam:

2.2

Piping Insulation Thickness (inches)							
Operating Temperature	Insulation Conductivity[a]		Pipe Size				
°F	Btu*in/ (h*ft^2*F)	Mean Rating Temperature, F	<1"	1" to < 1-1/2"	1-1/2" to < 4"	4" to < 8"	≤ 8"
Chilled Water, Brine							
< 32°F	0.20-0.26	75	4	4	4	4	4
Heating Water							
141°F - 200°F	0.25-0.29	125	1.5	1.5	2	2	2
Low Pressure Steam and Condensate (less than 15psig)							
201°F - 250°F	0.27-0.30	150	2.5	2.5	3	3	3

a. For insulation outside the stated conductivity range, the minimum thickness (T) shall be determined as follows:

$T= r \{(1+t/r)^{K/k}-1\}$

where:

T: minimum insulation thickness,

r: actual outside radius of pipe,

t: insulation thickness listed in the table for applicable fluid temperature and pipe size,

K: conductivity of alternate material at mean rating temperature indicated for the applicable fluid temperature (Btu x in/h x ft^2 x F) and

k: the upper value of the conductivity range listed in the table for the applicable fluid temperature.

1. Refrigerant Piping (Liquid, Suction and Hot Gas) and AC Condensate
   a. Up to 1” – ¾”
   b. Above 1” – 1”
2. Condenser Water
   a. Condenser Water utilized for Free Cooling shall be the same as Chilled Water
   b. All other Condenser Water: 1” in Conditioned Spaces.
3. Heat Traced Piping
   a. Size 2” and smaller: 1”

b. Size 2½” and larger: 2”
4. Condensate Drain Piping: 1”

B. Application: Unless otherwise indicated, use the following:

1. Inside, concealed: Fiberglass pipe insulation with vapor barrier.
2. Inside, exposed: Fiberglass pipe insulation with vapor barrier and PVC jacket (jacket not required in mechanical rooms).
   a. A vapor barrier mastic compatible with the PVC shall be applied around the edges of the adjoining pipe insulation and on the fitting cover throat overlap seam. The PVC fitting cover is then applied and shall be secured with pressure sensitive pearl gray Z-Tape along the circumferential edges. The tape shall extend over the adjacent pipe insulation and have an overlap on itself at least 2" on the downward side.
   b. 2 or more layers of the Hi-Lo Temp insulation inserts shall be applied with the first layer being secured with a few wrappings of fiberglass yarn.
   c. Refrigerant systems and cold systems in severe ambient conditions: Fittings shall be insulated to a full thickness the same as the adjacent pipe insulation, with insulation which has been mitered to conform to the PVC fitting cover. An intermediate vapor barrier mastic and reinforcing mesh compatible with the PVC shall be applied directly onto the insulation, completely sealing the insulation. The PVC fitting cover is then applied and shall be secured with pressure sensitive pearl gray Z-Tape along the throat seam and the circumferential edges overlapping itself 2" on the downward side.
   d. Qualifications for Using Insulation: Use one Hi-Lo Temp insert for each additional 1" of pipe insulation.
   e. Fitting Cover: the temperature of the PVC fitting cover must be kept below 150˚F by the use of proper thickness of insulation and by keeping the PVC cover away from contact with, or exposure to, sources of direct or radiant heat.
3. Outside, protected: Fiberglass pipe insulation with vapor barrier and aluminum jacket.
4. Outside, exposed to weather: Rigid closed cell pipe insulation with aluminum jacket.
5. All fittings, valves and flanges for pipe sizes 3" and below shall be insulated with preformed molded fiberglass insulation of same thickness as the adjoining pipe insulation, secured with No. 20 gauge galvanized annealed steel wire covered with Zeston 2000 molded PVC fitting covers as manufactured by Manville, or equal.
6. All fittings, valves and flanges for pipe sizes 4" and larger shall be insulated with fabricated mitered segments of pipe insulation of same thickness as the adjoining pipe insulation, secured with no. 20 gauge galvanized annealed steel wire and covered with Zeston 2000 molded PVC fitting covers as manufactured by Manville or equal.
7. Direct contact between pipe and hangers will not be accepted. Hangers shall pass outside of a metal saddle which shall cover a section of high density insulation of sufficient length to support pipe without crushing insulation. Hangers shall not

pierce insulation and all vapor barriers shall be unbroken and continuous. High density insulation shall be one of the following:
   a. Foam glass.
   b. Fiberglass, high density, minimum of 7 lb. material or heavier.
   c. High density calcium silicate insulation. See Part 3 of this Section for high density insulation lengths.
8. At pipe supports insulation shield protection saddles and matching hanger shall be used.
9. All strainers for chilled water and insulated condenser water piping shall be insulated and boxed in with galvanized sheet metal cover, and insulation shall be made removable.
10. The Contractor shall have the option to use Armaflex as made by Armstrong Co. pipe insulation in lieu of fiberglass hereinbefore specified for refrigerant, chilled, and hot water piping insulation in fan coil units. Pipe insulation shall meet flame spread index of 25 and smoke density of 50 when tested in accordance with ASTM-E-84.
11. Provide vapor barrier dams at locations and intervals recommended by the insulation manufacturer and as described in this specification.
12. All high pressure steam insulation for straight pipe is fiberglass and shall conform to ASTM C-547, Type I. Insulation shall consist of single layer thickness. Multi-layered and/or multi-section insulation is unacceptable.

C. Flexible elastomeric insulation (25/50 flame spread/smoke developed index) is acceptable in lieu of fiberglass on cold piping (roof leaders, chilled water, condensate drains from cooling units).

1. Use pre-molded roll on pipe sizes 3.5" and below.
2. Use either pre-molded roll or sheet on pipe sizes 4" and above, adhere insulation on 100% of the pipe. This requirement exceeds the typical industry standard of adhering to lower one-third of pipe on horizontal runs.
3. Match thickness of fiberglass insulation on all pipe sizes. Provide multiple layers when a single layer of material cannot accomplish required thickness.
4. No exposed cross section edges are permitted.

2.2 DUCT INSULATION

A. Manufacturer:

1. Design Basis: Johns Manville
2. Other Acceptable Manufacturers:
   a. Owens-Corning
   b. Certainteed
   c. Knauf

B. Materials:

1. Flexible fiberglass Ductwork Insulation: Johns-Manville Microlite XG, with FSK factory applied foil-scrim-kraft vapor barrier facing, with maximum K factor of 0.25 at 75˚F mean temperature.

2. Rigid Fiberglass Ductwork Insulation: Johns-Manville 800 Series, Spin-Glas Type 814, with FSK factory applied foil-scrim-kraft vapor barrier facing, with maximum K factor of 0.23 at 75˚F mean temperature.
3. Ductwork Insulation Accessories: Provide staples, bands, wires, tape, anchors, corner angles, and similar accessories as recommended by the insulation manufacturer for the applications indicated.
4. Cellular glass: Pittsburgh Corning with vapor barrier.

C. Thickness: (Thickness listed below are minimum required. Provide thickness required by Local Building or Energy Codes).

Ductwork Insulation				
Location	Exposed/Concealed	Insulation Type	R-Value	Thickness
Supply Ductwork (unlined)				
Indoor	Exposed	Rigid	R-6	1½”
Indoor	Concealed	Flexible	R-6	2”
Indoor, Unconditioned Space	Exposed	Rigid	R-6	1½”
Indoor, Unconditioned Space	Concealed	Flexible	R-6	2”
Outdoor	See Outdoor Duct Insulation Section			
Return Ductwork (unlined)				
Indoor	Exposed	Rigid	R-6	1½”
Indoor	Concealed	Flexible	R-6	2”
Indoor, Unconditioned Space	Exposed	Rigid	R-6	1½”
Indoor, Unconditioned Space	Concealed	Flexible	R-6	2”
Outdoor	See Outdoor Duct Insulation Section			
Outside Air Ductwork (unlined)				
Indoor	Exposed	Rigid	R-6	1½”
Indoor	Concealed	Flexible	R-6	2”
Indoor, Unconditioned Space	Exposed	Rigid	R-6	1½”
Indoor, Unconditioned Space	Concealed	Flexible	R-6	2”
Outdoor	See Outdoor Duct Insulation Section			
Exhaust Air Plenum or Ducts Behind Louver up to Automatic Damper (unlined)				
Indoor	Exposed	Rigid	R-6	1½”
Indoor	Concealed	Flexible	R-6	1½”

D. Application:

1. Where energy codes require additional insulation over that listed above, provide insulation in accordance with those codes.

2. The Contractor shall have the option to use the following material: Insulation for round ducts shall be of thickness noted above and shall be fiberglass Bend-a-Board having a factory applied ASJ vapor barrier jacket secured with stables and ASJ pressure sensitive tape. Bend-a-Board is a 3.00 p.c.f. board cut into strips, adhered to jacketing it must have a UL label.
3. Adhere insulation to duct with Foster water based, fire resistant adhesive 85-60, Chiders CP-127, or approved equal, applied in 3 inch wide transverse strips at 8 inch intervals. Insulation shall be butted with facing overlapping all joints at least 2 inches and sealed with Foster fire resistant adhesive 85-60, Childers CP-127, or approved equal. For insulation with vapor barrier use Foster fire resistant vapor barrier adhesive or equal and joints without tabs shall be firmly sealed with aluminum foil tape adhered with same adhesive. Secure insulation with 16 gauge copperclad wire spaced not more than 12 inches on center.
4. Additionally, secure insulation to bottom of rectangular ducts over 24" wide with welded pins or stick clips on 18" centers coated with a vapor barrier coating.
5. Rigid duct insulation shall be fastened to duct with 12 gauge welded pins and washers, or equivalent as approved. Fasteners shall be spaced 12 to 18 inches on center, a minimum of two rows per side of duct. Secure insulation in place with suitable speed washers firmly embedded in insulation, or push a self-locking cap over pin after coating with fitting mastic type C by Owens-Corning or equal. For rigid duct insulation, seal all joints, breaks and impressions with Foster water based, fire resistant vapor barrier mastic Foster 30-65, Childers CP-34, or approved equal, and apply 5" wide joint sealing tape to all joints. All surface must be clean and dry before applying tape and mastic.
6. Insulation for exposed round ductwork shall be of the same material as specified for concealed ductwork and shall be covered with glass cloth or all service jacket smoothly adhered with Foster 85-60 or Childers CP-127 adhesive. Seal joints with 5" wide tape.

E. Acoustical Duct Lagging

1. Manufacturers:

a. Design Basis: Sound Seal
b. Other acceptable manufacturers:
    1) Kinetics Noise Control
    2) The Proudfoot Company
    3) Acoustical Solutions
c. Model: B-10 LAG/QFA-3, foil face loaded vinyl or lead barrier sheet fully bonded to a minimum 1” thick fiberglass blanket, nominal density of 1.0psf, install so jacket edges overlap by minimum of 6”. Minimum STC-27 tested by independent laboratory in accordance with ASTM E90 and E413. Minimum insertion loss (IL) value at 500Hz shall be 23. Lagging shall meet IMC flame/smoke ratings in accordance with ASTM E84.
d. Duct lining shall be rated to prevent fiber erosion at air velocities up to 4,000 FPM and shall have a minimum density of 1.5 pounds per cubic foot. The liner must be installed with sheet metal nosing at the leading edge. Exposed edges-including butt joints – shall be sealed with mastic.

e. Lining shall be contained between outer wall of duct and perforated metal inner liner of material to match the duct material. Perforations shall not exceed 3/32” diameter, free area shall be approximately 22%. Metal liner need not be perforated at fittings. Provide continuous mylar liner between the perforated liner and insulation to prevent the erosion of the insulation. Provide transitions at end of insulated sections to adapt duct liner size to dimension of unlined ductwork. Liner and transition shall be concentric for low pressure drop.
f. Thickness shall be per thickness required for externally insulated ductwork of same function and location.

2.3 OUTDOOR DUCT INSULATION

A. Manufacturers:

1. Design Basis: Armstrong
2. Other Acceptable Manufacturers:
    a. Johns-Manville
    b. Nomaco

B. Materials:

1. Model: Armaflex
    a. Description: Flexible, cellular, elastomeric foam.
    b. Form: Sheet
2. Paint: Armaflex Finish
    a. Description: Vinyl lacquer. Contractor must coordinate color of vinyl lacquer with Architect. Submit color chart to Architect for his review.
3. Adhesive: Armstrong 520.
4. Cellular glass: Pittsburgh Corning with vapor barrier.
5. Weatherproofing Finishes for Outdoor Duct Insulation:
    a. VentureClad 1579CW Jacketing System, or equal. 13 Ply, 0.45 mm minimum thickness.
    b. Color selected by architect

C. Application:

1. All outdoor supply, return and transfer air ducts that are specified with acoustical duct lining shall be provided with 2” duct lining (minimum R=8).
2. All outdoor supply, return, and transfer air ducts that are not specified to have acoustical lining shall be insulated with two layers of one inch thick sheet on the exterior.
3. Jacketing shall be applied with minimum 2 inch overlaps facing down from the weather and the jacketing shall be secured with aluminum bands 1/2 inch by 0.020 inches and aluminum wing seals applied on 12 inch centers, with bands applied directly over butt overlaps or with Pli-Grip Rivets. Where jacketing is cut out or abuts an uninsulated surface, the joint shall be sealed with Foster 95-44, Childers CP-76, or Insul-Coustic Sure-Joint 405.

4. Over the insulated surface apply a tack coat of Foster 46-50, Childers CP-10/11, or Vi-AC Mastic and imbed in it a layer of glass cloth. A smooth finish coat of weather barrier mastic shall be applied to the entire area so that the total film thickness is a minimum of 1/8 inch. Provide high point at center, so that no water accumulation will occur.

2.4 EQUIPMENT INSULATION

A. Manufacturer:

1. Design Basis: Johns Mansville
2. Other Acceptable Manufacturers:
    a. Armstrong
    b. Certainteed
    c. Owens-Corning
    d. Knauf
    e. Pittsburgh Corning

B. Materials:

1. Model: Pipe and tank insulation.
   Description: Flexible board type insulation. 3 PCF glass fiber insulation with all purpose jacketing. Maximum thermal conductivity .32 BTU-IN/(hr-FT^2-ºF) at 150ºF. Glass fibers oriented such that insulation will conform to rounded shapes while maintaining high compressive strength.
2. Model: Johns-Manville 800 series, spin glass type 814.
   Description: 3 PCT density rigid glass fiberboard, with all purpose jacketing. Maximum thermal conductivity .27 BTU-IN/hr-FT^2--ºF).
3. Jacketing Material: PVC or aluminum jacketing material, except as otherwise indicated. Seal all joints.
4. Fiberglass: Johns-Manville Micro-Lok 850 insulation with APT jacket.
5. Flexible Unicellular Insulation: Armstrong Armacell sheet form.

C. Application:

1. Equipment Insulation Accessories: Provide staples, bands, wire, wire netting, tape, corner angles, anchors, stud pins, metal covers, adhesives, cements, sealers, mastics and protective finishes as recommended by insulation manufacturer for applications indicated.

PART 3 - EXECUTION

3.1 GENERAL

A. Verify acceptability of all materials which are to be used in air plenums (above ceiling, etc.). Materials must meet all requirements of Local Building Code and Authority having jurisdiction.

B. Insulation Packing:

1. Piping :
   a. Wherever piping penetrates walls, partitions, floor slabs, etc., the space between the piping and the sleeve shall be packed with mineral wool and sealed with approved type non-hardening fire resistant caulking compound for sleeves through exterior walls.
2. Ductwork:
   a. Provide 1/2" thick rigid fiberboard sleeve wherever ductwork penetrates walls, floor slabs, partitions, etc. Space between duct and wall sleeve and between duct and slab opening shall be tightly packed with mineral wool and sealed with approved type non-hardening fire resistant caulking compound.
3. Material:
   a. Packing material shall be rockwool insulation as manufactured by United Stated Gypsum Co. or equal and shall comply with Fed. Spec. HH-1-558, Form A, Class 4, K=0.24, melting point 2000˚F.

C. All Winterized Lines That Are Electrically Traced

1. The basic insulation shall be dual temperature, Manville Micro-Lok piping insulation. The insulation shall be sized to accommodate the electric heat tracing applied against the pipe surface.
2. Finish for insulation shall be aluminum jacket as specified under "Weatherproofing of Piping".

D. Contractor shall examine location where this insulation is to be installed and determine space conditions and notify the Architect in writing of conditions detrimental to proper and timely completion of the Work.

E. Do not proceed with the Work until unsatisfactory conditions have been corrected.

3.2 GENERAL INSTALLATION

A. Install insulation in accordance with manufacturer's written instructions and recommendations, and with recognized industry practices, to ensure that insulation complies with requirements and serves intended purposes.

B. Coordinate with other work as necessary to interface installation of insulation with other components of systems.

C. All insulating materials shall be applied only by experienced workmen, in accordance with the best covering practice. All piping, duct or equipment shall be blown out, cleaned, tested and painted prior to the application of any covering. Adhesives, sealers and mastics shall not be applied, when the ambient temperature is below 40˚F., or surfaces are wet.

3.3 PIPE INSULATION

A. Insulate the following:

1. Heating piping.
2. Brine Chilled water piping.
3. Steam and condensate piping.
4. Condenser water piping
5. All existing piping which is currently insulated and which is modified as a result of this work.
6. Condensate drain piping.
7. Heat traced piping

B. Installation:

1. Install insulation on pipe system subsequent to testing and acceptance of tests.
2. Install insulation materials with smooth and even surfaces. Insulate each continuous run of piping with full length units of insulation, with a single cut piece to complete the run. Do not use cut pieces or scraps abutting each other.
3. Clean and dry pipe surfaces prior to insulating. Butt insulation joints firmly together to ensure a complete and tight fit over surfaces to be covered. Provide vapor barrier joint sealant on all butt joints of cold pipe insulation.
4. Extend piping insulation without interruption through pipe clamps, hangers, walls, floors and similar piping penetrations, except where otherwise indicated. Notched insulation will not be acceptable.
5. Install protective metal shields and saddles where needed to prevent compression of insulation. Refer to Section 23 05 29.
6. Except as noted, cover valves, flanges, fittings and similar items in each piping system with equivalent thickness and composition of insulation as applied to adjoining pipe run.
    a. Install factory-molded, pre-cut or job-fabricated units (at Installer's option), except where a specific form or type is indicated.
    b. Do not cover:
        1) Valve operators.
        2) Nameplates or identification tags.
    c. Provide removable access for:
        1) Strainers.
        2) Other components requiring access for service.
7. Mark location of unions and flanges covered by insulation with permanent paint or ink, or approved label.
8. Maintain integrity of vapor-barrier sealant and jacketing on insulation of cold pipes and protect to prevent puncture or other damage. Insulation on cold surfaces where vapor barriers are used shall be applied with a continuous, unbroken vapor seal. Hangers, supports, anchors, etc., that are secured directly to cold services shall be adequately insulated and vapor sealed to prevent condensation.
9. Inserts shall be installed at hangers for insulated piping. Inserts between the pipe and pipe hangers shall consist of rigid pipe insulation of equal thickness to the

adjoining insulation and shall be provided with vapor barrier where required. Insulation inserts shall not be less than the following lengths:

2-1/2" pipe size and smaller	6" long
3" to 6" pipe size	9" long
8" to 10" pipe size	12" long
Larger than 10" pipe size	18" long

10. Provide 18 gauge galvanized metal shields between hangers or supports and pipe insulation. Form shields to fit insulation. Extend shields up to centerline of pipe. Make shields same length as that specified above for inserts.
11. Where insulation is specified for piping, insulate similarly all connections, vents, drains, and any piping connected to system.
12. Fill surface imperfections such as chipped edges, small joints or cracks and voids or holes with insulation material and smooth all such areas with a skim coat of insulating cement.
13. Seal ends of sections with Foster 30-65 or Childers CP-34 vapor barrier mastic and reinforcing mesh to create moisture dams at:
    a. 20 ft. intervals.
    b. Valves and fittings.
    c. All hangers and supports.
14. Replace existing insulation removed or damaged because of work of this project.
15. Insulate new pipes and replace insulation on existing pipes to remain where insulation was removed or damaged by demolition or revisions.
16. Do not insulate steam traps.
17. Insulate between fingers of spiders in alignment guides.
18. Insulate between pipe and pipe saddle.
19. Perform all work in a neat and workmanlike manner. Poor work (as determined by Architect or Engineer) will be cause for rejection.
20. Specialties shall be insulated to match those of the systems to which they are connected.
21. No insulation shall be installed until the piping systems have been hydrostatically tested as specified elsewhere to the satisfaction of the Engineer.
22. Provide glass cloth and aluminum bands 18" on center on calcium silicate insulation jacket and flared-out staples on all fiberglass hot pipe insulation. Tape vapor barrier joints and seams on all cold pipe insulation.
23. Provide insulation on all horizontal runs of condenser water piping running over occupied areas to avoid condensation on pipe surfaces during winter operation of the Water Side Economizer.
24. Provide extended valve stems to maintain vapor barriers on all chilled water valves as required.
25. In addition to the requirements above, provide ITW SARAN CX Vapor Retarder or vapor barrier mastic/reinforcing mesh on all Chilled Water vertical elbows.
26. When available, insulate fittings with factory pre-molded fittings of the same thickness as adjoining pipe insulation.
27. When pre-molded fittings are unavailable, use a hydraulic setting cement paste.
28. Clamps and anchors on cold piping shall be insulated. Full taping of pre-molded fittings is required.
29. Insulation at pipe strainer flanges shall be arranged for ease of servicing.

30. Insulation and vapor barriers shall be properly protected at all hangers and penetrations.
31. Insulated valves shall have extended handle stems so all operators or handles are outside of the insulation system. This is particularly true of high pressure steam piping.
32. Provide factory manufactured removable covers on all steam PRV's, constructed with 2" TEMPMAT insulation, fiberglass cloth, stainless steel grommets, and stitching. Cold side shall be silicone impregnated for moisture and soiling resistance.
33. Chilled water pumps shall be enclosed in a removable, insulated aluminum box that allows access to the pump with no disruption of piping or electrical connections, or with minimum 1-inch thick, flexible elastomeric insulation (25/50 flame spread/smoke developed index).
34. All refrigerant line accessories that are part of the suction and hot gas bypass refrigerant system (e.g. valves, vibration eliminators, P-traps, filters, etc.) shall be complete insulated.
35. All refrigerant insulation must be properly sized for the piping that it is being installed on.

    a. Insulation installed on horizontal runs of refrigerant piping will require that the insulation protection shield be installed between the insulation and the pipe hanger.
    b. All seams and joints in the insulation will be required to be sealed with the proper adhesive, for the product being use, to provide a continuous vapor barrier.
    c. Piping clamps that are in contact with the suction line are required to be covered with insulation.
    d. All thermostatic expansion valve sensor bulbs are required to be covered with insulation.

3.4 OUTDOOR PIPE INSULATION

A. Install rigid closed cell insulation with butt joints of half pipe sections staggered. Insulation shall be held in place with strapping tape. Install aluminum jacket with all joints lapped to shed water. Apply a bead of Foster 95-44 or Childers CP-76 metal jacketing sealant at all transverse and longitudinal seams. Secure with aluminum bands, minimum of 2 per jacket section.

3.5 DUCTWORK INSULATION

A. Insulate all ductwork except the following portions of ductwork:

1. Ducts and casings internally insulated or provided with sound absorptive lining.
2. All exhaust ductwork, except where otherwise noted.
3. Return air ductwork from air conditioning systems passing through air conditioned space and/or hung ceiling of air conditioned space.
4. Return air ductwork from heating and ventilating systems, where return air ducts pass through heated areas.

5. Exposed air conditioned supply and return air ducts in air conditioned spaces if same supply or return air ducts serve that area only.
6. Exposed supply air duct from heating and ventilating systems, if same duct serves that area only.

B. Except where otherwise noted, all concealed rectangular and round ductwork shall be covered with flexible duct insulation with or without vapor barrier.

C. Install insulation materials with smooth and even surfaces, after inspection and release for insulation application. Butt insulation joints firmly together to ensure complete and tight fit over surfaces to be covered.

D. Clean and dry ductwork prior to insulating.

E. Extend ductwork insulation without interruption through walls, floors, and similar ductwork penetrations, except where otherwise indicated.

F. Except as otherwise indicated, do not insulate lined ducts. However, extend duct insulation 12” beyond start of lining where lined ductwork meets insulated ductwork.

G. Maintain integrity of vapor-barrier on insulation of ducts carrying cold air, and protect it to prevent puncture and other damage. Insulation on cold surfaces where vapor barrier jackets are used shall be applied with a continuous, unbroken vapor seal. Hangers, supports, anchors, etc., that are secured directly to cold services shall be adequately insulated and vapor sealed to prevent condensation.

H. Do not install covering before ductwork has been tested and approved.

I. The finish including any vapor barrier treatment shall lap adjacent sections at both the transverse and longitudinal joints and 3" strips of matching finish material shall be adhered at the transverse joints.

J. For Outdoor Armaflex Insulation:

1. Stagger joints on multilayer applications.
2. Locate joints at sides of ducts whenever possible.
3. Use 520 adhesive to attach insulation. Provide full coverage.
4. Seal all seams and joints with adhesive.
5. Maintain full thickness at standing seams and flanges by additional layer(s).
6. Cover flexible connections.
7. Extend covering to inside face of outside wall.
8. Finish with two coats of Armaflex finish or Foster 30-64 coating.

K. The installer of the ductwork insulation shall advise the Contractor of required protection for the insulation work during the remainder of the construction period, to avoid damage and deterioration.

L. Ductwork directly connected to ovens shall be insulated to the requirements for breeching.

M. The use of flexible elastomeric insulation on ductwork is permitted as an acceptable alternative to fiberglass. Insulation shall be adhered to 100% of the duct surface area.

3.6 EQUIPMENT INSULATION

A. Install insulation materials with smooth and even surfaces and on clean and dry surfaces, after inspection and release for insulation application.

1. Re-do poorly fitted joints.
2. Do not use mastic or joint sealer as filler for gaping joints and excessive voids resulting from poor workmanship.

B. Maintain integrity of vapor-barrier on equipment insulation and protect it to prevent puncture and other damage.

C. Apply insulation using the staggered joint method for both single and double layer construction, where feasible. Apply each layer of insulation separately.

D. Do not insulate handholes, cleanouts, ASME stamp and manufacturer’s nameplate. Provide neatly beveled edge at interruptions of insulation.

E. Insulation for factory-fabricated air handling units shall be furnished as part of units.

F. Chilled/Brine water Pumps:

1. Chilled water pump and standby chilled water pump casings shall be encased in 14 GA aluminum casings, gasketed and bolted together with brass bolts, washers and nuts, split horizontally and removable in two sections and packed with 4" thick 1lbs. density fiberglass blanket insulation. Corners shall be constructed with a frame of 4" wide 0.05" thick aluminum corner angles put together with pop rivets or all welded. Frame sides shall be cut for pipes, flanges and pump shaft.

G. Heat Exchanger

1. Cover top and both sides of exchanger with 24 gauge galvanized steel panels with ½” flexible unicellular insulation cemented to the inside of the panels.
2. Panels shall be easily removable and easy to re-install.
3. Adhere flexible unicellular insulation to end plates with Armstrong No. 520 adhesive.
4. Insulate with 2" thick fiberglass, 3# density U.L. Labeled insulation and hexagonal mesh wire screen finished with glass jacket adhered and coated with two coats of Foster 30-36 or Childers CP-50AMV1 lagging adheasive. Flanges shall be treated as specified under Hot Pipe Insulation "Fittings, Valves & Flanges 4" and Larger".
5. The Contractor shall have the option of using 2" thick fiberglass Bend-A-Board insulation with .016" thick aluminum jacket with lock seams at longitudinal

seams and 1/2" aluminum bands 12" on center at traverse joints. Joints and jacket shall provide complete protected for the insulation.

H. Cold Equipment (At or below ambient equipment):

1. Includes chilled, condenser water system equipment such as air release tanks, air separators, expansion tanks, vessels, etc.
2. Insulate air release tanks (air separators) with 4 inches of pipe and tank insulation or 3 inches of rigid fiber glass board.
3. Vapor barrier to be provided on chilled water expansion tank, air separator and chemical treatment tank.
4. The Contractor shall have the option of using 2" thick fiberglass Bend-A-Board insulation with .016" thick aluminum jacket with lock seams at longitudinal seams and 1/2" aluminum bands 12" on center at traverse joints. Joints and jacket shall provide complete protection for the insulation.

I. Refrigeration Machines:

1. In general, the following areas on water chillers shall be insulated: the shell areas which are exposed to chilled water, suction connection, oil cooler, and water boxes (cooler section). The exact extent of these areas shall be recommended by the chiller manufacturer during the shop drawing submission. The insulation Sub-Contractor shall be responsible for determining the area to be insulated subject to Engineers approval.
2. Insulate all cold surfaces, except the heads, with a 3" thickness in two 1-1/2" thick layers of Manville No. 815 "Spinglas" fiberglass insulation with factory applied FSK vapor barrier facing. The insulation shall have an average thermal conductivity not to exceed .22 BTU/inch per sq. ft. per degree F. per hour at a mean temperature of 75˚.
3. Insulation shall be securely banded in place with 1/2" x .015" galvanized bands, or secured with weld pins or stick clips with washers spaced 18" apart. Lap joints shall be secured with Manville Therm-Lok. All joints shall be staggered and sealed to prevent moisture penetration with a vapor barrier mastic, Benjamin Foster 30-35. Cut, score or miter insulation to fit contour of equipment.
4. Apply tack coat of Foster 30-65 or Childers CP-34 vapor barrier mastic at 2 gallon per 100 sq feet spray or brush. Embed Foster Mast a Fab or Childers Chil Glas #10 (10 x 10) into wet coating, smoothing to avoid wrinkles. Overlap reinforcing mesh seams at least 2". Apply a finish coat of vapor barrier mastic 2 gallons per sq. ft. by spray or brush to the entire fabric surface. Finish to be applied not later than one half hour after the tack coat.
5. Insulated removable and replaceable metal covers shall be used on the heads. Type and thickness of insulation for removable covers shall be similar to that used for the other cold surfaces.

J. Filters:

1. Prefilter, afterfilter housing and flow measuring devices shall be insulated same as ductwork.

K. Insulate equipment to match adjoining piping insulation.

L. Outside Air Intakes and Exterior Ducts: 2-inch thick rigid, fiberglass board, 6.0 pounds per cubic foot density, to a minimum R-value of 8, complete with insulation faced and anchored as described for exposed ductwork.

3.7 FIRE RATED DUCT WRAP

A. Remove dirt and dust and clean all duct surfaces.

B. Install per manufacturers instructions and referenced standards. Where pins are required they shall be tack welded to duct.

C. Repair any damage in accordance with manufacturer's instruction.

3.8 PROTECTION AND REPLACEMENT

A. Replace damaged insulation which cannot be repaired satisfactorily. Including units with vapor barrier damage and moisture saturation. The insulation installer shall advise the Contractor of required protection for the insulation work during the remainder of the construction period, to avoid damage and deterioration.

3.9 ASBESTOS REMOVAL [Existing Job Only]

A. It is understood and agreed that this work does not contemplate handling of, or design including use of, asbestos or any hazardous waste material. Therefore, Owner and Contractor agree to hold harmless, defend and indemnify consultant (A/E) for all claims, lawsuits, expenses or damages arising from or related to the handling, use, treatment, purchase, sale, storage or disposal of asbestos, asbestos products or any hazardous waste materials.

B. In the event asbestos is encountered the Contractor shall immediately cease work in the area of the asbestos shall contact the Owner for instructions.

C. Site Monitoring:

1. Follow Section 1910.1001 Code of Federal Regulations Title 29, Part 1910 (OSHA Asbestos Regulations).
2. Provide daily sampling during removal instead of at six month intervals.
3. Stop work and notify Architect immediately if levels exceed those of Subparagraphs b (2) or b (3) of regulations.

END OF SECTION

SECTION 23 09 00

BUILDING AUTOMATION AND AUTOMATIC TEMPERATURE CONTROL SYSTEMS

PART 1 – GENERAL

1.1 GENERAL REQUIREMENTS

A. This Section is coordinated with and complementary to the General Conditions and Supplementary General Conditions of the Work, wherever applicable to Mechanical Work.

B. Section 23 05 02 – Basic Mechanical Requirements shall apply.

1.2 DESCRIPTION

A. The work described under this division is for all labor, materials, and equipment required for the construction of the Building Management System (BMS or BAS/Automatic Temperature Control/ (ATC) system.

B. The system shall be complete in all respects, tested and ready for operation.

C. All materials, equipment and apparatus shall be new and of first-class quality.

D. Electrical Standards: Provide electrical products which have been tested, listed and labeled by Underwriters' Laboratories and comply with NEMA standards, The Building Code of the City of New York, and the National Electric Code.

E. "Operator" is defined as the Owner's representative designated to operate the BMS/ATC system after Owner acceptance.

F. The work includes the providing of all labor, materials, equipment, accessories, services and tests necessary to complete and make ready for operation by the Owner, a building automatic system as shown on the drawings and hereinafter specified.

G. The Building Automation System shall be provided by the same manufacturer as the automation temperature controls.

H. The Automation System subcontractor shall furnish and install all equipment, accessories, wiring and instrument piping required for a complete and functioning system.

I. All materials and equipment used shall be standard components, regularly manufactured for this and/or other systems and not custom designed especially for this project. All systems and components shall have been thoroughly tested and proven in actual use.

J. The automation system shall be of a fully modular architecture permitting expansion by adding computer memory, application software, operator peripherals and field hardware.

K. If expansion of the automation system necessitates greater computer processing power, it shall be possible to transfer all existing software and data base, both vendor supplied and user-defined, to a new more powerful computer. This shall be accomplished by using removable, compatible disk cartridges.

L. Systems which require the existing user-defined data base to be reentered through the operator's terminal shall not be acceptable.

M. Although fire alarm and security points will not be installed or monitored, initially the system shall be installed completely ready to receive or accept these points at a later date without additional central hardware or software.

N. The system as specified shall monitor, control, and calculate all of the points and functions as listed in the Building Automation Schedule.

O. The system as installed shall have sufficient computer memory and application software for 100% point expansion above those points required and as listed in the Building Automation Schedule.

P. The Work includes the providing of all labor, materials, equipment, accessories, services and tests necessary to complete the place into satisfactory operation a complete system of automatic temperature controls as shown on the Drawings and hereinafter specified.

Q. The control system shall be of the electronic fully modulating type unless otherwise indicated, or as hereinafter specified. Control equipment shall be as manufactured by Automated Logic Corporation. All controls shall be the product of one manufacturer. The temperature control manufacturer shall be responsible for the quality and satisfactory operation of material provided even if not actually manufactured by him.

R. The control system shall include all necessary temperature sensors, damper motors, relays, sensors valves, etc., and all necessary equipment for a complete control system, regardless of whether or not specifically mentioned.

S. The control system shall include all control and interlock wiring. The control wiring shall include all wiring, including power wiring for sensors, controls, control devices, relays, freezestats, firestats and all other necessary equipment to provide a complete control system, regardless of whether or not specifically mentioned, unless otherwise shown on the electrical drawings, including electric relays and contactors required for control interlocking. Interlock wiring shall include interlocks between fan starters between pump starters between starters and remote condensing units, between pumps, chillers and cooling towers and wherever else called for in these specifications. Unless otherwise noted; all control circuits shall be 120 volts or less.

T. Provide nameplates on all devices, whether or not mounted on the face of local control panels. In occupied areas, nameplates shall be concealed beneath covers of room type instruments, to describe functions.

U. Contractor shall provide all source code, passwords, device addresses, BACNET set-up parameters and login information in hard copy and as a DVD as a condition for final payment.

1.3 GENERAL INSTRUCTIONS

A. The BMS/ATC systems as specified herein shall be provided in their entirety by the BMS/ATC Contractor. The BMS/ATC Contractor shall base his Bid on the systems as specified.

B. The general provision of the contract (Division 1 and sections 23 05 01, 23 05 02, and 23 05 03) apply to work specified in this section.

1.4 QUALITY ASSURANCE

A. Only firms regularly engaged in manufacture and installation of this equipment with characteristics and capacities required, whose products have been in satisfactory use in similar service for not less than 10 years shall be acceptable.

B. The entire building automation system shall be installed by skilled electricians and mechanics, all of whom are properly trained and qualified for this work. All wiring shall be installed in accordance with the Project Electrical Specifications.

C. Supervision and checkout of the system shall be by factory-trained engineers and technicians directly employed by the automation Contractor.

D. Provide system produced and installed by the manufacturers, which are listed in Section "Approved Manufacturer's List".

E. Provide equipment which performance, under specified conditions, is certified by the manufacturer.

1.5 SCOPE

A. The proposal shall be based on an electronic or system. Valve and damper actuators shall be electronic. Provide electronic sensors and transmitters with full DDC capabilities. Steam valves shall be electronically actuated and DDC controlled.

The engineering, installation, calibration, hardware, software programming and checkout necessary for complete and fully operational BMS/ATC systems, as specified hereafter, shall be provided under this division by the BMS/ATC Installer.

B. The BMS Contractor shall guarantee that the installed system is capable of maintaining the following comfort goals in conditioned areas served by the BMS.

1. Space Design Temperature +/- 1ºF.
2. Relative Humidity 50% +/- 5%.
3. The BMS Contractor is not responsible for improper installation by other Divisions, however the BMS Contractor is responsible for informing the Construction Manager and Engineer of any requirements of this specification or any installation problem which prevents these goals from being maintained.

C. The contractor shall be responsible for all power and control wiring for BMS equipment including BMS panels, actuators, dampers, controllers, control power transformers, relays, etc. work shall be sub-contracted to a licensed electrical contractor by the BMS contractor if the BMS contractor is not suitably licensed. All work shall be completed in accordance with the electrical specification sections of this specification.

1.6 ITEMS REQUIRED TO BE COORDINATED WITH OTHER DIVISIONS

A. Be responsible for coordinating the following:

1. Power requirements (voltage, amps, location) for all BMS equipment requiring power. See Section 23 05 01.

B. Installation and connection of all power wiring. Power wiring shall be defined as follows:

1. Wiring of power feeds through all disconnect starters and variable speed controllers to electric motors.
2. 120 VAC Emergency and 120V Normal power feeds to all BAS temperature control panels and equipment.
3. Wiring of any remote start/stop switches and manual or automatic motor speed control devices not furnished by the BAS/ATC Contractor.

C. Note that 120V to 24V surge protected transformers for low voltage wiring by this Division shall be furnished, set in place and wired (from designated circuit in electrical panel) by this Division, and all low voltage control wiring shall be installed under this Division.

1.7 WORK BY OTHERS

A. The following work shall be provided under separate divisions of the specifications:

1. Installation of all line size and non-line size automatic valves and separable wells. However, these devices shall be furnished under this division.
2. Provision of all necessary piping connections, taps and direct-contact wells required for flow, pressure or temperature devices specified under other divisions.

3. Provision of manual balancing dampers as specified under other divisions of Divisions 21 through 23.
4. Installation of all automatic control dampers shall be by HVAC Contractor. All control dampers shall be furnished under this division.

1.8 AGENCY LISTINGS

A. UL 916 PAZX Energy Management Systems.

B. FCC-Part 15 Subparagraph J. Class A. Emissions requirements.

C. UL-864/UUKL Smoke Removal.

1.9 RELATED SECTIONS

A. 23 05 01 - Mechanical and Electrical Coordination.

B. 23 05 02 - Basic Mechanical Requirements.

C. 23 05 03 - Basic Mechanical Materials and Methods.

1.10 BMS/ATC CONTRACTOR

A. The BMS/ATC Contractor shall have a local office within a 50 mile radius of the job site, staffed with factory trained engineers fully capable of providing instruction, routine maintenance and 24-hour emergency maintenance service on all system components. The BMS/ATC Contractor shall have a ten year experience record in the design and installation of computerized building systems similar in scope and performance to that specified herein, and shall be prepared to provide evidence of this history prior to Contract Award should the Owner request it.

B. The BMS/ATC Contractor shall be prepared to make a personal presentation of his systems to the Owner or his designated representatives prior to award of Contract should the Owner request it.

C. The engineering, installation, calibration, hardware, software programming and checkout necessary for complete and fully operational BMS/ATC systems, shall be provided under this division by the BMS/ATC Installer.

D. Control components shall be mounted and wired by the BAS/ATC Contractor except as noted. Controllers may be mounted on terminal units at the factory.

1.11 SUBMITTALS AFTER CONTRACT AWARD

A. The following data/information shall be submitted for approval:

1. Complete sequence of operation.

2. Control system CAD generated drawings including all pertinent data to provide a functional operating system.
3. Valve, and damper schedules showing size, configuration, capacity and location of all equipment.
4. Data sheets for all hardware and software control components.
5. A description of the installation materials including conduit, wire, flex, etc.
6. Building Management System panel locations.
7. Schematic and flow diagrams indicating sensor and device locations.
8. A list of all points with summary counts, including alarms and trend.
9. Operating schedules.

B. The Controls Contractor shall provide submittal drawings for the entire control system for review and approval before work shall begin. Included in the submittal drawings shall be a diagram depicting the system architecture complete with a communications riser. Drawings shall include point-to-point wiring diagrams and must show all temperature controls, start-stop arrangement for each piece of equipment, equipment interlocks, wiring terminal numbers and any special connection information required for properly controlling the mechanical equipment. The submittal shall include a bill of material reference list as well as equipment sequences of operation.

C. Points list includes, for each physical or logical point, the name, description, display units, alarm limits, and definitions, along with the object description, object ID, and associated device ID. The list shall also indicate whether Trend Log or Schedule objects have been established for the point.

D. The submittals shall include a specification compliance analysis for review and approval before work shall begin. The compliance document shall address each paragraph of this specification by indicating COMPLY, EXCEED, or EXCEPTION. Do not indicate COMPLY unless the proposed system exactly meets the paragraph requirement. If EXCEED or EXCEPTION is indicated, then provide a clear and concise explanation of the variance from the specifications and the net effect this would have on the specified system performance.

E. Wiring diagrams shall include internal wiring of all electrical control devices.

F. Submit completed computer graphics for all the equipment and building floor plans and equipment prior to scheduled completion of the project for approval.

PART 2 – PRODUCTS

2.1 GENERAL

A. The Building Management System (BMS) shall provide an easy to use interface for monitoring and managing the building. The Building Management System shall provide the necessary Hardware, Software, and Network Communication abilities to provide Scheduling, Monitoring, Trending, Historical Storage, and Alarm Functions for the HVAC equipment and systems as described in this specification. Control capabilities shall include: Time of Day scheduling, Direct Digital Control, Custom Control, Boolean Logic, Optimum Start/Stop, Duty Cycling, Electrical Demand Control, Temperature Control, After Hours Override, Reports and Logs, Trend Prints, Remote Communications, Alarm Logging, Run Time and Maintenance, and Expanded Informational Messages.

B. The Building Management system shall be designed to allow full Operator operation with a minimum of training. It shall have an on-screen “Help” Operator tutorial.

C. Specified application programs shall be engineered, programmed and pre-tested prior to site installation. This shall be verified by standard format programming worksheets or flow diagrams included with the submittals.

2.2 BUILDING MANAGEMENT SYSTEM

A. Each panel memory shall be protected for a minimum of 48 hours in the event of power failure. Internal clock shall continue to run during a power failure so that the system makes the appropriate adjustment to all connected points when power is restored.

B. When specified or indicated on the point list or where required by the sequence of operation, outputs shall have three position manual override switch (On/Off/Auto), a status light, and shall be selectable for either normally open or closed operation.

2.3 MANUFACTURERS

A. Acceptable Manufacturers Are:

1. Automated Logic

Any other manufacturer shall be considered a substitution and may submit for approval after the bid.

2.4 OPERATOR INTERFACE

A. The system shall be an extension of the existing Automated Logic control System.

2.5 SYSTEM PERFORMANCE

A. The system shall consist of Operator Workstation, Building Management Panels, and Application Specific Controllers. All elements of the system shall be designed for standalone operation. Control shall always occur at the lowest level of the system. Communication between the building management panels and workstations shall be over a high speed communications buss. All nodes on this LAN shall be peers. The operator shall not have to know the panel identifier or location to view or control an object. Application Specific Controllers shall be constantly scanned by the building management panels to update point information and alarm information.

2.6 SYSTEM APPLICATION CONTROLLER SOFTWARE

A. System Security: User access shall be secured using individual security passwords and user names.

B. Passwords shall restrict the user to only the object, applications and system functions as assigned by the system manager.

2.7 SYSTEM SOFTWARE

A. Furnish the following applications for building and energy management. All software applications shall reside and run in the system controllers. Editing of applications shall occur at the operator workstation.

1. Scheduling: Provide the capability to schedule each object or group of objects in the system. Each scheduler shall consist of the following:
   a. Weekly Schedule: Provide separate schedules for each day of the week. Each of these schedules should include the capability for start, stop, optimal start, optimal stop, and night economizer. Each scheduler may consist of up to 10 events. When a group of objects are scheduled together, provide the capability to adjust the start and stop times for each number.
   b. Exception Schedules: Provide the ability for the operator to designate any day of the year as an exception schedule. Exception schedules may be defined up to one year in advance. Once an exception schedule is executed, it will be discarded and replaced by the standard schedule for that day of the week.
   c. Holiday Schedules: Provide the capability for the operator to define up to 30 special or holiday schedules. These schedules may be placed on the scheduling calendar and will be repeated each year. The operator shall be able to define the length of each holiday period.
2. Optimal Start/Stop: The scheduling application outlined above shall support an optimal start/stop algorithm. This shall calculate the thermal characteristics of a zone and start the equipment prior to occupancy to achieve the desired space temperature at the specified occupancy time. Provide an early start limit in minutes to prevent the system from starting too early.
3. System Coordination: Provide a standard application for the proper coordination of equipment.
4. Alarm Reporting.
5. Trending.
6. Diagnostics.
7. Power Fail Recovery.
8. Reports and Logs.
9. Chiller Sequencing.

2.8 NETWORK CONTROLLERS

A. General. Provide an adequate number of Building Management Panels to provide the performance specified above. Each of these panels shall meet the following requirements.

1. The Building Automation System shall be composed of one or more independent stand-alone, microprocessor based Network Controllers to manage the global strategies describes in Application software section.
2. The Master Controller shall have substantial memory to support its operating system, database, and programming requirements.
3. The multi-tasking operating system of the Controller shall manage the input and output communications signals to allow distributed controllers to share real and virtual point information and allow central monitoring and alarms.
4. Data shall automatically be shared between Master Controllers when they are networked together.
5. The database and custom programming routines of remote Network Controllers shall be editable from a single operator station.
6. The Master Controller shall continually check the status of all processor and memory circuits. If a failure is detected, the controller shall:
   a. Assume a predetermined failure mode.
   b. Emit an alarm.
   c. Display card failure identification.

B. Communications. Each Master Controller and Operator Workstation shall communicate using 10/100/1000 Ethernet (IEEE802.3). This LAN shall be self configuring and shall automatically reconfigure as nodes are added or removed.

1. Hard Wired Connections. Provide a twisted pair copper (CAT.5E or higher) cable between all nodes on the system LAN. Provide all necessary network switches to complete the network.

C. All controllers shall allow communication over open protocol such as LonTalk or BACNET. Open protocol; shall be appropriate to the signal being transmitted and shall selected to best communicate with the domains open protocol for systems that have been previously installed at the facility.

D. Serviceability. The Network Controller should be designed in a modular fashion so that the enclosure may be roughed in prior to the installation of the electronics. Provide diagnostic LEDs for power, communications, and alarms. The controller shall have provisions for expansion and future controller architecture. All wiring connections shall be made to field serviceable terminal strips or to a termination card connected by a ribbon cable.

E. Memory. The Network Controller shall maintain all BIOS and programming information in EEPROM. The system BIOS shall be easily upgradable for the PC workstation without the need for going out to the panel. System manufacturer shall provide current version software and firmware at the end of the warranty period.

F. Controller software must be capable of detecting hardware and software failures and forcing all outputs to a predetermined state, consistent with the failure mode requirements defined on the drawings. In this state it shall issue an alarm.

G. Volatile memory is required to be backed up in the event of power loss. Software stored in non-volatile memory will not have to be downloaded from the central server after an interruption of power occurs.

H. Controllers used for time-scheduled operations must be equipped with a battery backed internal real-time clock function to provide a time base for implementing time-dependent programs. Provision shall be made for the routine updating of the controllers' clocks via a time master.

I. Resumption of power after an outage shall cause the controllers to automatically restart and establish communications as needed by their applications. Controller shutdown based on a self-diagnosed failure in the power supply, hardware, or software must set each piece of controlled equipment to a predetermined failure mode.

J. Controllers shall be powered from the most reliable source that powers any of the systems it serves. In the situation where a controller will be required to continuously collect data to be transmitted to a workstation, or where it monitors critical recovery information such as the presence of emergency power, it may be necessary to provide a UPS for the controller as well as any critical sensors. Where panels are provided with a different power source as the equipment (such as when the panel is on a UPS), the panel shall be provided with a means of monitoring the power source to the controlled equipment. This can be a dedicated power monitor or a value coming from transfer switch contacts.

2.9 APPLICATION SPECIFIC CONTROLLERS

A. Application Specific Controllers shall be stand-alone, microprocessor based Direct Digital Controllers with sufficient EEPROM memory to handle its operating system, database and programming requirements.

The controllers shall be clearly labeled as to controller type, where it is to be installed, and software address (if applicable). The controller shall be fully tested upon installation to ensure that it is properly matched to the equipment it is controlling.

B. The controller shall communicate with other devices on the communication network and be fully integrated with the other system components.

C. The hardware shall be suitable for the anticipated ambient conditions.

1. Controllers used outdoors and/or in wet ambient shall be mounted within waterproof enclosures, and shall be rated for operation at –40°F to 155°F.
2. Controller used in conditioned ambient shall be mounted in dust-proof enclosures, and shall be rated for operation at 32°F to 120°F.

D. Controller software must be capable of detecting hardware and software failures and forcing all outputs to a predetermined state, consistent with the failure mode requirements defined on the drawings. In this state it shall issue an alarm.

E. Volatile memory is required to be backed up in the event of power loss. Software stored in non-volatile memory will not have to be downloaded from the central server after an interruption of power occurs.

F. Controllers used for time-scheduled operations must be equipped with a battery backed internal real-time clock function to provide a time base for implementing time-dependent programs. Provision shall be made for the routine updating of the controllers' clocks via a time master.

G. Resumption of power after an outage shall cause the controllers to automatically restart and establish communications as needed by their applications. Controller shutdown based on a self-diagnosed failure in the power supply, hardware, or software must set each piece of controlled equipment to a predetermined failure mode.

H. Controllers shall be powered from the most reliable source that powers any of the systems it serves. In the situation where a controller will be required to continuously collect data to be transmitted to a workstation, or where it monitors critical recovery information such as the presence of emergency power, it may be necessary to provide a UPS for the controller as well as any critical sensors. Where panels are provided with a different power source as the equipment (such as when the panel is on a UPS), the panel shall be provided with a means of monitoring the power source to the controlled equipment. This can be a dedicated power monitor or a value coming from transfer switch contacts.

2.10 CUSTOM APPLICATION CONTROLLERS

A. The Custom Application Controllers shall provide stand-alone control and require no additional system components for complete operation. It shall have sufficient EEPROM memory to support its operation system, database, and programming requirements. Custom application controllers shall meet the requirements of 2.06 Master Control Panels except they shall reside on a communications network operating at a minimum of 38,400 KBPS.

B. All programming required for operation shall be memory resident and shall be retained in permanent memory.

C. The Custom Application Controller shall be configured such that the Portable Operators Terminal can be plugged directly into it or within sight for programming, editing, and other operator functions. Custom application controllers shall also be programmable from the operator workstation.

D. Controller hardware shall be suitable for the anticipated ambient conditions.

E. Controllers used outdoors and/or in wet ambient shall be mounted within waterproof enclosures and shall be rated for operation at –40°F to 155°F.

F. Controller used in conditioned ambient shall be mounted in dust-proof enclosures, and shall be rated for operation at 32°F to 120°F.

G. Controller software must be capable of detecting hardware and software failures and forcing all outputs to a predetermined state, consistent with the failure mode requirements defined on the drawings. In this state it shall issue an alarm.

H. Volatile memory is required to be backed up in the event of power loss. Software stored in non-volatile memory will not have to be downloaded from the central server after an interruption of power occurs.

I. Controllers used for time-scheduled operations must be equipped with a battery backed internal real-time clock function to provide a time base for implementing time-dependent programs. Provision shall be made for the routine updating of the controllers' clocks via a time master.

J. Resumption of power after an outage shall cause the controllers to automatically restart and establish communications as needed by their applications. Controller shutdown based on a self-diagnosed failure in the power supply, hardware, or software must set each piece of controlled equipment to a predetermined failure mode.

K. Controllers shall be powered from the most reliable source that powers any of the systems it serves. In the situation where a controller will be required to continuously collect data to be transmitted to a workstation, or where it monitors critical recovery information such as the presence of emergency power, it may be necessary to provide a UPS for the controller as well as any critical sensors. Where panels are provided with a different power source as the equipment (such as when the panel is on a UPS), the panel shall be provided with a means of monitoring the power source to the controlled equipment. This can be a dedicated power monitor or a value coming from transfer switch contacts

2.11 INPUT/OUTPUT INTERFACE

A. Hardwired inputs and outputs may tie into the system through Master Control Panel, Custom Application, or Application Specific Controllers. Any critical points requiring immediate reaction shall be tied directly in to the controller hosting the control software algorithm for the critical function.

B. Binary inputs shall allow the monitoring of on/off signals from remote devices. The binary inputs shall provide a sufficient wetting current to be compatible with commonly available control devices.

All status points shown on the point list shall be positive proof differential pressure or current sensing binary switches.

C. Analog inputs shall allow the monitoring of low voltage, current, or resistance signals and shall have a minimum resolution of 0.1% of the sensing range. Analog inputs shall be compatible with, and field configurable to commonly available sensing devices.

D. Binary outputs shall provide a continuous low voltage signal for on/off control of remote devices. Where specified in the sequence of operations or indicated on the points list, binary outputs shall have 3-position (on/off/auto) override switches, status lights, and shall be selectable for either normally open or normally closed position.

E. Analog outputs shall provide a modulating signal for the control of end devices. Outputs shall provide either a 0 to 10 VDC, 0 to 20 VDC or a 4 to 20 milliampere signal as required to provide proper control of the output device. Systems that utilize a pulse width modulating output (PWM) shall include a position feedback AI for each output.

F. System architecture shall allow for point expansion in one of the following ways:

1. The addition of input/output cards to an existing System Application Controller.
2. An additional panel and/or controller may be used to expand point capacity.
3. Ten (10) percent expansion capacity for all point types in all DDC panels.

2.12 IDENTIFICATION

A. Engraved Labels

1. Material: Melamine plastic laminate.
2. Thickness: 1/16”.
3. Color
   a. Surface: White.
   b. Core: Black (letter color).
4. Fastenings: Any of the following:
   a. Screws.
   b. Rivets.
   c. Permanent adhesive.
5. Lettering: Coordinate with shop drawings.

2.13 DUCT SMOKE DETECTORS

A. Duct smoke detectors shall be provided and wired in accordance with manufacturer’s requirements.

2.14 BMS/ATC CONTROL WIRING

A. General: 18 AWG Twisted pair cable shield wire shall be provided if required by system manufacturer.

B. Provide for all input and all analog output wiring.

C. Tinned copper conductors.

D. Do not run input/output wires together in the same conduit or wire bundle with 120V power wiring.

E. Pneumatic or sensor tubing shall not be installed in conduit with any wiring conductors.

F. All control wiring shall be run in metal conduit as follows:

1. EMT in Mechanical/Electrical Rooms.
2. Rigid at exterior.
3. Plenum rated for concealed spaces/hung ceiling.

G. Unless specifically required otherwise by the BACS equipment manufacturer, all I/O wiring shall be twisted shielded cable. For communications, the BACS equipment manufacturer's installation guidelines and recommendations shall apply.

H. All control wiring in mechanical equipment rooms or other spaces in which it is readily accessible shall be installed in electrical metal tubing (EMT) with compression fittings.

I. All control wiring run in interstitial spaces shall either be run in EMT or a cable tray or raceway.

J. All control wiring installed outdoors or any area subject to moisture shall be installed per code.

K. All control wiring installed in vertical chases shall be installed in EMT.

L. All control wiring above non-accessible ceilings shall be installed in EMT.

M. All control wiring installed above accessible ceiling spaces which are not laboratories or AHU's shall be plenum type, not installed in conduit, but neatly run with generous use of rings or ties.

N. Wire shall be unspliced from the controller to the sensor or device.

O. Control wiring shall not be routed in the same raceway as power wiring.

P. For sensors with twisted shielded pair cable, the shield shall be grounded at the panel and taped back at the sensor.

Q. Control wiring shall be color coded and labeled at all points of termination.

R. Remove and properly dispose of all abandoned control wiring, conduit, tubing, boxes, enclosures, components, and other controls-related work.

2.15 DAMPERS

A. The Building Automation System supplier shall provide all automatic control dampers not specified to be supplied integral to the HVAC equipment.

B. Dampers shall be low leakage or high velocity low leakage air foil as specified in the sequence of operation or in the equipment specifications and schedules. All proportional dampers shall be opposed blade type, except mixing dampers shall be parallel type. Two position dampers may be opposed or parallel blade type.

C. Damper frames and blades shall be galvanized steel and a minimum of 16 gauge. Blade width shall not exceed 8 inches. Dampers and seals shall be suitable for temperature ranges of –50°F to 250ºF.

D. Blades: 14-gauge,or 16-gauge air foil shaped, double, galvanized steel or extruded aluminum.

E. Bearings: Nylon or oil impregnated.

F. Axles: Welded, hexagonal or pin lock, or with other approved method to prevent blade rotating on axle.

G. Hardware: Zinc plated steel or aluminum.

H. Standard Low Leakage Dampers:

1. Standard low leakage dampers shall be provided to conserve energy. Dampers shall be equipped with neoprene edge seals and compressible metal jamb seals. Leakage shall not exceed 10 CFM/Sq. Ft. at 4” W.G. differential and 3 CFM/Sq. Ft. at 1” W.G. differential.
2. Standard Low Leakage dampers shall be Ruskin, Model CD36 or equivalent.

I. High Velocity Low Leakage Dampers:

1. Where specifically called out as “LOW LEAKAGE”, provide the following:
   a. Field replaceable edge and end seals with be installed along the top, bottom, and side of the frame and each blade. Seals and bearings shall be suitable for temperature ranges from –40ºF to 200ºF. Leakage shall not exceed 6 CFM/Sq. Ft. at 4” W.G. differential and 3 CFM/Sq. Ft. at 1” W.G. differential.
   b. High Velocity Low Leakage dampers shall be Ruskin, Model CD60 or equivalent.

J. Provide low leakage dampers in the following locations:

1. Outside air dampers.
2. All dampers isolating ice plant chillers from adjacent spaces.
3. Motorized backdraft dampers.

4. Motorized intake dampers.

K. Dampers shall be applicable for the rated pressure and velocity service. Damper structural rating shall exceed extreme anticipated conditions like fan deadhead.

L. Modulating dampers shall be carefully selected to control in a smooth and stable fashion across the range of anticipated conditions. Except where size dictates a single blade, dampers shall always be opposed blade. When a large section of damper is to be connected to a single jackshaft, size limitations shall be followed. This will prevent excessive damper area or, more importantly, length from being connected to a single jackshaft. Typically, the manufacturer's recommendation shall be sufficient for specifying a limit to the size of a damper bank that may have field fabricated jackshaft connections.

M. Whenever possible, dampers shall have external crankshafts to allow the connection of the damper actuator outside of the air stream. This will allow for easier access to the actuators for maintenance.

N. Outside air control dampers shall be low leakage dampers with damper seals.

O. Output to modulating control dampers shall be analog.

P. Acceptable Manufacturers:

1. Ruskin
2. Greenheck
3. Nailor

2.16 CONTROL VALVES

A. Provide control valves of the type, body material and pressure class as determined by manufacturer, based on operating requirements and maximum pressure and temperature in the piping system.

B. Equip control valves with actuators of proper close-off rating.

C. Modulating control valves shall have equal percentage or linear flow characteristics.

D. Valve bodies shall be 2-way normally open or closed, or 3-way mixing as specified or as required. Valve bodies 2" and smaller shall be bronze, screwed type and 2½" and larger shall be iron, flanged and rated at 240°F 125 psig except where otherwise noted.

E. Valves shall have stainless steel stems and allow for servicing including packing, stem, and disk replacement, or offer a 5 year warranty on parts and labor.

F. Size valves for 50% coil pressure drop (minimum 3', maximum 12' pressure drop).

G. Two-position, two-way control valves shall have quick opening characteristics.

H. All steam control valves shall be single seated. No single valve shall be larger than 2-1/2”. Wherever the flow rate is such as to require a valve larger than 2-1/2”, then multiple valves in parallel shall be used, with one no larger than 2-1/2”. The valves shall operate sequentially. Trim shall be stainless steel for inlet pressures above 15 psig steam. Actuators shall be electronic.

I. Valves shall be applicable for the rated pressure and temperature service. Close off pressures must be determined in concert with the actuators and valves shall be provided to close off against extreme anticipated conditions. Valves shall be selected such that they are not, as a practice, “oversized.”

J. Modulating valves shall be carefully selected to control in a smooth and stable fashion across the range of anticipated conditions. “Split ranging” of heating and cooling valves controlled by the BACS is not acceptable. A separate output from the BACS shall be provided for all control valves. General guidelines are indicated below. When the selection criteria indicated below are not met, flow characteristic analyses shall be submitted to demonstrate reasonable correlation between stroke and flow. Valves with a CV greater than 30 may be pneumatically actuated, but should only be used if a cost benefit analysis shows they are preferred. Actuator positioning requirements are as follows for each type, if used:

1. Electric Input: 4-20 mA or 0-10 VDC.

K. Acceptable Manufacturers:

a. Belimo
b. Valve Solutions

2.17 VALVE ACTUATORS: (ELECTRIC)

A. Valve actuators shall be electronic low voltage (24VAC), and properly selected for the valve body and service. Belimo or equivalent.

B. Actuators shall be fully proportioning (if modulating) and be spring return for normally open or normally closed operation as called out in the sequence of operations.

C. Provide a handwheel or manual positioner mounted adjacent to valve to allow manual positioning of valve in the absence of power.

D. Tri-state floating control non-spring return actuators are acceptable for terminal reheat applications for sizes less than one inch.

E. Actuators that rely on heating a medium are not acceptable.

2.18 BUTTERFLY VALVES

A. Butterfly valves used for automatic control shall be lug type rated for 125 psi non-shock water service to 180°F. Valve body shall be ductile iron with B-Nitrite (BUNA N) or EPDM molded seat and seals.

B. Disc material shall be cast bronze of aluminum-bronze with ASTM A-492 Type 416SS stainless steel stem and fittings.

C. Valves shall be tight close off suitable for end of the line service.

D. Butterfly valves used for two position control shall be line size. Valves used for modulating control shall be sized for a minimum 5 psig differential pressure at full flow. Butterfly valves shall not be used for modulating control without specific approval from the engineer.

E. Three way valve mixing or diverting configurations shall have factory provided linkage kits specifically manufactured for the piping arrangement and actuator used. Keystone or approved equivalent.

2.19 DAMPER ACTUATORS

A. General: Size actuators and linkages to operate their appropriate dampers or valves with sufficient reserve torque or force to provide smooth modulating action or two-position action and adequate close off rating as required.

B. For Duct mounted dampers:

1. Actuators shall be electronic.
2. Standard Electronic Actuators: Shall be designed for a minimum of 60,000 full cycles at full torque and be UL 873 listed. Provide stroke indicator. Actuators shall have a positive positioning circuit and selectable inputs. Full stroke shall be within 90 seconds. Where fail positions are required, provide spring return on the actuator with adequate close off force.
3. Acceptable Manufacturers:
   a. Belimo

2.20 TEMPERATURE SENSORS

A. Temperature sensors shall be Resistance Temperature Detector (RTD) or Thermistor as dictated by the requirements of this specification.

B. Duct sensors shall be rigid or averaging as specified in the sequence of operations. Averaging sensors shall be a minimum of 5 feet in length.

C. Immersion sensors shall be provided with a separable stainless steel or brass well to match pipe material.

D. Space sensors shall be equipped with setpoint adjustment and/or override switch as specified on the plans or in the sequence of operations. Space sensor shall have a portable service tool jack.

E. Accuracies shall be +/-1°F for standard applications. Where high accuracy is required, accuracies shall be +/- .2°F.

F. Duct mounted averaging sensors shall utilize a sensing element incorporated in a copper capillary with a minimum length of 20 feet. The sensor shall be installed according to manufacturer's recommendation and looped and fastened at a minimum of every 36 inches.

G. Sunshields shall be provided for outside air sensors.

1. Provide one OA sensor per mechanical room and whenever the communication rated is greater than 100 kbps.

H. Sensor Resolution: When matched with A/D converter of the controller, sensor range shall provide a resolution of no less than 0.4 °F (unless noted otherwise).

I. Room Temperature Sensor: These shall be an element contained within a ventilated cover, suitable for wall mounting. Provide an insulated base.

1. Sensing element: RTD or thermistor, +/- 0.8°F accuracy at calibration point.
2. Setpoint Adjustment: Provide where indicated. Public spaces shall not have setpoint adjustment. The setpoint adjustment shall be a warmer/cooler indication that shall be scalable via the BACS.
3. Display: Alphanumeric.
4. Sensors shall be provided with communication jack and appropriate cabling for connection to the BACS.

J. Single Point Duct Temperature Sensor: These shall consist of a sensing element, junction box for wiring connections, and a gasket to prevent air leakage or vibration noise. The sensor probe shall be stainless steel.

1. Sensing element: RTD or thermistor, +/- 0.5°F accuracy at calibration point.

K. Averaging Duct Temperature Sensor: These shall consist of an averaging element, junction box for wiring connections and gasket to prevent air leakage. Provide sensor lengths and quantities to result in one foot of sensing element for each, two square feet of coil/duct face area.

1. Sensing element: RTD or thermistor, +/- 0.5°F accuracy at calibration point.

L. Liquid Immersion Temperature Sensor: These shall include brass or stainless steel thermowell, sensor and connection head for wiring connections.

1. Sensing element: RTD, thermistor, or integrated circuit, +/- 0.4°F accuracy at calibration point.
2. Temperature Range: As required for resolution of 0.3°F.

M. Outside Air Temperature Sensor: These shall consist of a sensor, sun shield, utility box, and watertight gasket to prevent water seepage. On major/critical systems, one outside air temperature sensor shall be provided for each system; and one sensor shall be provided per mechanical room, or building-level controller. Generally, these shall be located on a north wall of the building and installed with stand-offs. On 100% outside air systems, locate the sensor in the outside air plenum.

1. Sensing element: RTD, thermistor, or integrated circuit, +/- 0.4°F accuracy at calibration point.

2.21 HUMIDITY SENSORS

A. Humidity sensors shall be capacitance or bulk polymer resistance type.

B. Duct and room sensors shall have a sensing range of 20 to 80% with accuracy of +/-3% R.H. Duct sensors shall be provided with a sampling chamber.

C. Outdoor air humidity sensors shall have a sensing range of 20 to 95% RH. They shall be suitable for ambient conditions of –40°F to 170°F.

D. Units shall be suitable for duct, wall (room), or outdoor mounting. Sensors shall be two-wire transmitters utilizing bulk polymer resistance change or thin film capacitance change. Units shall produce linear continuous output of 4-20 mA for % RH. Sensors shall have the following minimum performance and application criteria:

1. Input Range: 0 to 100% RH.
2. Accuracy (% RH): +/- 2% (when used for enthalpy calculation, dew point calculation, or humidifier control); or +/- 3% (when used for monitoring) between 20-90% RH at 77°F, including hysteresis, linearity, and repeatability.
3. Operating Range: As required by the application.
4. Long Term Stability: Less than 1% drift per year.
5. Acceptable Manufacturers:

   a. Vaisala
   b. Mamac
   c. Veris Industries

2.22 DIFFERENTIAL PRESSURE & CURRENT SWITCHES

A. Differential Pressure Switches shall be furnished as indicated for status purposes in air and water applications. Provide single pole double throw switch with fully adjustable differential pressure settings.

B. Sensing range shall be suitable for the application with accuracy of +/-2% of range and repeatability of +/-.5 % of range. Sensor shall be capable of withstanding up to 150% of rated pressure without damage.

C. Current switches shall be provided for status indications on variable air flow fans and variable pump speed applications. These switches shall be capable of installation and replacement without removing power wiring.

2.23 STATIC PRESSURE SENSORS

A. Static pressure sensors shall be differential pressure type. The sensor range shall be closely matched to the system static pressure, - .5 to .5 inches, -1 to 1 inches, 0 to 2.5 inches.

B. Sensor accuracy shall be plus or minus 5% of the sensing range, and repeatability of 2% of sensor range.

2.24 FREEZE PROTECTION DUCTSTATS

A. An electric freeze protection ductstat with 20 feet low temperature sensing capillary, and with manual reset, shall be located across the entering face of each cooling coil or bank of coils in the air conditioning unit or in the discharge of each heating coil in the heating and ventilating units, which shall on a fall in temperature below 35˚F., shut down its respective supply fan and close the outdoor air damper. Case of instrument shall be located outside of supply unit, within 10 feet of supply fan motor.

B. For systems with return air fans, on fan shut down, the return fan shall continue running or shall start, if not running.

2.25 PRESSURE SENSORS

A. Differential air pressure, static pressure and velocity pressure sensors shall be furnished by Modus, Air Monitor or equivalent.

B. Liquid, water or steam pressure sensing shall be furnished by Rosemount, Robinson Halpern or equivalent.

C. Pressure switches shall be furnished by United Electric, Dwyer or equivalent.

D. Air Differential Pressure Sensors

1. General: Pressure transducers shall be either diaphragm or strain gauge types.
2. Applications: Duct static pressure, filter DP, fan DP, air flow VP, etc.
3. Provide the smallest range feasible for the application. Provide zero and span adjustments.
4. Accuracy: Plus or minus 1% of full scale for static and 0.25% for air velocity.

5. Acceptable Manufacturers:

    a. Filter DP: Dwyer
    b. General and Static Pressure: Mamac, Setra, Veris Industries
    c. Air Flow: Air Monitor, Paragon

E. Liquid Differential Pressure Sensors:

1. Pressure transducers shall be either diaphragm or strain gauge types. Pressure transmitters shall gauge pressure in the form of a linear 4 to 20 mA or 0-10 VDC signal. Sensor shall be installed with a valve manifold and pressure/temperature test ports in lieu of pressure gauges. DP transmitter shall be rated for 150 PSIG static pressure. Wetted parts shall be stainless steel with a silicone fluid-filled diaphragm. Provide external span and zero adjustments.
2. Span shall be no greater than 2 times the working differential pressure of the system to allow the highest possible resolution.
3. Accuracy: 1% accuracy over the entire span.
4. Repeatability: Plus or minus 0.5% at maximum span.
5. Transmitters shall have a three-valve manifold for venting, draining, and calibration.
6. Acceptable Manufacturers:

    a. Gauge and Differential Pressure: Mamac, Setra, Veris Industries.

F. Air Differential Pressure Switches:

1. Cleveland Controls, Inc., products shall be used. The switches shall be installed in accordance with the manufacturer's installation instructions. All switches shall be mounted in accessible and, to the extent possible, vibration-free locations (i.e., not on duct work).

G. Liquid Differential Pressure Switches:

1. Barksdale Model EPD1HAA40 or Penn P74 differential pressure switches shall be provided when pressure sensing is required to determine status. All switches shall be mounted in accessible and, to the extent possible, vibration-free locations.
2. Do not use differential pressure switches for run status on pumps. Current switches shall be used on constant volume pumps and drive contacts shall be used for pumps with VFDs.

2.26 FLOW SENSORS

A. Differential pressure flow meters shall be furnished by Annubar or equivalent.

B. Vortex flow meters shall be furnished by EMCO or equivalent.

C. Flow sensors shall be carefully placed to ensure flow profiles that are required for accurate flow sensing. Designs shall specifically indicate the location of the sensors and indicate the length of unobstructed duct or pipe upstream and downstream from the sensor.

D. Water flow sensors shall meet the requirements necessary for use for test and balance duty as defined in the BACS specifications.

2.27 DIGITAL SENSORS

A. All digital inputs will be provided by dry contacts. The contacts will be wired normally open or normally closed as required.

B. Motor status (pumps, fans, etc.) by current sensing switch shall use Neilsen-Kuljian current-operated switch.

C. Pump flow status by differential water pressure shall use Penn P74 or equivalent.

D. Fan status by differential pressure shall be Dwyer or equivalent.

2.28 POWER SENSORS (CURRENT, KW, KWH)

A. Chiller amps shall be sensed by current transducers. The range of operation shall be from zero to a value not more than 50% of FLA. Use Ohio Semitronics CT-E series or equivalent.

B. Utility metered or submetered KWH or KW shall be sensed by a pulse producing transducer.

C. Current Sensors

1. Application: Status indication on constant speed motors.
2. Sensor shall indicate loss of status when current falls below an adjustable trip point.
3. CS shall include LED indication of status.
4. Acceptable Manufacturer: Veris Industries.

D. Current Switches (CS) for Constant Speed Motors:

1. CS shall be provided for status indication of constant speed motors.
2. Switch shall indicate loss of status when current falls below an adjustable trip point.
3. CS shall include LED indication of status.
4. Acceptable Manufacturer: Veris Industries (H708/ H908 series).

E. Current Switches for Variable Speed Motors:

1. Typically, status indication that indicates VSD or bypass operation shall be derived from contacts on the VSD. The VSD must be specified to include this option.
2. Otherwise, a current switch shall be provided for status indication. The switch shall be microprocessor based and suitable for use on a VSD.
3. Self-adjusting trip setpoint.
4. Factory programmed to detect belt loss undercurrent conditions.
5. CS shall include LED indication of status.
6. Acceptable Manufacturer: Hawkeye.

2.29 CARBON MONOXIDE SENSOR

A. Carbon Monoxide Sensor shall be 3M Model CM-6, 0 to 200 PPM, 4 to 20 mA analog output.

B. Provide C.O. sensor in all rooms with combustion equipment.

C. Installation shall be per manufacturer’s recommendations.

2.30 CARBON DIOXIDE SENSOR

A. Carbon Dioxide Sensor shall be Kele & Associates Model BA/AQS, 0 to 100% measuring range, 4 to 20 mA analog output.

B. Provide CO_2 sensor for all system specified, in all rooms or zones required to be measured or duct mounted for systems specified.

C. Application: Demand controlled ventilation of high density occupancy spaces, such as auditoriums, classrooms, lecture rooms, and conference rooms.

D. Acceptable Manufacturer: Vaisala

2.31 OCCUPANCY SENSORS

A. Single mode infrared sensors, with a minimum of two sensors per laboratory area, shall be used to establish occupancy/unoccupancy intervals. Schemes that utilize Time-of-Day (TOD), light switches and/or manual switches to establish lab occupancy shall be avoided. An unoccupied laboratory will be defined as having no people present in the room for a specified period of time (30 min. adjustable).

B. Occupancy sensors used in labs, classrooms, offices, and comparable spaces shall be Watt Stopper Model # CI-24 ceiling-mounted, 24VAC, passive infrared occupancy sensors. No substitutions considered.

C. Occupancy sensors used in auditoriums and comparable spaces shall be Watt Stopper Model # DT-200 wall-mounted, 24VAC, dual technology (passive infrared and ultrasonic) occupancy sensors. No substitutions considered.

D. Occupancy sensors shall be installed in quantities such that unobstructed coverage of the entire space is provided.

2.32 METERING

A. Temperature and flow metering points are to be as shown on Drawings.

B. Brine Chilled water BTU metering includes a flow meter, two temperature sensors, and a BTU processor. Basis of design shall use an electromagnetic meter. Acceptable manufacturers and models shall be as follows:

1. Basis of Design: Siemens Sitrans MAG 3100 (electromagnetic).
2. Alternate: Flexim FLUXUS ADM 7407 (ultrasonic).

C. Temperature sensors associated with the chilled water meter shall be Resistance Temperature Device (RTD) as manufactured by JMS Southeast, Inc. Model 3X(X=3TF3)SBK6BZZ312ZWZ2AX(X=Fully Potted). Probe shall have date of manufacture stamped on the surface. Thermowells shall be JMS model 51AT2CUK ½ inch step shank, 316 stainless steel, 0.260 bore sized to insert a minimum of 1/3 pipe diameter into flow stream. The junction box shall be a 2 x 4 handy box connected to the thermowell with CPVC nipples from the well to the head. Terminal connections shall be to a termination strip on the back of the handy box so probe can be removed through the front with the handy box cover removed. Provide a spare test well (identical to the sensing well) with brass cap and chain at all sensor locations.

D. The flow meter and temperature sensors shall be coupled to a BTU meter flow processor “FP93” as manufactured by EMCO. The flow processor shall be connected to the BMS via Ethernet.

E. If more than one building loop, or sub meters are required in a single building, multiple FP93 meters shall be connected to the BMS via Ethernet.

2.33 CONDENSATE SENSORS

A. Application: Moisture sensing on chilled water supply systems to terminal chilled beam devices.

B. Acceptable Manufacturers and Model Numbers:

1. Siemens QXA 2000
2. Sauter EGH 102
3. Honeywell H7018A1003

2.34 CONTROL VALVES

A. Valves shall be applicable for the rated pressure and temperature service. Close off pressures must be determined in concert with the actuators and valves shall be provided to close off against extreme anticipated conditions.

B. Modulating valves shall be carefully selected to control in a smooth and stable fashion across the range of anticipated conditions. “Split ranging” of heating and cooling valves controlled by the BACS is not acceptable. A separate output from the BACS shall be provided for all control valves. General guidelines are indicated below. When the selection criteria indicated below are not met, flow characteristic analyses shall be submitted to demonstrate reasonable correlation between stroke and flow. Actuator positioning requirements are as follows for each type, if used:

1. Electric Input: 4-20 mA or 0-10 VDC

C. The BMS output to modulating valves shall be analog.

D. Two-way Pressure Independent Control Valves: Pressure independent control valves can be utilized, but are not required. If used, they shall be two-way pressure independent control valves such that balancing of the valves and associated branch piping shall not be required. In addition:

1. The absolute flow accuracy through the valve shall be:
   a. +/- 5% due to system pressure fluctuations across the valve in the selected operating range
   b. +/- 5% due to manufacturing tolerances
2. The control signal shall be modulating as described above
3. The valves shall accurately control the flow from 0% to 100% full rated flow
4. A minimum of 2 PSI shall be required to operate the valve pressure independently
5. The valves shall require no maintenance and shall not include replaceable cartridges
6. The valves shall be available with optional pressure/temperature ports to allow flow verification.

2.35 STEAM CONTROL VALVES

A. Steam control valves shall be rated for the highest system pressure and temperature and shall not lift when subjected to that pressure with the control system set to “fully closed.”

B. All steam control valves shall be pneumatically or electrically actuated and have a flanged or screw body with a rating of 475°F or higher, as appropriate. Trim shall be rated for 475°F.

C. Use high performance segmented V-ball control valves for all steam control applications. Steam valves shall have the following characteristics:

1. Leakage Class: ANSI Class IV, minimum
2. Flow Characteristic: Equal Percentage
3. Rangeability: 300:1 turndown

D. Steam control valves shall have an equal percentage or modified characteristic depending on the converter pressure rise.

E. On steam control valves with a normal differential pressure of 15 PSIG or greater, stainless steel noise reducing trim shall be used.

F. Acceptable Manufacturers:

1. Fisher
2. Neles
3. Valve Solutions, Inc

G. Fail positions shall generally be as follows:

1. Heat Exchangers/Converters: Normally closed spring return (to protect for high temperature).
2. Heating Coil: Normally Open

2.36 COIL CONTROL VALVES

A. Water and glycol control valves shall be rated to remain closed (zero leakage) against 120% of the full shutoff head of the pumps, when the control signal is set to "fully closed"
1. Valves shall all be two-way
2. V-port ball valve
3. 1/4 turn;
4. Packing: EPDM O-rings, lubricated;
5. Stem: Chrome plated brass or stainless steel
6. Seat: Fiberglass reinforced Teflon
7. Actuator: Electric, one motor only
8. Flow characteristics: Equal percentage
9. Ball and Stem shall be chrome plated brass or stainless steel
10. Fail positions shall generally be as follows
    a. Heating: Normally open
    b. Cooling: Normally open or fail last position serving 100% outdoor air units, otherwise, normally closed
11. Acceptable Manufacturers:
    a. Belimo
    b. Valve Solutions
    c. Fisher
    d. Neles
    e. Marwin.

2.37 CONTROL PANELS

A. Enclosures

1. Enclosures located in mechanical rooms shall be NEMA 4.
2. Enclosures located in labs and other relatively dust free and dry spaces may be NEMA 1.
3. Enclosures shall be mounted on walls or free-standing supports.

B. Power Supplies

1. The Contractor shall provide a regulated, protected power supply as required with the ability to produce at least 33% more current than required by the transmitters and controls being installed. Output regulation shall be less than 0.5mV. There shall be no overshoot on turn on or off. Operating temperature shall be -20 to +70ºC.
2. The BACS Contractor shall certify, in writing, at the time of shop drawing submittal that the DDC equipment provided will not cause, as a result of its operation, either directly or indirectly, electrical interference to be induced into the building's electrical power systems.
3. Class II transformers shall be used.

C. Panel Fabrication

1. The Contractor shall size the panel such that no more than 80% of the surface of the enclosure back plate is used.
2. Plastic wire way (e.g., Panduit) shall be used to organize all wiring in the panel.
3. Sufficient wire way shall be provided in the panel such that it is filled no more than 80% capacity.
4. Panel layout and construction shall be neat and professional.
5. All controllers, wiring, and components in the panels shall be labeled. All labeling shall match the reference numbers on the cabinet drawings that shall be provided for each panel.
6. Label the power source and circuit number for each panel.

PART 3 – EXECUTION

3.1 FUNCTION

A. Provide all components necessary to achieve the Sequences of Operation listed in Part IV and any additional industry standard functions normally required of a first class BMS/ATC installation.

B. This division shall provide a project manager who shall, as a part of his duties, be responsible for the following activities:

1. Coordination between this Contractor and all other trades, Owner, local authorities and the design team.
2. Scheduling of manpower, material delivery, equipment installation and checkout.
3. Maintenance of construction records such as project scheduling, manpower planning, and as-built drawings for project coordination and as-built drawings.

3.2 INSTALLATION METHODS

A. Install systems and materials in accordance with manufacturer's instructions, rough-in drawings and equipment details. Install electrical components and use electrical products complying with requirements of applicable Electrical sections of these specifications.

B. The term "control wiring" is defined to include providing of wire, conduit, and miscellaneous materials as required for mounting and connecting electric or electronic control devices.

C. Control Wiring:

1. Number-code or color-code conductors appropriately for future identification and servicing of control system.
2. All line voltage power wiring required because of substitution of low voltage power wiring equipment specified in this division, shall be provided by this division.
3. Comply with the applicable requirements of Division 26 for the installation of electrical wiring incidental to the temperature control system.
4. Comply with the applicable requirements of National Electrical, New York City Building Code, and Building Code for the installation of electrical wiring incidental to the temperature control system.
5. Control wiring shall be run in conduit in accordance with the electrical sections of this specification.
6. Conduit shall be run parallel to building lines properly supported and sized at a maximum of 40% fill. In no cases shall field installed conduit smaller than ½" trade size be allowed. Where conductors are not in conduit, cable rated for use in return air plenums shall be used.
7. BMS/ATC division shall provide all control transformers and all control wiring (including low voltage actuator power wiring). This division shall also provide power wiring from the control circuits to the transformer locations and all other temperature control devices requiring power wiring. Electrical Contractor shall furnish appropriate control circuits (both normal and emergency) in suitable panelboards located throughout the project.
8. BMS/ATC division shall provide UL listed surge protectors for all control circuits upstream of control transformers.

D. Equipment installed under other divisions of the specifications:

1. Furnish dampers, valves, temperature sensor wells, flow switches and other equipment to Installers at proper time.

2. Provide installation instructions.

E. Adjust low-leakage dampers so all gaskets and seals are properly compressed.

F. Provide outside air and relative humidity sensors at each outside air intake louvers for air handlers.

G. Unless specifically indicated on plans, do not install wall mounted thermostat or temperature sensor on exterior wall. For thermostats or temperature sensors located on an exterior wall, provide insulated base behind device.

H. The access panels or doors shall be a minimum size of 18 x 18 inches.

I. Devices (i.e., sensors, meters, instruments, etc.) that are resettable must be installed in a readily accessible location (e.g., the device must be accessible at floor level without the use of a ladder). No device shall require shutting down a building system for calibration.

J. Devices that are installed in an exposed location (i.e., not mounted within a cabinet) must be suitable for such installations (e.g., do not install a device that is intended to be installed in a cabinet in an exposed location).

K. Control panels and enclosures housing the controllers shall be coordinated to the extent possible, to share vertical and horizontal wire-ways to facilitate and minimize the cost of home-runs to terminal equipment. All penetration of the controller enclosure within mechanical rooms shall be from the bottom of the enclosure with wireway and conduit stubs from the wireway up to the panel.

L. Control panels shall be located in equipment rooms, where practicable, and in locations maintaining ambient conditions between 50 and 90°F and 10 to 85% relative humidity. Control panels located in areas where conditions are outside of these ranges shall have enclosures outfitted with heating or cooling devices to provide the proper environmental conditions. Hoffman style enclosures with removable back plates and keyed, hinged covers shall be used. Enclosures shall be rated NEMA 4 when located in mechanical spaces and NEMA 1 when located in occupied spaces. Provide enclosures with key lockable doors.

M. All transformers and power supplies shall be mounted outside of the central panel.

N. Fabrication

1. The Contractor shall size the panel such that no more than 80% of the surface of the enclosure back plate is used.
2. Plastic wire way (e.g., Panduit) shall be used to organize all wiring in the panel.
3. Sufficient wire way shall be provided in the panel such that it is filled no more than 80% capacity.
4. Panel layout and construction shall be neat and professional.

5. All controllers, wiring, and components in the panels shall be labeled. All labeling shall match the reference numbers on the cabinet drawings that shall be provided for each panel.
6. Label the power source and circuit number for each panel.

3.3 IDENTIFICATION

A. Devices Inside Panels: Either of the following:
   1. Engraved labels.
   2. Lettered in permanent ink with felt tip marker.

B. Exposed Devices: Engraved labels.

C. Location: On the body of the device or on the surface to which it is mounted.
   1. Do not put identification on removable covers.

D. Label each remotely mounted control panel as to the device it controls.

3.4 OPERATING AMBIENT CONDITIONS

A. Electronic controls mounted in unconditioned space shall be rated for ambient operating conditions from -40°F to 155°F. Controls not meeting these limits shall be mounted in an accessible location within conditioned space.

3.5 OWNER TRAINING

A. The BAS/ATC contractor shall provide 4 copies of an operator’s manual describing all operating and routine maintenance service procedures to be used with the temperature control and Building Automation System supplied. This contractor shall instruct the owner’s designated representatives in these procedures during the startup and test period. The owner training shall consist of a minimum of three (3) 8 hour instruction periods scheduled by the owner over the first 12 months of system operation. The training shall be scheduled during normal working hours.

B. Follow up training shall be provided under this Division for two (2) eight hour instruction periods at six months and twelve months after building acceptance.

C. Provide minimum 40 classroom hours of factory training in programming and use of the BMS/ATC system for each of two people (designated by Owner). Provide room and board for trainees’ class during this period if factory is located more than 30 miles from the project. Provide this training no more than eighteen months after building acceptance.

D. Upon completion of the work and acceptance by the Owner, factory representatives of the control manufacturer shall provide instruction to the Owner’s operating personnel who have responsibility for the mechanical systems and controls installed by the contractor. The amount of training that is provided shall match the size of the project (e.g., no less than eight hours for small projects and up to 80 hours for large projects).

E. The contractor shall make available to the Owner regular, scheduled training courses for ongoing training of the Owner's operating personnel. Programs shall include hardware- and software-oriented courses as well as energy conservation and management courses.

F. In addition to the normal training listed above, all vendors will be required to provide two weeks of training at the BACS manufacturer's training facility for four people. This training only needs to be provided once for a particular set of installed BACS products. If a contractor has provided this training previously (on a previous project or directly with the Owner) then the additional training does not need to be provided again.

3.6 CALIBRATION AND ADJUSTMENTS

A. After completion of the installation, perform final calibrations and adjustments of the equipment provided under this contract and supply services incidental to the proper performance of the ATC and BAS system under warranty below.

3.7 OPERATION BY OWNER

A. Owner may require operation of part of the system prior to final acceptance. Operation is not to be construed as acceptance of work.

3.8 ACCEPTANCE PROCEDURE

A. General: The system installation shall be complete and tested for proper operation prior to acceptance testing for the Owner's authorized representative.

B. Upon completion of the calibration, Contractor shall startup the system and perform all necessary testing and run diagnostic tests to ensure proper operation. Test shall include a 100% point to point check-out of all BMS devices to confirm proper response to manual input. Installer shall be responsible for generating all software and entering all database necessary to perform the sequence of control and specified software routines. An acceptance test in the presence of the Owner's representative or Architect shall be performed.

1. If more than two of the first 10 devices tested, or more than 10%of the first 20 or more devices tested, fail to operate properly, the test shall be discontinued.
2. Additional testing, after corrections are made, shall be done at the Installer's expense.

C. A letter shall be submitted to the Architect requesting system acceptance. This letter shall certify all controls are installed and the software programs have been completely exercised for proper equipment operation. Acceptance testing will commence at a mutually agreeable time within ten (10) calendar days of request. When the field test procedures have been demonstrated to the Owner's representative, the system will be accepted. The warranty period will start at this time.

D. Field Equipment Test Procedures: DDC Zone and Local Controllers shall be demonstrated via a functional end-to-end test as follows:

1. All output channels shall be commanded (on/off, stop/start, adjust, etc.) and their operations verified. (Point -to- Point Checkout)
2. All analog input channels shall be verified for proper operation.
3. All digital input channels shall be verified by changing the state of the field device and observing the appropriate change of displayed value.
4. If a point should fail testing, perform necessary repair action and retest failed point and all interlocked points.
5. Automatic control operation shall be verified by introducing an error into the system and observing the proper corrective system response.
6. Selected time and setpoint schedules shall be verified by changing the schedule and observing the correct response on the controlled outputs.

E. Workstation Test Procedures: The System Workstation test procedures shall be as follows:

1. Communication with each DDC Zone and Local Controller shall be demonstrated.
2. Operator commands will be explained and demonstrated.
3. Control sequences shall be demonstrated for proper operation.
4. All available system reports and logs shall be demonstrated at the System Workstation.
5. Correct system start-up and shutdown procedures shall be demonstrated.
6. All controllers shall be demonstrated to operate in standalone mode.

F. Acceptance Test of Mechanical Systems

1. Perform at least two (2) operational tests of the entire mechanical system as described in the specifications.
2. Give each element of the system an operating test of not less than 48 hours' duration to demonstrate to the satisfaction of the Architect that the control system is functioning properly and that the system is capable of producing the required environmental conditions. During this test, operate the system entirely on automatic control and take periodic readings of the inside and outside wet and dry bulb temperatures. Obtain wet and dry bulb temperatures with a recording thermometer-hygrometer. Conduct tests with outside temperature and humidity conditions as near design conditions as practical.
3. Winter acceptance test shall be conducted when outside temperatures are at or near 10^0F, summer acceptance test shall be conducted when outside temperatures are at or near 90^0F db.
4. Conduct tests during summer and winter outdoor temperature extremes as specified above. Notify Owner seven (7) days in advance of proposed tests.
5. Record temperature and humidity at an exterior and interior location for each system as designated by the Engineer at least once every hour for 48 hours during tests.

6. Submit a report detailing the following:
    a. Instrument used:
        1) Most recent calibration date.
    b. Date of tests.
    c. Description of test apparatus locations and methods.
    d. Results of tests.
    e. Any abnormal usage of the building or abnormal system characteristics observed during the course of the test.

3.9 RECORD DOCUMENTS

A. Electronic Media As-Built Documentation: After a successful acceptance demonstration, the Contractor shall submit as-built drawings of the completed project for final approval. After receiving final approval, supply complete 11X17 hard copy as-built drawing sets, together with CD's to the owner. Provide (3) copies of O & M Manuals.

B. Operation and Maintenance Manuals: Submit Operation and Maintenance manuals. Include the following in each manual:

1. BMS/ATC information for insertion into the Manufacturer's catalog data and specifications on all sensors, transmitters, controllers, control valves, damper actuators, gauges, indicators, terminals, and any miscellaneous components used in the system.
2. An Operator's Manual which will include detailed instructions for all operations of the system.
3. An Operator's Reference Table listing the addresses of all connected input points and output points. Settings shall be shown where applicable.
4. A Programmer's Manual which will include all information necessary to perform programming functions.
5. A language manual which will include a detailed description of the language used and all routines used by the system.
6. Flow charts of the control software programs utilized in the Temperature Control System.
7. Flow charts of the custom software programs utilized in the Temperature Control System.
8. Complete program listing file and parameter listing file for all programs.
9. A copy of the warranty.
10. Operating and maintenance cautions and instructions.
11. Recommended spare parts list.
12. Twenty-four (24) hour service phone number and point of contact.
13. Controlled Schematic Drawings.
14. Detailed written sequences of operation.
15. Valve, damper, and laboratory airflow devices schedules.
16. Floor Plans.
17. Wiring Diagrams.
18. Sample Graphics and Trends.

3.10 WARRANTY

A. All BAS/ATC devices and installation shall be warranted to be free from defects in workmanship and material for a period of one year from the date of job acceptance by the owner. Any equipment, software, or labor found to be defective during this period shall be repaired or replaced without expense to the owner. Factory authorized warranty service shall be available within 50 miles of jobsite.

B. Except as otherwise specified, the Contractor shall warrant and guarantee all work against defects in materials, equipment, and workmanship for a period of one (1) year from the date of acceptance of the work as evidenced by a resolution to that effect by the Owner, and for that period of time noted in special or extended warranties.

C. The period of one (1) year shall be extended with respect to portions of the work first performed after substantial completion by the period of time between substantial completion and the actual performance of the work.

D. The Contractor shall provide all recommended preventative maintenance of the materials, equipment, and workmanship as necessary and as described in the operating and maintenance manuals during the warranty period. In addition, the Contractor shall provide two (2) semi-annual service visits (i.e., one visit during the peak cooling season and one visit during the peak heating season) to test and evaluate the performance of the equipment. The Contractor shall provide a written report of the test and evaluation results. The service visits shall include, but not be limited to:

1. Checking and, if necessary, correcting the calibration of the sensors, transducers, and transmitters for airflow, liquid flow, pressure, temperature, and humidity.
2. Checking and, if necessary, correcting the operation of the dampers and damper actuators.
3. Checking and, if necessary, correcting the operation (i.e., monitoring and command) of the system points.

E. Software and Hardware Updates: At the end of the first six months after acceptance, and during the subsequent six month period, the BACS contractor shall update the equipment and any controllers, servers, workstations and HMI web servers with the latest modification and improvements in software, firmware, and hardware that the manufacturer may have incorporated in the furnished equipment.

3.11 INSPECTION

A. Examine location where controls and equipment are to be installed and determine space conditions and notify architect in writing of conditions detrimental to proper and timely completion of the work.

1. Do not proceed with the work until unsatisfactory conditions have been corrected.

3.12 INSTALLATION

A. Install in accordance with manufacturer's written instructions, and with recognized industry practices, to ensure that equipment comply with requirements and serve intended purposes.

B. Coordinate with the work as necessary to interface installation of equipment with other components of systems.

3.13 FIELD QUALITY CONTROL

A. Upon completion of installation of the automatic temperature control system and after motors have been energized with normal power source, test system to demonstrate compliance with requirement. When possible, field correct malfunctioning controls then retest to demonstrate compliance. Replace controls which cannot be satisfactorily corrected. Refer to Testing and Balancing Section of this specification.

3.14 SERVICE

A. After completion of the control system installation, the control manufacturer shall regulate and adjust all temperature sensors, control valves, damper motors, etc., and place in complete operating condition, subject to the approval of the Architect. The control contractor shall provide two complete instruction manuals, in addition to any other manuals called for in this specification, to the Owner's operating personnel. The manual shall include the function and operation of all control components on this project. Complete instructions shall be given to the operating personnel. There shall be two day's instruction given for Winter cycle and two day's instruction for Summer cycle operation.

3.15 SUBMISSION REQUIREMENTS

A. Control Schematics

1. BACS legend and abbreviations.
2. BACS one-line Architecture diagram.
3. Point names and types.
4. Normal position of output devices.
5. Setpoints.
6. Point addresses and device ranges.
7. Bill of materials listing all devices and manufacturer numbers.

B. Point and Alarm List

1. Point type (AI, BI, AO, BO, BV, AV)
2. Specific input points that must be able to be put in test mode to facilitate commissioning.
3. Listing, for each point, of any associated alarms. Control loops shall an adjustable setpoint deviation alarm based upon error and time. The alarm

parameters shall be the state the point is in to cause a particular including whether the source system is also enabled. Examples of points in this list are as follows:
a. Supply air temperature (AI) +/- 4°F from setpoint for 30 minutes.
b. Space air temperature (AI) +/- 4°F from setpoint for 30 minutes, baseboard radiation heating system is enabled.
4. Listing, for each point, of its trending and scheduling requirements.
5. Listing of whether the point is to be included on the BACS graphics.
6. Point address.

C. Sequences of Operation

1. Sequences in all modes of operation: on, off, occupied, unoccupied, warm-up, cool-down, night setback, summer, winter, economizer, etc.
2. Sequences shall be organized into logical groupings including: run/stop, pressure, economizer, coils, discharge air, humidification, dehumidification, hydronic temperature, etc.
3. Detailed steps during mode switches.
4. Details of operation during and after a power outage. Loss of status associated with power outages are not to be indicated as failures with a subsequent alarm or lock out.
5. Specific direction on failure scenarios for loss of proof and all safety device trips.
6. Setpoints, trip points, and ranges.
7. Fire/smoke control system interfaces.
8. Schedule of operation, including holidays and breaks.
9. Fire alarm panel interlocks and special operating modes.

D. Valve Schedule

1. Manufacturer and Model Number.
2. Valve Size, valve type, and CV Rating.
3. Actuator and Model Number.
4. Type (2-way/3-way, spring return/non spring return, etc.)
5. Flow and pressure drop at design maximum flow.
6. Normal positions.
7. Position of valve at design conditions.
8. Close off rating.
9. Valve characteristic = (i.e., equal percentage, linear, etc.)
10. Valve turndown.
11. Design Flow.
12. Design controlled circuit pressure differential range (BACS vendor only, coordinated with the submittals).

E. Damper Schedule

1. Manufacturer and Model Number.
2. System Served.
3. Damper Size and Leakage Class.

4. Actuator and Model Number, Pilot (Y/N), Range and Mounting Position.
5. Size and Type (parallel blade/opposed blade, etc.).
6. Design flow and pressure drop.
7. Normal positions.

F. The BACS vendor shall submit manufacturer's technical product data for each control device, panel, controller, and accessory furnished indicating dimensions, capacities, performance and electrical characteristics, and material finishes. Also include installation, start-up, calibration, and maintenance instructions as well as all cable and tubing requirements.

G. System architecture one-line diagram indicating schematic location of all controllers, workstations, LAN interface devices, gateways, etc. The ACS vendor shall indicate address and type for each control unit; as well as indicate physical media, protocol, communication speed, and type of each LAN.

H. Set of floor plans with all controllers/control panels, sensors, operator workstations, interface devices, UPS's, etc., located and identified. The BACS vendor shall indicate all network components (repeaters, routers, etc.); network wiring shall be shown and identified on the floor plan drawings.

I. Detailed Wiring Diagrams: The BACS vendor shall include detailed wiring. Indicate all required electrical wiring. Wiring diagrams shall include both ladder logic type diagrams for motor starter, control, and safety circuits and detailed digital interface panel point termination diagrams with all wire numbers and terminal block numbers identified. Provide panel termination drawings on separate drawings. Ladder diagrams shall appear on the system schematic. Clearly differentiate between portions of wiring that are factory-installed and portions to be field-installed. All wiring of related components that make up a system shall be grouped together in one diagram (e.g., all wiring diagrams for the components and devices on a particular AHU shall be shown on one drawing. The supply fan components and devices should not be shown separate from return fan components and devices, etc.).

J. Operation and Maintenance Materials: The BACS vendor shall provide Operation and Maintenance (O&M) materials generally in concert with training. O&M materials shall include the following:

1. Maintenance instructions and spare parts list for each type of control device, control unit, and accessory.
2. BACS User's Guides (Operating Manuals) for each controller type and for all workstation hardware and software and workstation peripheral.
3. BACS Programming Manuals for each controller type and for all workstation software.
4. All information provided during the submittal phase; updated with as-built information. As-built panel drawings shall also be included as part of the O&M manual process. The drawings that are located in each panel shall incorporate all the systems controlled from that particular panel. The drawings shall include the system schematic and detailed panel wiring diagram. Also included (typically

noted on the system schematic diagrams) should be the specific locations of any remote devices such as remote static pressure sensors, differential pressure sensors, etc.

5. Each control panel on the project shall include an as-built hard copy of all drawings and documentation associated with that panel and its field devices. This documentation shall be provided in a plastic protective pocket mounted inside the panel door.
6. The final as-built controls drawings (PDF) shall also be accessible via the web based graphics.

PART4 – SEQUENCE OF OPERATION

4.1 GENERAL

A. BMS/ATC Contractor shall design, install, program, test, commission and demonstrate a complete and fully functional system capable of meeting the Sequences of Operation detailed below. Provide additional control points and functions as required, even if not specifically called for, if normally considered necessary for a BMS/ATC installation of the size and complexity of this project or if required to implement control sequence.

B. Listed items of equipment shall be individually controlled by standalone controller. Each controller shall serve only one individual unit. The unit controller shall be supplied by the BMS Contractor and may be furnished to the equipment supplier for factory mounting. The cost to mount, calibrate, program and test the controller and actuator shall be coordinated prior to bid day and included in the BMS price.

1. Ice Chiller Plant including brine and condenser water pumps
2. Water cooled package unit
3. Ice Out Heat exchanger
4. Emergency ventilation/exhaust system

C. Multiple units may be controlled by individual standalone controllers for all other control points.

D. Sensor and transducer installation, control power and wiring and communications wiring shall be provided under this division by BMS/ATC Contractor.

E. Refer to the Systems Points List at the end of this division and equipment schedules on the drawings for required control inputs and outputs for each item of equipment listed in the Sequence of Operation.

F. Where control sequences depend on global variables such as outside air temperature, the controller shall have the capability of either using the last value or a default value.

1. All points and functions required to control an air handler with all directly associated supply, return, and exhaust fans. This excludes the terminals that may be associated with that air handler. Values that may be received across the

network include humidity, emergency power source indication, terminal based reset parameters, and smoke modes.

2. All points associated with the supply side of a hydronic system such as pumps, flow meters, temperature and pressure sensors, proof indications, valves etc. This excludes the terminals on that hydronic system. Values that may be received across the network include outside air temperature and humidity, emergency power source indication, and terminal based reset parameters.
3. All points and functions required to control one terminal system including dampers, valves, flow meters, temperature and humidity sensors, etc. This does not include the scheduling period or any outside air that may be necessary for control.

G. Trending: Tthe BACS shall be capable of trending and archiving all points on building- and system-level controllers at a minimum of 15 minute intervals. The BACS shall also have the capability of trending at least five points on each field-level controller at an interval of 15 minutes. The trend data shall be uploaded to a central database as needed to prevent buffer overflow in the controller. Controller memory capability, network architecture, and communications bandwidth shall be designed to account for this trending. The BACS vendor shall provide control trends during start up and prior to functional performance testing of the systems. Reports shall be scheduled to output the data to a common format such as comma separated text, Microsoft formats such as Excel and Access, and portable database format. Trended data shall also be archived in an Owner-accessible SQL database.

H. Trend Graphs: Web-based software shall provide for displaying graphic plots of the trended values. The software shall support multiple scales, points and point types simultaneously. The BACS vendor shall configure these graphs in a logical manner for each system. Consult with the commissioning team members and project manager for required configuration. Provide a trend for every analog control loop that includes the setpoint, process variable, and control output.

I. Alarms: All alarms shall be provided with a means of output as an e-mail and a text message through an owner provided internet connection. User interface shall include all provisions and screens required for the end-user to select which alarms shall output as an e-mail or text message without the involvement of a service technician.

J. Real-time Plotting: Software shall be provided for real time plotting/graphing of multiple values in user-defined time intervals. These graphs will typically be used in commissioning to observe loop responses and system reactions. The BACS vendor shall configure these graphs in a logical manner for each system. Consult with the commissioning team members and project manager for required configuration.

K. Alarm Programming: Alarms shall be “intelligent” based upon the algorithms in this section.

1. In general, alarm programming related to DDC controlled equipment should reside at the controller level along with the functional programming for equipment control.

a. Intrinsic alarming associated with AI, AV, BI or BV objects (or any of the other 23 BACnet objects that support intrinsic alarming) shall only be used where the alarm is valid regardless of the state of the associated equipment or where there is a ready means for automatically suppressing alarm generation when the associated equipment is operationally secured.
b. Alarm points shall be separate BACnet objects (e.g., BV or EEO) actuated by associated alarm programming.
c. Alarm objects shall have descriptive BACnet object names. BACnet alarm object names shall end in "Alarm". For detailed information on proper point naming conventions, coordinate with owner's Facilities and Engineering staff.
d. If it is necessary for the alarm to have latching functionality, the user shall be provided easy unlatching capability from within the DDC system if appropriate, taking into account equipment safety concerns. This is in addition to any local alarm reset.
e. Alarms designated for monitoring by EMCS shall be set up in the DDC system to report to the EMCS alarm server.

2. Analog Deviation Alarms: Analog deviation alarms shall be based upon the comparison between the controlled variable and the controlled variable setpoint (whether calculated or fixed).

a. When controlled variable deviates from setpoint above or below user adjustable high or low alarm thresholds, the alarm shall be activated.
b. High and low alarm threshold values shall have associated adjustable deadbands (hysteresis values) for alarm clearing conditions as the controlled variable falls below the high alarm threshold or rises above the low alarm threshold.
c. Alarm programming shall include user adjustable alarm delays for active equipment operation.
d. Alarm programming shall include startup delays to prevent nuisance alarms during equipment startup.
e. Analog deviation alarms shall be disabled if the associated equipment is operationally secured.

3. Analog High Limit Alarms: Analog high limit alarms shall be based upon the comparison between the controlled variable and a user adjustable high limit alarm value.

a. When controlled variable rises above the user adjustable high limit, the alarm shall be activated.
b. High alarm limit value shall have associated adjustable deadband (hysteresis value) for alarm clearing condition as the controlled variable falls below the high alarm limit.
c. Alarm programming shall include user adjustable alarm delays.

d. High limit alarms shall be disabled if the associated equipment is operationally secured, unless needed due to equipment safety considerations.

4. Analog Low Limit Alarms: Analog low limit alarms shall be based upon the comparison between the controlled variable and a user adjustable low limit alarm value.

   a. When controlled variable falls below the user adjustable low limit, the alarm shall be activated.
   b. Low alarm limit value shall have associated adjustable deadband (hysteresis value) for alarm clearing condition as the controlled variable rises above the low alarm limit.
   c. Alarm programming shall include user adjustable alarm delays.
   d. Low limit alarms shall be disabled if the associated equipment is operationally secured, unless needed due to equipment safety considerations.

5. Binary Run Status Alarms: Status alarms shall be based upon the comparison between run status and equipment command where applicable.

   a. Alarm Status programming shall include user adjustable alarm delays.

6. Binary Alarming: Alarms shall be triggered upon associated BI changing state to the non-normal or alarm state.

   a. Alarm Status programming shall include user adjustable alarm delays.
   b. Binary alarms shall be disabled if the associated equipment is operationally secured, unless needed due to equipment safety considerations.

7. Steam Shell and Tube Heat Exchanger Temperature Alarming: Steam shell and tube heat exchangers shall have two temperature alarms associated with them.

   a. Operational Supply Temperature Deviation Alarm when heat exchanger is in operation.
   b. High Supply Temperature Alarm that is always enabled whether or not the heat exchanger is operational or not, so as to monitor for steam control valve leak by.

4.2 ICE CHILLER PLANT

A. Refer to Water Chiller specification for additional requirements:

B. The controls vendors shall provide a chiller optimization strategy based on the requirements expressed below. This system shall operate as a stand-alone system with all equipment and programing installed on site and licensed for indefinite use without the need for outside intervention, support, subscription or annual cost. Refer to Water Chiller and other specifications for additional requirements.

C. The BAS shall monitor and control the packaged chiller microprocessor, or the chillers directly as described below:

1. The chiller sequencing software shall perform the following control strategies, provide the points as listed on the chiller point list and support specified monitoring and diagnostics.
2. All points available in the chiller controller shall be provided with a means of collecting, displaying and recording (logging) via the BMS.

D. Chiller interface to the BAS may be accomplished by any combination of the three methods outlined below:

1. Packaged chiller microprocessor which is fully compatible with, and fully conversant with the BAS/ATC System.
2. Packaged chiller microprocessor with RS-232 interface and open protocol which is fully compatible with the BMS/ATC system.
3. Duplicate input/output interfaces and sensor signals, factory installed by the chiller manufacture and fully accessible for use by the BMS/ATC system.

E. The chiller plant sequencing software may be contained in the chiller microprocessor or in the BMS/ATC system.

F. System Scheduling: The chiller sequencing software shall start the chiller system based upon a calendar time of day schedule.

G. Chiller Sequencing: The chiller sequencing software shall start and stop the production and distribution pumps and chillers based upon:

- Event Schedule
- Time of day schedule
- Optimal Start/Stop
- System Load
- Timed Override

These five (5) start types shall be options for the building operator using the building Automation software. These five (5) start types shall be represented by software icons, which can be selected by using a pointing device.

1. When the chilled water system is enabled, the chiller system control shall:
    a. Enable the variable speed pumping systems.
    b. Open the lead chiller isolation valve.
    c. Start and prove the lead production chilled water pump.
    d. Start and prove the lead condenser water pump.
    e. Enable the lead chiller.

2. When an additional chiller is required, the chiller system control shall:
   a. Open lad chiller isolation valve
   b. Start and prove the lag production chilled water pump.
   c. Start and prove the lead condenser water pump.
   d. Enable the lag chiller.

3. When the chilled water system load allows a chiller to be removed from operation, the chiller control system shall:
   a. Shut-down the chiller
   b. Confirm that the chiller compressor has stopped.
   c. Modulate the chiller isolation valves closed while ramping the chilled and condenser water pumping system flow to the flow required for the required number of operating chillers. Valve shall close at a rate of 5% per minute (adjustable) to minimize upset to system flow during shut-down.
   d. Balance load between operating chillers to optimize energy efficiency considering chiller efficiency, pumping efficiency and cooling tower efficiency.

4. When the chilled water system is disabled, the chiller system control shall:
   a. Shut down the chiller(s)
   b. Confirm the respective compressor(s) has stopped.
   c. Shut down the respective production pump(s).
   d. Close respective chiller isolation valve(s).
   e. Shut down distribution (secondary) pumping system.
   f. Compressor shall not be restarted for a five minute (adj) delay.

5. The chiller sequencing software shall consider starting the lag chiller whenever there is deficit flow (production flow less than distribution flow) in the production-distribution decoupler (bypass) pipe. Deficit flow shall be determined by a comparison of water temperatures.

   When deficit flow exists continuously for 15 minutes (adj), the chiller sequencing software shall initiate the start of the lag chiller.
   a. Lag chiller shall start in similar manner to the lead chiller start sequence.
   b. The BAS shall control each chiller's leaving chilled water setpoint to equalize chiller loading.

6. The chiller sequencing software shall consider stopping a chiller when excess flow (production flow greater than distribution flow) is greater than 55% (adj.) continuously for 15 minutes (adj.).

   The chiller sequencing software will not shut down the respective production pump until it has confirmed that the compressor has stopped.

7. The chiller sequencing software shall control individual chiller setpoints to maintain the system supply water setpoint and equalize chiller loading.

8. Prior to the start of the lag chiller, the lead chiller shall be unloaded to 80% capacity (adj.). This is done to prevent the lead chiller from shutting down on freeze protection due to rapid decrease in evaporator flow when the lag production pump is started. Following confirmation of the lag chiller operation, the chillers are allowed to load as necessary.

9. Chiller Failure: Upon sensing a chiller failure, the chiller sequencing software shall alarm and lockout that chiller and immediately initiate the start sequence for the lag chiller. Automatic isolation valves shall maintain lead chiller operation with lag pump.

10. Chiller Rotation: Automatic rotation of chiller operation shall equalize chiller run time. Rotation shall be initiated by the following operator selectable methods:
    a. Real Time: Based on day intervals
    b. Run Time: Actual chiller run times
    c. Manual or Forced: Operator initiated start/stops

11. System Soft Start: The chiller sequencing software shall provide operator adjustable chiller water temperature ramp rates to insure that the system water temperature doesn't approach setpoint too quickly or too slowly at system start-up. This prevents the unnecessary operation of chillers and limits system electrical demand during distribution loop temperature pulldown.

12. The Maximum Cool Down Rate in the production loop shall not exceed 2 °F per minute (adj.).

13. Chiller Start Interval: The chiller sequencing software shall include a 30 minute (adj.) time interval to delay the lag chiller from starting or stopping from the lead chiller.

14. Chiller Demand Limiting: As part of the demand limiting scheme on the building, the chiller sequencing software shall be able to reduce peak power demand through the limiting of chiller system capacity.

15. Chiller Sequencing Status: The following sequence status information shall be displayed to the operator:
    a. Chiller Addition Pending (Yes/No)
    b. Chiller Subtraction Pending (Yes/No)
    c. Chiller Start Delay Time Remaining (Time)
    d. Chillers on (0, 1, 2)
    e. Chillers Failed (0, 1, 2)
    f. Chiller Operating Mode (0, 1, 2)
    g. System Setpoint

16. Individual Chiller Status Display - The chiller sequencing software shall provide an operating status report for each chiller. The displays shall include:
    a. Chiller Operating Mode.
    b. Chiller Water Setpoint.

c. Entering Chilled Water at each Chiller (actual)
d. Leaving Chilled Water at each Chiller (actual)
e. Entering Condenser Water at each Chiller (actual)
f. Leaving Condenser Water at each Chiller (actual)
g. Leaving Chilled Water at each Chiller (set-point)
h. Instantaneous KW Demand – each Chiller
i. Instantaneous KW Demand as a percentage of rated KW
j. Current Limit Setpoint.
k. Output of each chiller (tons)
l. Total Operating Capacity
m. Chiller Load (%)

17. Diagnostics/Protection - The chiller sequencing software shall be able to alarm from all sensed points and diagnostic alarms sensed by the chiller controller.

18. Alarm limits shall be designated for all sensed points.

H. System diagnostic and alarm indication:

1. The chiller unit control panel shall display locally the following conditions. It shall also supply to the BAS a common binary status for any of these alarm conditions:

I. Condenser water control

1. The cooling towers shall be controlled to maintain supply condenser water temperature to the chilled water plant. Two (2) fans, 2 stages each, shall be cycled w/ PI control to maintain setpoint (adj.). The cooling tower staging shall be as follow:
a. No. 1 fan on, low speed
b. No. 1 fan, high speed
c. No. 2 fan on, low speed
d. No. 2 fan, high speed

2. When all fans are cycled off and condenser water temperature is below setpoint, the chillers 2-way valves shall be modulated to maintain safe (stable) and efficient chiller operation.
a. Below 32°F (adj.) O.A.T.

3. The condenser water temperature setpoint shall be reset between 80° F and 90°F based on the lowest return water temp. of any operating chiller.

4. The condenser water pumps shall operate in a lead/lag control configuration (parallel when both chillers are operational). Either pump can be designated as lead or lag pump. Pump rotation shall be initiated by either "real time", "run time", or "manual/forced" control modes.

5. Indication of condenser water pump (s) flow failure shall start the lag condenser pump (if not already sequenced). Failures shall also be alarmed at operator's workstation.

6. Automatic isolation valves and sequencing software shall maintain lead cooling tower (and/or chiller) with lag condenser water pump if required by tower or pump failure.

7. All automatic isolation valves at cooling towers shall not close until all condenser water pumps have proved off.

8. A self-contained level controller shall monitor water level in the remote sump and alarm high and low water conditions to the BMS.
   a. Cycle the slow-closing solenoid valve to maintain normal (operation) water level. (Hard wire)

J. Chiller/Cooling Tower Optimization:

The controls contractor shall provide controls that calculate the optimal cooling tower setpoint at any chiller(s) load and ambient wet bulb temperature. The optimization program shall provide as an output a leaving tower water temperature setpoint.

As part of the controls contractor's proposal for bid, the contractor shall provide optimal setpoint and estimated chiller + tower power (KW) for the following load and ambient conditions:

Load (% full load)	Amb. Wet Bulb	Tower Setpoint	Chiller + Tower KW
100%	77		
75%	77		
50%	77		
25%	77		
100%	60		
75%	60		
50%	60		
25%	60		
100%	40		
75%	40		
50%	40		
25%	40		

A Chiller/Cooling Tower Optimization Program shall be provided by the controls contractor. As a minimum, the following chiller and tower characteristics shall be used in the optimization routine:

<u>Chiller Characteristics (per chiller)</u>	<u>Tower characteristics (per tower)</u>
Tons	Cond. H_2O flowrate
Cond. H_2O flowrate	Approach Temp. (Lvg. H_2O temp-amb.
air	temp.)
Full load Efficiency (Kw/ton)	Total Fan(s) HP
Part Load Performance (Kw/ton)	Range (Ent. H_2O temp-Lvg. H_2O
temp.)	
(Efficiencies from 100-10% in 10% increments)	

The Chiller/Tower Optimization Program routine shall scan every 5 minutes (adj.) the chiller(s) load and ambient WB temperature. Using these inputs and both the chiller and cooling tower characteristics noted above, the program shall provide optimal chiller and cooling tower performance. Optimal performance is defined as lowest total KW input consumed by both chiller(s) and cooling tower(s) while maintaining chilled water setpoint.

K. Refrigerant Management Monitoring:

1. Install a refrigerant monitor supplied by the chiller manufacturer for low level refrigerant leak detection. The monitor shall be installed and calibrated by the direction of the chiller manufacturer's representative.
2. Provide and install an audible alarm (100 dB) which shall indicate refrigerant levels of 3 PPM (adj.) detectible in chiller equipment room. The refrigerant sensor shall be located by engineer.
3. The refrigerant monitor shall be tended and alarmed at the operator's workstation. An alarm and specialized message indicating a refrigerant alarm shall appear on the operator's monitor.

L. Chiller Room Ventilation System:

1. Divisions 21 through 23 Contractor shall verify (in a letter to the Architect) that this work has been done:
   a. Balance the supply and exhaust air system such that a minimum 0.05" W.C. negative static pressure (with respect to the adjacent spaces) is maintained in the chiller room when all doors are closed and the ventilation system is operating.
2. Provide a wall mounted temperature sensor and three (3) wall mounted occupancy sensors.
3. Energize the ventilation system whenever any of the following conditions occur:
   a. Alarm condition at either chiller's refrigerant monitor.
   b. Occupancy (as sensed by motion detectors) continue to ventilate for 10 minutes (adj.) after room vacancy is detected.
4. Alarm a loss of flow in either fan at highest priority level.
   a. De-energize supply fan if exhaust fan loses flow.

5. Provide an emergency power off (EPO) switch in the chiller room which will shut off (via the DDC system) all equipment in the room.

4.3 DUCT HEATING COILS

A. Provide manual over-ride and setpoint control capabilities for all sensors.

B. Provide separate heating setpoints for occupied and unoccupied schedules.

C. Status report: For each coil, the BMS shall provide an operating status summary of all unit sensed values setpoints and modes.

D. All valves shall fail in the open position, but if communication is lost, the valve shall continue to operate in the current mode.

E. Valve shall modulate to maintain current zone temperature setpoint or called for by the space sensor.

4.4 H&V SYSTEM (100% OA-F&BP-HC- RH ZONES)

A. Whenever the unit fan motor is energized the outdoor air damper shall open, the interlocked exhaust fan shall start and the control system shall be activated. Whenever the unit fan motor is off the outdoor air damper shall be closed and the face damper open. The BMS shall index the system between summer and winter.

B. Winter:

1. During "winter" the face and bypass dampers and the heating coil valve, shall modulate in sequence, to maintain a fan discharge temperature of 50˚F. With a rise in temperature, the face damper shall gradually close and the bypass damper shall gradually open. With a continuous temperature rise, the heating coil valve shall gradually close. A low limit temperature sensor may overcall the fan discharge temperature sensor to maintain a heating coil discharge temperature of 45˚F., by gradually opening the heating coil valve.

C. Summer:

1. The summer-winter switch shall be indexed to "summer" the heating coil valve shall close, the face damper shall open and the bypass damper shall close.

2. A room temperature sensor shall be provided for each reheat coil, to modulate a coil control valve, to maintain its setting.

4.5 CHILLED-CONDENSER WATER SYSTEM

A. When chiller "start" button is pushed, it shall energize a pilot relay. When the pilot relay energizes, the chilled water pumps shall start, then the condenser water pump or chilled-condenser water standby pump shall start, then the cooling tower fan control shall be energized, through a condenser water flow switch. Provide an adjustable (30 to 180 sec.) time delay relay for each motor control circuit.

B. When the chilled and condenser water pump starters are energized, and chilled and condenser water flow are established by flow switches, the chiller starting circuit shall be energized.

C. Provide all necessary controls and wiring for the above sequence.

D. The chiller manufacturer shall provide the capacity control system, to maintain leaving chilled water temperature.

4.6 COOLING TOWER

A. A basin water electric temperature sensor shall cycle the tower fan motors, on a rise in condenser water leaving temperature, and vice versa. Tower fans shall be off at 80˚F., motors on low speed at 82˚F., and motors on high speed at 84˚F. Fans shall stop when chiller and water cooled package unit stops.

B. A condenser water bypass valve shall be controlled from a temperature sensor in the condenser water to the absorption refrigeration machine, to maintain 85˚F in the summer and 45˚F in the winter.

C. Two-way bypass valves, for pipe sizes larger than 8", shall be Continental Equipment Co. Model 7610, or approved equal, heavy pattern, Class 2, 60˚F. disc opening, line size butterfly valve, with pneumatic piston type operator.

D. Provide a remote temperature sensor, sensing the tower basin water temperature for the winterized cell, to modulate the basin heater to maintain 45˚F. Temperature sensor shall be located inside the building.

4.7 PRESSURE BYPASS CONTROL

A. A differential pressure controller, sensing supply water and return water pressures for its system, shall modulate a bypass valve to maintain its setting. Valve shall be normally closed for hot water and normally open for chilled water.

4.8 EXHAUST FAN CONTROL

A. When the exhaust fan is started, a normally closed damper in the fan outlet shall open. When the fan is stopped, the damper shall close.

B. For dampers furnished by the fan manufacturer, fan manufacturer shall provide electric, totally enclosed, spring return damper motors and dampers, and control manufacturer shall wire to load side of local disconnect switch.

C. For Elevator Equipment Room, provide a room temperature sensor, set at 80˚F., to cycle its respective exhaust fan motor, on a rise in temperature. When the fan starts, its outside air intake damper shall open. For two speed motors, fan shall operate at low speed below 80˚F. and at high speed above 80˚F.

4.9 CABINET HEATER (RETURN AIR CONTROL)

A. When the hot water supply temperature is above 100˚F., the cabinet heater fan shall run continuously. Provide a strap-on aquastat.

B. A return air temperature sensor, accessible through the removable unit access panel or return grille, shall modulate a hot water control valve to maintain its setting.

4.10 CONTROL OF SMOKE DAMPERS

A. Provide a normally closed automatic damper in each duct crossing a smoke barrier, and as indicated on the Drawings, at the point where the duct crosses the barriers and at supply fan discharge. Whenever supply fan stops, smoke damper at the fan discharge shall close. Provide one minute time delay to prevent fan start-up until all smoke dampers have opened and 20 second time delay to prevent dampers from closing until fan has stopped. All smoke detectors located at the supply, return and exhaust ductwork of same system shall be one zone. Any smoke detector actuated on the zone shall:

1. Stop supply fan and exhaust fans. (Interlocked fans shall be shut down by means of interlocking).
2. Start return air fan. (Give consideration to making this fan 2 speed starting fan at low speed).
3. Close return air damper and open relief air damper.
4. Open all smoke dampers on return air duct of that system. Whenever return air fan is off, smoke dampers on return air duct shall close. (Provide time delay as described above).
5. Close smoke dampers in supply and exhaust ductwork. This can be done either by using E-p switch at supply fan starter or by using an E-p switch at each floor wired from same zone.

4.11 CONTROL OF SMOKE DAMPERS

A. Provide a normally closed automatic damper in each duct crossing a smoke barrier, as indicated on the Drawings, at the point where the duct crosses the barriers and at supply fan discharge. Whenever supply fan stops, smoke damper at the fan discharge shall close. Provide one minute time delay to prevent fan start-up until smoke damper has opened and 20 second time delay to prevent damper from closing until fan stopped. All smoke dampers on each floor, shall be connected to E-p switches on that floor, which shall close the dampers when deenergized by the smoke detection system provided under Division 16. E-p switches shall be 1/4", 3-way air valve, connected to the damper air piping system. Provide one-minute time delay to prevent fan start-up until its respective smoke dampers have opened, and 20-second time delay to prevent dampers from closing until fan has stopped. E-p switch shall be furnished under this Section of the specifications.

4.12 VARIABLE FREQUENCY DRIVES

A. The BACS shall provide for seamless integration with the control of the VFDs and associated systems. The interface shall be hardwired (point-by-point wiring to applicable terminations on the drives interface board) for start/stop, status and speed signals. The status shall be determined via contacts from the drive. The drive specification must be coordinated to ensure that the status contacts are available and are a true feedback indication that the motor is running. The speed signal shall be 0-10VDC. Digital communications via a controller LAN shall be used to gather all other available diagnostic information.

4.13 MOTOR STARTERS

A. An HOA switch shall be provided with the starter. In the hand position the motor shall start and run continuously unless a safety device trips; in the off position the motor shall stop; in the auto position the BACS shall control the motor per described sequences of operation.

B. Status shall be monitored by the BACS, preferably with a current sensor. Motor status shall be monitored via an adjustable de-bounce time. The BACS shall annunciate a “failure” alarm whenever the motor is commanded to run and status is not proved within an adjustable de-bounce time. In the failure mode, the run command shall remain, except on headered systems for which the run command will be removed requiring manual acknowledgement. In no case shall a loss of status coincident with a loss in power be alarmed as a failure. The BACS shall include controller arrangement and/or points or programming as required to accomplish the above.

4.14 COILS

A. General

1. Coils shall generally be controlled by a modulating valve and include a temperature sensor immediately downstream of the coil before any other coil or heat transfer element. Coil selection must be coordinated with the control design and valve selection to ensure stable control particularly at light loading conditions.

2. When heating and cooling coils are included in one supply system, programming shall prohibit simultaneous heating and cooling operation (unless required for dehumidification) and smoothly sequence the coils as loading changes. All control valves shall have dedicated analog outputs. Coil control programming shall be coordinated with all other elements that affect the temperature of the supply air to minimize the energy use.

3. Generally, sensors within an air handler shall be averaging unless they are after a well-mixed condition such as downstream of a fan.

4. Provide an alarm if there is an air temperature difference across the coil the control valve is commanded closed.

5. The discharge air temperature shall be reset in ventilation-driven systems to minimize cooling and reheat as follows:

   OAT 75 °F & above => DAT = 55 °F
   OAT 55 °F & below => DAT = 65 °F

B. Heating Coils

1. Heating coil control valves shall be sized for smooth and stable control.
2. Control valves on heating coils provided with a supply air handler shall close when the system is off.

4.15 DDC SYSTEM POINTS LIST

A. General: Provide individual inputs or output for each point listed in the points list (See Appendix). Provide any additional points not listed in the points list, but required to meet the sequences of operation, at no additional cost to the owner. All analog outputs shall be 4-20mA, 0-10VDC, or 0-20VDC unless otherwise indicated. AO = Analog Output; AI = Analog Input; DO = Digital (binary) Output; DI = Digital (binary) Input.

B. Points types include the following:

1. Binary Input (BI)/Digital Input (DI): An on/off indication that has a maximum cycle rate of 1 Hz. This is typically sensing a contact closure.
2. Binary Output (BO)/Digital Output (DO): A contact closure on the controller that will cause an action in the system.
3. Binary Value (BV)/Digital Value (DV): A network-visible binary point whose value is determined by a controller computation.
4. Analog Input (AI): A continuously varying voltage or amperage signal that is varied by a sensor in relation to a sensed variable. This signal is processed in the controller after an analog-to-digital converter on the controller that converts the analog signal to a digital value.
5. Analog Output (AO): A continuously varying voltage or amperage signal that is generated from the controller after digital-to-analog conversion. The voltage or amperage signal will be used, for instance, to drive a modulating actuator or reset a hardwired setpoint on a packaged device.
6. Analog Value (AV): A network-visible analog point whose value is determined by a controller computation.

7. Pulse-Width-Modulated Output (PWM): A time-based algorithm converts a standard BO into a modulating signal. Based on the duration of the pulse, the recipient of the signal positions the device proportional to the duration of the pulse.
8. Pulsed Input (PI): A binary input with increased cycle rate capabilities, capable of directly counting and buffering pulses that may emanate from a metering

device.

4.16 MISCELLANEOUS DDC CONTROL

A. See the points list for additional required alarm and status points which shall be monitored by the BMS.

B. The following points/alarms shall be monitored and displayed on the BMS:

1. Status of the Emergency Ventilation/Exhaust fan.
2. Refrigerant monitor alarms.
3. Status Emergency stop switches
4. Status Emergency ventilation switches
5. Loss of power at the refrigerant monitor.

C. Reference mechanical equipment schedules (especially "fans") for additional control sequences.

4.17 MISCELLANEOUS NON-DDC CONTROL

A. Chemical Treatment: Provide required field wiring interlocks.

END OF SECTION

SECTION 23 21 13

HYDRONIC PIPING AND ACCESSORIES

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK

A. This Section covers water piping carrying water at 200ºF or less, used in the following systems:

1. Heating system
2. Cooling system
3. Condensate drain system
4. Condenser water system

1.2 SUBMITTALS

A. Submit manufacturer's product data on the following:

1. Pipe
2. Accessories

PART 2 - PRODUCTS

2.1 GENERAL

A. All pipe shall be new, free from scale or rust, of the material and weight specified under the various services. Each length of pipe shall be properly marked at the mill for proper identification with name or symbol of manufacturer.

B. All steel piping, except where otherwise rated, shall be standard or extra strong weight, in conformance with the ASTM A-53 Grade B seamless.

C. All brass piping shall be standard or extra heavy weight 85% red brass semi-annealed seamless-drawn, in conformance with the ASTM B-43, as manufactured by Anaconda, American Brass Co., Chase Brass and Copper Co., or Revere Copper and Brass, Inc.

D. All copper tubing shall be of weight as required for service specified, with conformance with ASTM B-88 for Type "L" and "K" tubing, as manufactured by Chase, Anaconda, Revere, or approved equal. Tubing and fittings shall be thoroughly cleaned with sand cloth and treated with an approved non-corrosive flux before solder is applied.

E. All galvanized steel piping shall be standard or extra strong weight, as specified, in conformance with the ASTM A-53 Grade B. Pipe shall be hot-dripped zinc-coated with Prime Western smelter and not wiped.

F. Fittings shall be of material conforming to the following schedule:

1. Malleable Iron Fittings ASTM A-197
2. Cast-Iron Fittings ASTM A-126
3. Brass Fittings ASTM B-62
4. Solder Fittings ASTM B-88
5. Steel Welding Fittings ASTM B16.9.
6. Wrought Copper ASTM B16.22

G. Dielectric Fittings: Install dielectric nipple, coupling or flange, to prevent galvanic action between ferrous and non-ferrous piping. Dielectric fittings shall be accessible for inspection and service. Provide dielectric fittings at all connectors to dissimilar metals, including at air handling unit coil connections.

H. All fittings used at expansion loops or bends shall be extra heavy.

I. Cast-iron, malleable-iron, and bronze fittings shall be of Crane manufacturer or approved equal.

J. Flanges shall be raised face, of the same weight as the fittings in each service category. All flanges shall be drilled to "US Standard" hex nuts and washers. Bolting shall conform to ASTM 193 Grade B-7, threads Class 7 fit. Nuts shall be semi-finished hexagonal, ANSI B18.2 ASTM A194 Grade 2H.

K. Provide permanent signage on expansion tank of hydronic systems treated with chemicals that include the chemical type, concentration system volume and direction to drain to sanitary drain.

2.2 PIPE AND FITTINGS

Piping Types and Materials				
Service & Location	**Pipe Size**	**Pipe Material & Weight**	**Joint Type**	**Fitting Material**
Heating Hot Water (<250°F)				
Inside Building	3" or smaller	Copper, Type L, ASTM B88	Soldered, below 175 PSI, Brazed above 175 PSI	Wrought Copper
Outside Building	3" or smaller	Copper, Type L, ASTM B88	Soldered, below 175 PSI, Brazed above 175 PSI	Wrought Copper
Chilled Water, Brine				
Inside Building	3" or smaller	Copper, Type L, ASTM B88	Soldered, below 175 PSI, Brazed above 175 PSI	Wrought Copper
	4" or larger	Steel, Schedule 40, ASTM A53, Type S, Grade B	Welded	Steel

Condenser Water				
Inside Building	3" or smaller	Copper, Type L, ASTM B88	Soldered, below 175 PSI, Brazed above 175 PSI	Wrought Copper
	4" or larger	Steel, Schedule 40, ASTM A53, Type S, Grade B	Welded	Steel
Outside Building	3" or smaller	Copper, Type L	Soldered, below 175 PSI, Brazed above 175 PSI	Wrought Copper
	4" or larger	Steel, Schedule 40, ASTM A53, Type S, Grade B	Welded	Steel
Air Conditioning Coil Condensate				
All Locations	All Sizes	Copper, Type M, Drawn, ASTM B88	Soldered	Wrought Copper

2.3 WELDING PIPING AND FITTINGS

A. All fittings for welded piping shall be as manufactured by Tube Turn, Anvil, Bonney Forge or equal as approved by the Architect. The fittings shall be of the same weight and material as the piping to which they are attached.

B. For piping 3” and larger, full size branch connection shall be made with manufactured welding tees, branch connections for less than full size, shall be made with welding tees or with Weldolet forged branch outlet fittings. Fishmounting, shaped nipples, and stubbing not permitted.

C. Welding outlet fittings shall be Weldolets as manufactured by Donney Forge, Inc., or approved equal 2 or 3 and smaller branches shall be made with thredolets as made by Bonney Forge or approved equal.

D. Welding fittings shall be of the same material and schedule as the pipe to which they are welded. Welding elbows shall be long radius pattern unless clearance conditions necessitate the use of standard radius pattern. Welding fittings shall be as made by Tube-Turn.

E. All flanges shall be welding neck flanges ANSI B16.5 ATM 181 Grade I. All systems, except where otherwise noted - 150 lbs. Class, forged steel.

2.4 STRAINERS

A. Manufacturers:

1. Design Basis: Armstrong
2. Other Acceptable Manufacturers:
   a. Mueller
   b. Sarco
   c. Hoffman

d. Dunham Bush

B. Size 2” and Smaller: 250-lb cast iron, threaded.

C. Size 2½” and Larger: 125-lb cast iron, flanged.

D. Screens:

1. Final Screen:
   a. Material: Type 304 stainless steel.
   b. Perforations: 0.045” diameter, 233 holes per square inch.
2. Roughing Screen:
   a. Material: Carbon steel.
3. Provide roughing screens at all circulation pumps and at any additional strainers upstream of primary plant equipment such as boilers, chillers, etc.
4. Screen shall be removable without removing piping.

2.5 EXPANSION TANKS

A. Manufacturers:

1. Design Basis: As scheduled
2. Other Acceptable Manufacturers:
   a. Amtrol
   b. ITT Bell & Gossett
   c. Taco
   d. GFC Corp
   e. J.J. Finnigan
   f. Woods
   g. Wessels

B. Type: Bladder

C. Design Temperature: Per schedule

D. Maximum working pressure: Coordinate with pressure of system

E. Design pre-charge pressure: Same as boiler make-up water PR fill valve.

F. Bladder or Diaphragm Material: EPDM, compatible with propylene glycol.

2.6 AIR PURGERS

A. Manufacturers:

1. Design Basis: Bell & Gossett
2. Other Acceptable Manufacturers:
   a. Amtrol
   b. Taco

c. Thrush

B. Model: 107

C. Float actuated, non-modulating, rated at 250 psig at 250ºF.

2.7 AIR VENTS

A. Manufacturer:

1. Design Basis: Amtrol
2. Other Acceptable Manufacturers:
   a. Bell & Gossett
   b. Taco
   c. Thrush
   d. Armstrong

B. Resilient Parts: EPDM

C. Vents on Pipes Size 2” and Smaller: Model 706

D. Vents on Pipes Size 2½” and Larger: Model 706

E. Vents on Air Purgers: Model 706

F. Provide manual air vents on system high points located in finished spaces and on all systems that contain glycol.

G. Provide automatic air vents on water system high points located in unfinished spaces.

2.8 PRESSURE REDUCING FILL VALVES

A. Manufacturers:

1. Design Basis: Bell & Gossett
2. Other Acceptable Manufacturers:
   a. Taco
   b. Thrush
   c. Watts

B. Size: ¾”- for systems up to 300 gallons
1” - for systems larger than 300 gallons

C. Model:

1. 8 psig to 25 psig: No. 12
2. 25 psig to 60 psig: No. 7

2.9 PRESSURE TEMPERATURE TAPS

A. Manufacturers:

1. Design Basis: Sysco
2. Other Acceptable Manufacturers:
   a. Universal Lancaster, Inc.
   b. Petes Plug

B. Model: BNO-500, ¼” NPT, or ½” NPT.

C. Construction:

1. Body and Cap: Brass
2. Pressure: 500 psig
3. Temperature: 350ºF
4. Core: Hot water – EDPM, Glycol – EPDM, Chilled Water – Neoprene, Cold Water - Neoprene
5. Cap: Gasketed, threaded.

D. Thermometer:

1. Number required: 1
2. Dial diameter: 2”
3. Range: 0º to 220º

E. Pressure Gauge Adapter:

1. Number required: 1
2. Model: GA-125

F. Pressure Gauge:

1. Number required: 1
2. Dial diameter: 4½”
3. Range: 0 to 100 psig
4. Accuracy: ½%

G. Provide manual vents (accessible from floor) piped to sinks or floor drains for all glycol systems. This may result in significant lengths of pipe.

2.10 THERMOMETERS

A. Manufacturers:

1. Design Basis: American, Trerice
2. Other Acceptable Manufacturers:
   a. Ernst
   b. Marsh

c. Marshalltown
d. Weksler
e. Weiss

B. Housing: 9” adjustable angle stem.

C. Tube: Lens front, red liquid.

D. Range:

1. Chilled water, brine, condenser water, 0ºF to 100ºF.
2. Condenser water: 0 ºF to 120 ºF.
3. Dial thermometers shall be 5 inch hermetically sealed, bimetal with stainless steel cases, antiparallax dials with raised jet black figures, stainless steel stems, and brass separable sockets unless otherwise specified. Thermometers for duct mounting shall have union connections in lieu of separable sockets. Separable wells shall be stainless steel for steel pipe and brass for copper pipe. Separable wells shall be standard type for uninsulated pipe and locking extension type of proper length for insulated pipe. Stem shall extend a minimum of 2-1/2” into the fluid.

E. Thermometers for duct mounting shall have union connections in lieu of separable sockets. Separable wells shall be stainless steel for steel pipe and brass for copper pipe. Separable wells shall be standard type for uninsulated pipe and locking extension type of proper length for insulated pipe. Stem shall extend a minimum of 2-1/2” into the fluid.

F. The accuracy of all thermometers shall be within 1% of the scale range.

G. Thermowells: All thermowells for steam service shall be stainless steel and for water service shall be brass. Thermowell length shall be in accordance with ISA standards and shall include the appropriate extension to allow for pipe installation. Extension neck shall be included when required to match thermowell and insulation thickness.

H. Locking adjustable angle body and a case of aluminum or non-metallic material. Thermometer shall be secured to well by tapered bushing and not by set screws. Provide the following characteristics:

1. Scale Graduations: 2˚F.
2. Range: Select to provide a mid-scale reading at normal operating temperature.
3. Accuracy: 1%.

I. Industrial light-powered digital thermometer with adjustable-angle stem and a case of aluminum or high impact ABS plastic. Thermometer shall be secured to thermowell by tapered bushing and not by set screws. Installation shall insure that thermometer is accessible and has been adjusted to be readable from a 5-foot level as viewed from the floor. Display shall be LCD with digits a minimum of 0.5-inch high with the following characteristics:
1. Resolution :0.1 °F.

2. Range; -40 to 300 °F.
3. Sensor: Glass passivated thermistor.
4. Accuracy: 1%

J. Acceptable Manufacturers

1. Trerice
2. Weiss Instruments
3. Weksler

2.11 PRESSURE GAUGES

A. Design Basis: Trerice

1. Other Acceptable Manufacturers:
   a. Ernst
   b. Marsh
   c. Marshalltown
   d. Winters
   e. U.S. Gauge
   f. Weksler
   g. Ashcroft
   h. Or approved equal.

B. Model: 800LF Series. Liquid filled.

C. Dial Face 4½ inch diameter; 270º arc.

1. Range: As required to keep normal operating point in mid 2/3 to ¾ of dial.
   a. Use 30" vacuum to 100 psi gauge for pumps designed to operate at pressures up to 75 psig total pressure. (Total pressure = required pump-off static pressure plus scheduled pump head).
   b. High pressure steam: 0 to 200 psig.
   c. Chilled water: 0 to 100 psig.
   d. Brine water: 0 to 100 psig.
   e. Condenser water: 0 to 100 psig.
   f. Hot water: 0 to 100 psig.
   g. Discharge side of water pressure reducing valve: 0 to 100 psig.
   h. Low pressure valve: 0 to 30 psig.

2. Use higher pressure ranges as required such that scheduled total pressure does not exceed an operating point above ¾ range of dial.

D. Accuracy: 2% of full scale over middle of range.

E. The gauges shall have silicone filled stainless steel casings with chrome plated bezels or rims. The gauges shall have white faces with black filled engraved numerals and adjustable pointer. The diameter of the dial shall not be less than 4-1/2 inches. Gauges shall have brass bronzed brushed rotary type movement.

F. Provide isolating ball valve, not a gauge cock.

2.12 POT FEEDERS

A. Manufacturers:

1. Design Basis: H-O-H
2. Other Acceptable Manufacturers:
    a. Dearborn

B. Model: HV

C. Size: 2 gal.

2.13 RELIEF VALVES

A. Manufacturers:

1. Design Basis: Bell & Gossett
2. Other Acceptable Manufacturers:
    a. Taco
    b. Thrush
    c. Watts

B. Type: ASME

C. Size: Maximum input capacity of system at design pressure.

D. Setting: Operating pressure of system plus 2 psi.

2.14 PROPYLENE GLYCOL

A. Manufacturers:

1. Design Basis: Dow Chemical Company

2. Other Acceptable Manufacturers:
    a. Dupont

B. Model: Dowfrost

C. Type: Propylene Glycol based with corrosion inhibitors.

2.15 ETHYLENE GLYCOL

A. Manufacturers:

1. Design Basis: Dow Chemical Company
2. Other Acceptable Manufacturers:
    a. Dupont

B. Ethylene Glycol based with corrosion inhibitors.

2.16 VENTURIS

A. Manufacturers:

1. Gerand
2. Barco
3. Presso

B. Identification:

1. Provide engraved metal tag indicating Beta Ratio or flow curve.
2. Hang on chain to clear insulation.

C. Size:

1. Select Beta ratio to provide 10” to 30” water gauge meter reading.

2.17 FLEXIBLE PIPE CONNECTORS

A. Manufacturers - Design Basis: Mason

1. Other Acceptable Manufacturers:
    a. Metraflex
    b. Flexonics
    c. Victaulic
2. Model: MFTNC, Twin Sphere 225 psi.

B. Pipe Alignment Guides:

1. Manufacturers - Design Basis: Flexonics
2. Other Acceptable Manufacturers:
    a. Adsco

b. Keflex
3. Model: PG
4. Material:
a. Spider: Steel for steel pipe, bronze for copper tubing.
b. Ring: Steel
c. Travel: 3"

C. Victaulic Style 177, 75, or 77 flexible couplings may be used in lieu of flexible connectors for vibration isolation and noise reduction at equipment connections. Three (3) couplings, for each connector, shall be placed in close proximity to the source of vibration.

2.18 SLEEVES

A. Steel-Pipe Sleeves: Fabricate from Schedule 40 steel pipe. Remove burrs.

B. Iron-Pipe Sleeves: Fabricate from service weight cast-iron pipe. Remove burrs.

C. Sheet-Metal Pipe Sleeves: Fabricate from galvanized sheet-metal, closed with lock-seam joints.

1. For following pipe sizes, provide gauge indicated:
a. Three Inch Pipe and Smaller: 20 gauge
b. Four Inch to Six Inch Pipe: 16 gauge
c. Over Six Inch Pipe: 14 gauge

PART 3 - EXECUTION

3.1 INSPECTION

A. Contractor shall examine location where these specialties are to be installed and determine space conditions and notify Architect in writing of conditions detrimental to proper and timely completion of the work.

B. Do not proceed with the work until unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install HVAC Specialties where shown, in accordance with manufacturer's written instructions and with recognized industry practices, to ensure that HVAC Specialties comply with requirements and serve intended purposes.

B. Coordinate with other work as necessary to interface installation of HVAC Specialties with other components of systems.

C. All coils and heat exchangers shall be equipped to measure and adjust flow. Adjustable valves with flow measuring taps are preferred. The balancing valve shall not be used for coil isolation--provide ball or butterfly isolation valves in addition to the balancing valves.

3.3 FIELD QUALITY CONTROL

A. Upon completion of installation of HVAC Specialties, test HVAC Specialties to demonstrate compliance with requirements. When possible, field correct malfunctioning units, then retest to demonstrate compliance. Replace units which cannot be satisfactorily corrected.

3.4 PIPE INSTALLATION

A. Install horizontal piping level (except drain piping and as otherwise noted) and parallel to building construction. All vertical piping to be plumb.

B. Make any changes in direction with fittings, do not kink or bend piping. Elbows are to be long radius type wherever possible.

C. Regardless of how shown on schematic piping diagrams, do not install a tee so that flow enters from opposite directions.

D. Do not rearrange piping in a manner to increase pressure drop without written approval from Architect/Engineer.

E. Install drains with cap and brass hose connector at all low points and traps of the system.

F. Vent piping from the high temperature hot water system shall comply with all requirements of high temperature hot water piping specified herein before. This shall also apply for the high temperature water safety valve discharge piping.

G. General:

1. Install pipe, tube and fittings in accordance with recognized industry practices which will achieve permanently-leakproof piping systems, capable of performing each indicated service without piping failure.
2. Install each run with a minimum of joints and couplings, but with adequate and accessible unions for disassembly, maintenance or replacement of valves and equipment.
3. Reduce sizes by use of reducing fittings.
4. Install piping without springing or forcing.
5. Provide sufficient swing joints, anchors, expansion loops and devices necessary to permit free expansion and contraction without causing undue stresses.
6. Support piping independently at equipment so its weight will not be supported by the equipment.
7. Support piping to maintain a consistent slope as indicated on the drawings without sagging or pocketing of any kind. Where not otherwise indicated, all horizontal piping shall slope a minimum of 1/16 inch per foot to drain at system low points.

8. Provide air vents at high points of all pumped piping systems. Provide drains at all low points and traps.
9. Install horizontal piping parallel to building construction, make any changes in direction with fittings.

H. Location:

1. Locate piping runs, except as otherwise indicated, both vertically and horizontally to allow for complete drainage of piping system (pitched to drain).
   a. Avoid diagonal runs wherever possible.
   b. Orient horizontal runs parallel with walls and column lines.
2. Hold piping close to walls, overhead construction, columns and other structural and permanent-enclosure elements of the building.
   a. Limit clearance to 0.5” where furring is shown for enclosure or concealment of piping, but allow for insulation thickness, if any.
   b. Where possible, locate insulated piping for 1.0” clearance outside insulation.
3. Wherever possible in finished and occupied spaces, conceal piping from view by locating in column enclosures, in hollow wall construction or above suspended ceilings.
   a. Do not encase horizontal runs in solid partitions, except as otherwise indicated.

I. Electrical Equipment Spaces: Do not run piping through transformer vaults and other electrical or electronic equipment spaces and enclosures.

1. Exception: where shown on drawings or where accepted by the Engineer, provide drip pan under piping, and conform to NEC.
2. In no case shall piping run directly above transformers, electrical panels or switchgear.

J. Unless otherwise specified, all flanged joints shall be fitted with Manville or equal ring gaskets designed for the intended service.

K. Coordinate with other work as necessary to interface installation of piping with other components of systems.

L. Provide and erect in a workmanlike manner, according to the best practices of the trade, all piping shown on the Drawings or required to complete the installation intended by these Specifications.

M. All piping taps shall be from the top of the pipe unless approved by the Engineer.

N. The Drawings indicate schematically the size and location of piping. Piping shall be set up and down and offset to meet field conditions and to provide adequate maintenance room and headroom in the Mechanical Rooms.

O. Study the General Construction Specifications and Plans, of the exact dimension of finished work and of the height of finished ceilings in all rooms where radiation, units, equipment or pipes are to be placed and arrange the work in accordance with the Schedule of Interior Finishes, as indicated on the Architectural Drawings.

P. All exposed piping shall be run perpendicular and/or parallel to floors, interior walls, etc. Piping and valves shall be grouped neatly and shall be run so as to avoid reducing headroom or passage clearance. All valves, controls and accessories concealed in furred spaces and requiring access for operation and maintenance shall be arranged to assure the use of a minimum number of access doors.

Q. All pipe lines made with screwed fittings must be provided with a sufficient number of flanges or unions to make possible any taking down of the pipes without breakage of fittings.

R. All piping shall be erected as to insure a perfect and noiseless circulation throughout the system. No bull head tees will be permitted.

S. All valves and specialties shall be so placed as to permit easy operation and access.

T. Provide proper provision for expansion and contraction in all portions of pipework, to prevent undue strains on piping or apparatus connected therewith. Provide double swings at riser transfers and other offsets wherever possible, to take up expansion. Arrange riser branches to take up motion of riser.

U. Approved bolted, gasketed, flanges (screwed or welded) shall be installed at all apparatus and appurtenances, and wherever else required to permit easy connection and disconnection. Screwed unions shall be used on piping 2 ½ " or less.

V. All piping connections to coils and equipment shall be made with offsets provided with screwed or welded bolted flanges so arranged that the equipment can be serviced or removed without dismantling the piping.

W. If, after plant is in operation, any coils or other apparatus are stratified or air bound (by vacuum or pressure), they shall be repiped with approved and necessary fittings, air vents, or vacuum breakers at no extra cost. If connections are concealed in furring, floors, or ceilings, bear all expenses of tearing up and refinishing construction and finish, leaving same in as good condition as before it was disturbed.

X. Fittings shall be of the eccentric reducing type, where changes of size occur in horizontal piping to provide for a proper drainage or venting. Steel pipe bends shall be made of the very best grade open hearth, low carbon steel, leaving uniform exterior and interior surface. Pipe bends shall be made with seamless steel pipe, having a minimum radius of not less than five (5) pipe diameters.

Y. Tubing shall be erected neatly in a workmanlike manner. Bends in soft copper tubing shall be made by benders to prevent deformation of the tubing in the bends. Approved seat-to-pipe threaded adapters shall be provided for junctions with valves and other equipment having threaded connections.

Z. Vertical sections of main risers shall be constructed of pipe lengths welded together. No couplings shall be used.

AA. The ends of all pipe and nipples shall be thoroughly reamed to the full inside diameter of the pipe and all burrs formed in the cutting of the pipe shall be removed.

BB. Piping shall be installed in accordance with the latest edition of the ASME Code for Pressure Piping.

CC. All piping shall be concealed above furred ceilings in rooms where such ceilings are provided (except where specifically indicated otherwise on the drawings, or in walls or partitions, except as otherwise indicated).

DD. Piping at all equipment and control valves shall be supported to prevent strains or distortions in the connected equipment and control valves. Piping shall be supported to allow for removal of equipment, valves and accessories with a minimum of dismantling and without requiring additional supports after these items are removed.

EE. Pipe nipples - Any piece of pipe 3" in length and less shall be considered a nipple. All nipples shall be extra heavy. Only shoulder nipples shall be used. No close nipples will be permitted.

FF. Screw threads shall be cut clean and true; screw joints made tight without caulking. No caulking will be permitted. A non-hardening lubricant shall be used. No bushings shall be used. Reductions, otherwise causing objectionable water or air pockets, to be made with eccentric reducers or eccentric fittings.

GG. Provide vents with hose connector and cap at all high points.

3.5 WELDING

A. Before any operator shall perform any pipe welding, also submit the operator's qualification record in conformance with provisions of the code having jurisdiction, showing that the operator was tested and certified under the Procedure Specification as before mentioned.

B. Welding:

1. Conform to the latest revision of the applicable code, whether it is the ASME Boiler and Pressure Vessel Code, Code for Pressure Piping ANSI B31, or such state or local requirements as may supercede codes mentioned above.
2. All pipe welding operators shall comply with the requirements of the American Welding Society.
3. Machine cut and bevel piping ends for v-type joints.

4. Use recommended bevels and spacing between ends of pipe to assure full penetration complete to inside diameter of pipe.

C. Welded Joints:

1. Will be observed visually by the Architect/Engineer.
2. Any weld judged defective from a visual observation, shall be ordered tested at the expense of the Contractor or chipped out for full depth and re-welded.
3. Welded joints shall be x-rayed at a frequency determined by ASME codes. Welds that prove deficient shall be chipped out to full depth and replaced.

D. Welding Fittings:

1. Unless otherwise noted, make all changes in direction and branch take offs with manufactured fittings.
    a. Use long radius (R=1.50) fittings wherever possible.

2. Shop Fabricated Fittings:
    a. Branches more than two pipe sizes smaller than main line may be made with “weld-o-let” type pre-manufactured saddle fittings.
    b. Where specifically allowed by the Engineer, angles of less than 22½º and branch piping from headers may be made by shop fabricated or manufactured metered fittings.
    c. Submit shop drawings.
    d. Thoroughly clean fittings to remove slag.
    e. Fittings shall be available for observation by the engineer prior to installation.
3. In no case will field made miters or weld-o-let fittings be allowed. Exception: Temperature control wells and water treatment taps may be made with weld-o-let fittings in pipe 3” or larger in diameter.

E. Installation

1. Weld ells shall have a center line radius not less than diameter of the pipes.
2. Instrumentation connections 3/4" and smaller on all systems shall be provided by welding threaded 2000# forged steel half couplings to the pipe.
3. All pipe to be welded shall be cut off clean and beveled. All welding shot shall be removed.
4. Composition of welding electrodes shall be in accordance with manufacturer's recommendations.
5. Assume responsibility for the quality of welding done and repair or replace any work not in accordance with these specifications.
6. Cut weld test plugs at locations selected at random by the Architect. The test plugs shall be tested by the testing agency approved for this project. Failure of the test plugs to meet the standards of the specified codes and agencies shall result in the complete removal and replacement of the joint and retesting of the operator who performed the welding. The removal and replacement of the joints shall be at no additional cost to the Owner.

3.6 COPPER TUBING JOINTS AND FITTINGS

A. Unless otherwise noted, make all couplings, changes in direction, branch outlets, and transitions to other materials or joining methods with standard manufactured fittings.

B. Do not expand or swage piping in lieu of proper solder fittings.

C. Do not extrude or “pull” branch outlets with “tee-drill” type equipment.

D. Do not use self tapping type branch outlets.

1. See “hot taps” below.

3.7 THREADED JOINTS AND FITTINGS

A. All threaded joints shall be made in accordance with American National Standard B2.1.

1. Do not overthread pipe.
2. Apply pipe joint compound on male threads only.
3. Do not use right and left hand threaded joints to make a “union”.

B. Do not thread steel pipe schedule 10 or lighter.

1. UL listed light wall pipe may be threaded in accordance with its listing.

C. Screwed Piping

1. All connections to apparatus with screwed piping shall be made with 250 pound brass seat unions.
2. All screwed nipples shall be Schedule 80 nipples.

3.8 EQUIPMENT CONNECTIONS

A. Do not allow weight of piping or expansion of piping to put stress on equipment connections.

B. Pipe equipment to allow for servicing (coil pull, tube pull, etc.) with minimum of disruption to piping.

C. Provide unions or flanges at all equipment connections.

3.9 FREEZE PROTECTION

A. Fill systems with indicated solution by volume of ethylene/propylene glycol and water.

B. Pre-mix all solutions before injection into system.

3.10 AIR VENTS

A. Install automatic air vents at high points.

B. In installing water piping systems and all equipment, carefully plan the actual installation in such a manner that high points and air pockets are kept to a minimum and are properly vented where they are unavoidable. All air elimination devices called for on the Drawings and in these Specifications shall be provided and properly installed. In addition, furnish and install all other air elimination devices which may be required due to job conditions. Assume responsibility for a proper, continuous and automatic air elimination to assure even and balanced distribution of water to all equipment.

3.11 RELIEF VALVES

A. Install pressure relief valves on all vessels, which may be isolated from other relief valves by closing valves. Pipe discharge full size to nearest floor drain.

3.12 PRESSURE TEMPERATURE TAPS

A. In Pipes 2” and Smaller: Install taps in tee at change in direction so inserted thermometer stem will be parallel to center line of pipe.

1. Add extra change in direction if necessary.
2. Allow clearance for insertion of thermometer.
3. Insure that gauge or thermometer will be in a readable position.

B. Furnish and install in each supply and return runout to each reheat coil and where indicated on the Drawings, a 1/4" MPT fitting to receive either a temperature or pressure probe 1/8" OD. Fitting shall be solid brass with valve core of Nordel (Max. 275˚F), fitted with a color coded and marked cap with gasket, and shall be rated at 1000 psig.

C. In addition, the installing contractor shall supply the Owner with six pressure gauge adapters with 1/8" OD probe and 6 five inch stem pocket testing thermometers; 25-125˚F for chilled water and six 50-500˚F for hot water.

D. Provide one pressure and temperature test kit consisting of one 0-60 PSI, water pressure gauge and one 0-30 psi water pressure gauge each with no. 500 gauge adapter attached, a 25-120˚F pocket testing thermometer, a 0.220 F. pocket test thermometer, a No. 500 gauge adapter, and a protective carrying case. Provide one additional 0-60 psi pressure gauge and one additional 0 - 30 psi pressure gauge.

E. Test kit shall be used by the Balancing Contractor to balance the systems and then it shall be turned over to the Owner.

F. Test stations and test kit shall be manufactured by Paterson Engineering Company, Inc. or approved equal.

3.13 HOT TAPS

A. Installing a branch line in piping while under service or static pressure (hot taps) shall only be done where specifically authorized

B. Submit the proposed method of procedure for each fluid service and pipe material.

1. Hot tap procedure shall remove a plug of main tap material and retrieve it. The plug shall be a maximum of 1 pipe size smaller than the branch size. Hang the removed plug by a chain at the completed tap.
2. Hot tap procedure shall not affect the temperature or pressure rating of the piping system.
3. Hot tap procedure shall be done through a gate or ball valve.

3.14 CLEANING

A. All piping systems shall be thoroughly flushed out with the approved cleaning chemicals to remove pipe dope, slushing compounds, cutting oils, and other loose extraneous materials. This also includes any piping systems which are not listed as requiring water treatment.

B. Develop plan for flushing and cleaning piping. Submit plan for approval prior to completion of piping. Provide all temporary and permanent piping, equipment, materials necessary to complete flushing and cleaning.

C. Prior to flushing, temporarily isolate or bypass dirt sensitive equipment and devices, including the following:

1. Automatic flow control valves
2. Heating and cooling coils
3. Chillers
4. Heat Exchangers
5. Flow measuring devices

A full size bypass pipe with shut-off valve shall be installed at each piece of hydronic equipment, as noted above, and at the end of risers serving fan coil units and fin tube radiation.

D. Prior to flushing, install fine mesh construction strainers at inlet to all equipment with connections 2-1/2” and larger. Install fine mesh construction element in permanent strainers. During flushing and cleaning, remove and clean strainers periodically. At completion of final flush, clean permanent strainers, remove construction strainers.

E. Circulate flush water and clean strainers prior to installing cleaning chemicals. Following flushing, install cleaning chemicals and circulate through the entire system for a minimum of one hour, or as directed chemical supplier. Take water sample for owner’s use. Drain system, including all low points. Flush, drain and fill system, circulate for one hour, sample for owner’s use. Drain, flush, fill, circulate and sample until system is free of cleaning chemicals, as indicated by analysis of samples.

F. Clean all water piping and chiller tubes as follows:

1. All new equipment and piping needs to be pre-cleaned to remove the oils of manufacture prior to equipment start-up.
2. The cleaning of new systems is accomplished with an alkaline phosphate cleaner supplied by the water treatment supplier. Coordinate with the Chemical Water Treatment section of this specification.
3. Upon completion of a system cleaning, the system should be flushed until the ortho phosphate is within 1 PPM of City Water. If the flushing occurs over an extended period of time (more than 24 hours) the flush water shall be treated water.
4. The system should then be immediately sterilized and treated. Systems containing copper should boost azole levels to 20 PPM.
5. Systems that contain piping that cannot be isolated for alkaline phosphate cleaning must be cleaned by adding a surfactant for 48 hours to the system. This will help remove the oils of manufacture.
6. New chillers require the following cleaning:
   a. Remove both heads
   b. Punch tubes with reversible tube brushing machine with “Christmas Tree Brushes” and appropriate torque setting for specific tube size. Brushes shall be changed every 5-10 tubes.
   c. Inject alkaline phosphate cleaner into each tube during punching to remove oils of manufacture.
   d. Inspect a minimum of three cleaned tubes with boroscope to confirm removal of all oils. A minimum of one hot, one high flow, and one low flow tube must be inspected.
   e. Tubes shall not be left open to atmosphere for more than one week after exposure to water.
   f. Upon flooding of tubes, azole levels shall be bumped to 20 PPM to insure re-passivation of the copper.

G. After flushing, contractor shall remove all temporary strainers and hang on strainer bodies for inspection.

H. Chemical cleaning and flush water shall be circulated at a minimum velocity of 6 feet per second. Contractors are responsible to supply temporary pumps as required for circulation of water at requisite velocities. Use of system pumps for circulation of cleaning and flush water, where available, is acceptable.

I. The chemical supplier shall verify that all chemicals utilized during cleaning are compatible with the materials in the systems. The chemical supplier shall instruct as to the proper feed rates, shall check that the cleaning solution is actually in each system, shall instruct the contractor as to when to flush the system and shall check each system following flush to insure all cleaning chemicals have been removed from each system.

J. A certificate of cleaning shall be submitted by the cleaning chemical supplier to the Owner's representative.

3.15 CORROSION PROTECTION

A. Provide dielectric unions at unions between piping of different materials.

B. See water treatment program requirement elsewhere in this specification.

C. All components of system shall be compatible with propylene glycol and water solution.

D. At no time should water be introduced to a system without inhibitor being added.

E. Vapor phase inhibitor shall be used in any case where a system will be drained down prior to turnover.

3.16 PRESSURE GAUGES

A. Pressure/temperature test ports shall be provided on each coil bank, heat exchanger, fan coil, and at all permanent pressure gauge locations. Use extended body style to allow for insulation thickness. Seals shall be appropriate for operating water temperature and pressure as follows.

1. Cold Water, Brine Water, Chilled Water - Neoprene Seat

B. Pump assemblies: Use a single gauge with multiple taps to pumped system (strainer inlet, strainer outlet, pump suction and pump discharge) per the detail on the drawings.

C. Allow clearance for removal of gauge.

D. Insure that gauge will be in a readable position.

E. Furnish and install where indicated on the Drawings and where specified herein.

F. All gauges shall be installed so as to be easily readable from the floor. Where conditions are such that gauges on piping would not be readable from the floor, the gauges shall be installed on panelboards.

G. Panel mounted gauges shall be designed for flush mounting with back connections and shall be provided with an engraved nameplate mounted below each gauge to identify its service. The nameplates shall be chrome plated with black filled letters.

H. Differential pressure switches, pressure sensing pipe taps, furnished by temperature control manufacturers shall be installed under this Section.

I. All gauges on water lines shall be fitted with filter type pressure snubbers consisting of 3/8" dia. x 1/8" thick, micro metallic stainless steel filter, as manufactured by Operating and Maintenance Specialties or approved equal. All gauges on steam lines shall be fitted with pigtails.

J. A pressure gauge shall be installed in the suction and discharge of each pump. A pressure gauge shall be installed in the brine/chilled water and condenser water inlet and outlet of each refrigerating machine. A pressure gauge shall be installed in the inlet and outlet of each heat exchanger and coil. Additional pressure gauges shall be installed where indicated on the Drawings.

K. On devices such as pumps, strainers, coils, etc., where the differential pressure is the desired information, install only one pressure gauge with valved connections to the upstream and downstream pressure taps. Include a P/T test port in addition to the pressure gauge. Provide a second set of isolating valves at the gauge if gauge location is not within reach of tap points.

3.17 THERMOMETERS

A. Furnish and install, where indicated on the Drawings and where specified herein, thermometers as manufactured by American Trerice, Weksler, Weiss or approved equal.

B. All thermometers shall be installed in such a manner as to cause a minimum of restriction to flow in the pipes and so that they can easily be read from the floor.

C. All instrument wells for controls and indicators furnished by the temperature control manufacturer shall be installed under this Section.

D. Where conditions are such that thermometers would not be readable from the floor, remote bulb dial thermometers shall be mounted on panelboards. The thermometers shall be 5 inch dials and shall be vapor actuated. The thermometers shall have separable wells. Panel mounted thermometers shall be provided with an engraved nameplate mounted below each thermometer to identify its service. The nameplate shall be chrome plated with black filled letters.

E. A thermometer shall be installed in inlet and outlet of each heat exchanger and coil. A thermometer shall be installed in the brine water, chilled water and condenser water inlet and outlet of each refrigerator machine. Additional thermometers shall be installed where indicated on the Drawings.

3.18 MACHINERY GUARDS

A. Moving parts of machinery exposed to contact by personnel shall be guarded by barrier to a type which complies with OSHA Code.

B. Exposed moving parts such as belts and couplings shall have not less than 3/4" No. 16 gauge metal guards with all edges rounded an gauge, material and construction shall be in accordance with OSHA standards - paragraphs 7173.3, 7173.5 and 7174.1. Guards shall have 1-1/4" x 1-1/4" x 1/8" angle iron frame properly supported.

C. All machinery guards covering the ends of motor or equipment shafts shall have openings for the insertion of a tachometer. Machinery guards shall be painted with two coast of machinery gray enamel.

3.19 EXPANSION TANKS

A. Expansion tanks shall be welded, and of the size as indicated on the Drawings. Tanks shall be galvanized after fabrication. Tanks shall be steel with dished heads and equipped with connections for fill, drain and system connections. Water column and connections shall be furnished. Tanks shall be constructed in accordance with ASME Code for Unfired Pressure Vessels and so stamped.

B. Tanks shall be provided with gauge glasses for full height, and for closed tanks provide combination air charger and tank drainer. Gauge glasses shall have protective shield.

C. Furnish and install as shown on the Drawings, EX-TROL Pressurized Diaphragm Type Expansion Tanks as manufactured by AMTROL INC. It shall be air precharged to the initial fill pressure of the system. It shall be suitable for a maximum working pressure in excess of anticipated system pressure at maximum operating temperature and shall be furnished with ASME stamp and certification papers. It shall have a sealed-in elastomer diaphragm suitable for an operating temperature of 240°F. Horizontal tanks to be furnished with saddles for horizontal installation where applicable.

3.20 EXPANSION JOINTS, LOOPS, ANCHORS AND GUIDES

A. Provisions for expansion in piping mains, branches, and risers shall be made by the installation of offsets, expansion loops, or compensators as indicated on the Drawings or as required by these specifications. Every 100'-0" horizontal steam and hot water piping shall have expansion loop and anchors. Minimum loop shall be 8'-0" by 6'-0" if not indicated on the Drawings.

B. All piping with loops or compensators shall be anchored so as to throw all expansion toward the loops or compensators.

C. Guides shall be installed on both sides of each expansion loop and compensator. Guides shall be Flexonics pipe alignment guides or approved equal. Anchors and guides shall be secured to beams, columns or concrete slabs.

D. Pipe hangers and rollers are not considered guides.

E. Provide 12" long guides for each expansion joint. Guides shall be located 3'-0" on each side of the expansion joints.

F. Copper Piping: Furnish and install as shown on plans, or where necessary to absorb max. 1-3/4" expansion and max. 1/4" contraction between two anchor points in copper lines, up to and including 2-1/2", Flexonics Model HB Expansion Compensators having two-ply phosphor bronze bellows and brass shrouds and end fittings, as manufactured by Flexonics Division of Calumet and Heela, Inc., Bartlett, Illinois. All internal parts shall be of non-ferrous metals. Service pressure shall be external to the bellows.

Compensators shall have internal guide extending the full length of the bellows travel. Compensators shall have internal positive anti-torque devices to prevent twist or torque on installation and shall have properly located positioning clip to insure installation of correct end-to-end dimension to allow full rated traverse. Compensator shall be for max. 125 psig. working pressure. Test pressure shall not exceed 175 psig.

G. Steel Piping: Furnish and install as shown on plans, or where necessary to absorb max. 1-3/4" expansion and max. 1/4" contraction between two anchor points in iron and steel pipe lines up to and including 2-1/2", Flexonics Model II Expansion Compensators having two-ply stainless steel bellows and carbon steel shrouds and end fittings, as manufactured by Flexonics Division of Calumet & Heela, Inc., Bartlett, Illinois. Service pressure shall be external to the bellows. Compensators shall have properly located positioning clip to insure installation at correct end-to-end dimension to allow full rated traverse. Compensator shall be for Max. 150 psig. working pressure. Test pressure shall not exceed 200 psig.

H. Manufacturer shall note on all submittal forms the resultant anchor loads due to pressure thrust and compressive forces at design conditions. Expansion joints shall be as manufactured by ADSCO, Zallea, Flexonic, or approved equal.

3.21 STRAINERS FOR WATER SYSTEM

A. Furnish and install a full size Y-pattern strainer on the inlet of each control valve at each water pump and where indicated on the Drawings.

B. An approved blow-out connection with gate valve shall be made to each strainer. The valves shall be located not higher than 8 feet above the floors. All drain connections shall be piped to floor drains.

3.22 REDUCING AND SAFETY VALVES FOR WATER SYSTEM

A. Furnish and install pressure reducing and safety valves for makeup water systems and where indicated on the drawings.

B. The reducing valve shall be Model 7 pressure reducing valve with field adjustable setting as manufactured by Bell & Gossett or equal as approved by the Architect.

C. The safety valves shall be of size and capacity as indicated on the Drawings. The valves shall be made by Bell and Gossett or approved equal and shall have 150 pound raised face flange on the inlet and discharge for all sizes 2-1/2" and above 2" and below shall be screwed.

D. The safety valve shall be steel valves with stainless steel trim. The bonnet shall be enclosed and equipped with a packed lifting lever. The spring shall be carbon steel rated for 450˚F.

E. The vertical discharge line from the safety valves shall be installed as close to the safety valves as possible and piped to drain.

3.23 PIPE SLEEVES

A. Install pipe sleeves where piping passes through walls, floors, ceilings, roofs and structural members, except soil pipe penetrations through concrete slab on grade.

B. Where possible pour sleeve in place or grout.

C. Provide sleeves of adequate size, accurately centered on pipe runs, so that piping and insulation (if any) will have free movement in the sleeve in non-fire rated penetrations.

D. In fire rated penetrations, size sleeves such that the resulting annular space is in accordance with the application requirements of the fire stopping system. All above grade floor penetrations shall be considered to be fire-rated.

E. Install length of sleeve equal to thickness of construction penetrated, except extend floor sleeves 0.25” above floor finish and, where floor surface drains to a floor drain, extend floor sleeve 0.75” above floor finish.

F. Provide temporary support of sleeves during placement of concrete and other work around sleeves.

G. Provide temporary closure to prevent concrete and other materials from entering pipe sleeves.

H. Except as otherwise indicated, install steel pipe sleeves.

I. At interior partitions and ceiling, install sheet metal sleeves.

J. At exterior penetrations below grade, install iron pipe sleeves.

K. Seal exterior sleeve penetrations at grade weather tight.

L. Caulking:

1. Where water seal or sound seal, but not fire seal, is needed, (foundation walls, slab on grade): fiberglass backing and heavy bead of silicone caulking compound.
2. Where sleeve pierces a fire separation: Fire stop material in accordance with manufacturer’s directions and UL listing.

M. Install escutcheon plates at pipe sleeves where piping is exposed to view in occupied spaces of the building, on the exterior, and elsewhere as indicated.

N. Compensators: Install where shown or where required because piping arrangement does not provide sufficient flexibility.

1. Protect compensators from over-travel and over-stress during remaining installation and testing.

O. Flexible Connectors: Install at right angles to displacement. Install one end immediately adjacent to isolated equipment and anchor other end.

P. Guides: Install where shown and where required in accordance with expansion compensators published requirements. As a minimum, install one guide within four pipe diameters of compensator, and one guide 14 pipe diameters from first guide.

3.24 TEST

A. Hydronic piping systems other than ground source heat pump loop shall be hydrostatically tested at one and one half times the system design operating pressure unless a higher pressure is required elsewhere, but not less than 100 psi. The duration of each test shall be not less than 4 hours.

B. See additional requirements elsewhere in this specification.

END OF SECTION

SECTION 23 21 23

HVAC PUMPS

PART 1 - GENERAL

1.1 MOTOR HORSEPOWER

A. Do not increase or decrease motor horsepower from that specified without written approval from Architect/Engineer. See Section 23 05 01.

B. Select pumps so that for single pump application at a minimum, brake horsepower does not exceed motor horsepower at rating point, and does not exceed motor horsepower plus service factor on impeller curve at 125% rated flow. For parallel pump application motor horsepower shall be selected such that pump can operate at any point on the pump curve without overloading.

1.2 PARALLEL PUMP SELECTION

A. Select pumps for parallel pump application such that a single pump can operate and not exceed the end operating point of the pump curve.

1.3 SUBMITTALS

A. Manufacturers Product Data: Submit manufacturer’s product data on pumps.

1. Include pump curve and mark rating point. Also include single pump operating point for a parallel pump application.
2. Show maximum allowable operating temperature and pressure.
3. Note in red any deviations from specified construction.
4. Show impeller diameter indicate maximum impeller diameter for pump volute provided, and indicate if impeller is machined down.

1.4 SUBMITTALS

A. All pumps controlled by variable frequency drives shall have shaft grounding kits.

PART 2 - PRODUCTS

2.1 BASE MOUNTED END SUCTION

A. Manufacturers:

1. Design Basis: Bell & Gossett
2. Other Acceptable Manufacturers:
    a. Allis-Chalmers

b. Taco
c. Armstrong
d. Peerless
e. Aurora
f. Weinman

B. Design Conditions:

1. Pressure: 150 psig
2. Temperature: 225ºF

C. Construction:

1. Casing: Cast iron, with integral pedestal support.
2. Impeller: Bronze, statically and dynamically balanced.
3. Wear Ring: Bronze, Replaceable
4. Shaft: Steel with bronze sleeve or stainless steel.
5. Shaft Seal: Mechanical, carbon-ceramic, internally flushed.
6. Base Plate: Steel or cast iron. Integral drip pan on chilled water and waterside economizer service.
7. Drive: Flexible couple.
8. Bearings: Grease lubricated ball bearings. Bearing housing supported from base plate.

D. The casing and suction head of the pump shall be of cast iron material and end suction, vertical split type. Casing and suction head shall be equipped with 125# ANSI flanges. Pumps shall be assembled on heavy duty fabricated structural steel base plates, which bases must include drip rim with tapped drain connections, which shall be piped to nearest floor drain. The impeller shall be of the enclosed type and shall be bronze. The impeller shall be statically and hydraulically balanced and keyed to the shaft. Efficiency and unit maximum BHP shall be quoted and guaranteed. Maximum head shall occur at and only at the no flow condition. The shaft shall be of steel material and removable shaft and shall be stainless steel. Bearings shall be single row, ball type and lubricated.

E. Stuffing box housing shall be deep enough to allow for a single John Crane type (1) mechanical seal. Each pump shall be flexibly coupled to a motor, Class B, DP enclosure. A flexible coupling with coupling guard shall be used. Except where otherwise noted, bearings shall be grease lubricated. Seals to be capable to withstand system condition for water temperature chemical treatment content as hereinafter specified. Provide John Crane cyclone separator to insure clear water flushing of the seal faces.

F. Pumps shall have capacities as scheduled on the Drawings. Pumps shall be selected to operate at or near their point of peak efficiency thus allowing for operation at capacities of approximately 25% beyond design capacity. In addition, the design impeller diameter shall be selected so that the design capacity of each pump (GPM and TDH) shall not exceed 90% of the capacity obtainable with maximum impeller diameter at the design speed for that model or as approved.

G. Casings shall be provided with suitable steel lifting lugs and gauge tappings.

H. Pump shall be drawn down slightly on the foundation bolt nuts. Provide a form or dam around the contour of the bed plate. Pour grout through holes, provided for this purpose, in sufficient quantity to reach a level of 3/4" to 1" above the bottom of the bed plate. Allow grouting to set thoroughly, then proceed with pipe connections.

I. INLINE PUMPS (Vertical Motor)

Manufacturers:

1. Design Basis: Bell & Gossett
2. Other Acceptable Manufacturers:
    a. Armstrong
    b. Taco
    c. Allis Chalmers
    d. Dunham Bush
    e. Peerless
    f. Paco
    g. Aurora

J. Construction:

1. Pump Body: Cast Iron, Double or Single suction as shown on drawings. Provide mounting pedestal or bolt circle for flange where floor support is required.
2. Impeller: Bronze, enclosed.
3. Shaft: Steel with bonze sleeve or stainless steel.
4. Shaft Seal: Mechanical, internally flushed, carbon-ceramic.

PART 3 - EXECUTION

3.1 INSTALLATION

A. General:

1. Install pumps to allow complete removal without dismantling connecting piping.
2. Provide air cock and drain connection on pump casing.
3. Decrease from line size with long radius reducing elbows or concentric reducers, or suction diffusers.
4. Support piping adjacent to pump so that no weight is carried on pump casings.
5. Comply with manufacturers recommendations for support of inline pumps. Provide support for motors when mounted horizontally. Verify Manufacturer’s allowable motor position and install accordingly.
6. Provide supports under elbows on pump suction and discharge line.

7. Provide pressure gauge with piping and gauge cock to measure pressure of strainer inlet, pump suction, and pump discharge.
8. Manufacturer's representative shall verify proper pump operation.
9. Provide gate valves to allow isolation of pump from system.
10. Provide check valve as pump discharge.

B. Level and Alignment - Base Mounted Pumps:

1. Before any piping or electrical connections are made, level and align pumps and motors on bases and foundation pads using an indicating micrometer.
2. After connections have been made and just prior to placing each pump in operation, recheck levels and alignments.
    a. Make adjustments to assure that shaft rotates freely when turned by hand and that pump is quiet in operation.
    b. When adjustments are completed, tightly bolt and grout motor and pump.

C. Motor Mount – Inline Pumps:

1. Verify motor position (vertical or horizontal) with manufacturer's installation instructions.
2. Provide proper pump support in accordance with manufacturer's installation instructions. Do not support pump from equipment.
3. Provide adequate clearance around pump for motor and shaft removal.

D. Lubrication: After completion of the system and before start-up, lubricate the pumps.

E. Impeller Trim: Remove impeller and machine down if more than 25% of the total pump head must be throttled by the pump discharge valve.

F. For inline pumps with motors 7.5 HP and larger, provide a suitable lifting point (eye bolt, strut channel) directly over the motor to aid in removal of the rotating element.

G. Pipe drip pan base to floor drain.

H. Fully grout base mounted pumps to housekeeping pads or inertia base per manufacturer's recommendations.

I. All pump casings shall be hydrostatically tested at 1-1/2" times design working pressure. The pump manufacturer shall be responsible for his service department aligning in the field prior to start-up of all flexibly coupled units. Alignment shall be with dial indicator with accuracy of plus or minus .002 inches. The pump manufacturer must submit a written report certifying that the alignment work had been performed by his personnel and that the pumps are ready for operation.

END OF SECTION

SECTION 23 22 13

STEAM AND CONDENSATE PIPING AND ACCESSORIES

PART 1 - GENERAL

1.1 SUBMITTALS

A. Submit manufacturer's data for the following:

1. Steam traps
2. Strainers
3. Safety valves
4. Pressure reducing valves
5. Vacuum breakers
6. Blowdown separator

PART 2 - PRODUCTS

2.1 PIPING

A. Provide products complying with ANSI B31.1 for Power Piping.

Piping Types and Materials				
Service & Location	Pipe Size	Pipe Material & Weight	Joint Type	Fitting Material
Low Pressure Steam (15 psig or less)				
Inside Building	2" or smaller	Steel, Schedule 40, ASTM A53, Type S, Grade B (Schedule 80 within 20' of PRV station)	Threaded or Welded	Cast Iron or Steel
	2-1/2" or larger	Steel, Schedule 40, ASTM A53, Type S, Grade B (Schedule 80 within 20' of PRV station)	Welded	Steel
Low Pressure Steam Condensate (15 psig or less)				
Inside Building	2" or smaller	Steel, Schedule 80, ASTM A53, Type S, Grade B	Threaded or Welded	Cast Iron or Steel
	2-1/2" or larger	Steel, Schedule 80, ASTM A53, Type S, Grade B	Welded	Steel

B. Vents (steam safety and relief): 2½" and below: Steel, Schedule 80; 2" and below: C.I., 125#, screwed welding.

C. All pump condensate piping above ground (steel): Schedule 40. Below ground (steel): Schedule 80. All fittings (C.I.): 250#, screwed.

2.2 STEAM TRAPS

A. Manufacturers:

1. Design Basis: Armstrong
2. Other Acceptable Manufacturers:
   a. AAF
   b. Dunham-Bush
   c. Hoffman
   d. Sarco
   e. Trane

B. Capacity: Continuous flow capacity of twice the maximum equipment condensing rate.

C. Connection Size: ¾ inch, minimum.

D. Access to Internal Parts: Without disturbing piping connections.

E. Valve and Seat: Heat-treated.

1. Stainless steel.
2. Chrome steel.

F. Float and Thermostatic:

1. Model: Series B.
2. Body: Cast iron or semi-steel.
3. Float: Stainless steel.
4. Ratings: SHEMA.
5. Combination float and thermostatic traps shall have a valve mechanism, the position of which is controlled by a closed, stainless steel ball float. The seat of the valve will be watertight at all times. The action of this type of trap must be gradual and modulating, it must discharge the condensate as soon as it enters the trap and its rate of discharge must be proportionate to the rate of the flow of condensate to the trap.

   The traps shall be provided with an automatic, thermostatic air bypass of the balanced pressure, multiple bellows type or disc diaphragm.

   All working parts shall be of non-corrosive metal (hard bronze, monel or stainless steel) and shall be removable without disconnecting the piping. Floats shall be of stainless steel.

Body and cover shall be of high grade cast iron suitable for 125 psi pressure for the 0-15 psi line.

G. Thermostatic:

1. Model: Dunham-Bush 1E or 2E.
2. Body: Cast brass.
3. Thermostatic traps shall be of the corrugated-bellows, balanced pressure type, with a bellows made of high grade red brass or phosphor bronze. Regardless of working pressure traps shall have a minimum working pressure of 125 psi. All steam traps to be sized on condensate at steam temperature.

   The bellows shall be either of Phosphor Bronze (with high temperature solder and brass sleeve protection) or Monel metal, properly brazed.

   Low pressure (0-15 psi) and medium pressure (15-65 psi) thermostatic traps shall have castbrass or forged brass bodies suitable for 125 psi pressure and shall be provided with a union connection at the inlet. Self-aligning valve heads and seats for the low pressure traps shall be of a suitable, non-corrosive material. Seats shall be removable.

   Valve heads and seats for medium pressure (0-65 psi) traps shall be removable and shall be of stainless steel. The solder used for the bellows shall be suitable for the higher temperature of medium pressure steam.

2.3 STRAINERS

A. Manufacturers:

1. Design Basis: Armstrong
2. Other Acceptable Manufacturers:
   a. AAF
   b. Hoffman
   c. Mueller
   d. Sarco
   e. Trane

B. Body: Cast Iron or bronze.

C. Removable Screen:

1. Material: Stainless steel.
2. Net Free Area: Four times pipe area.
3. Perforations:
   a. Size 2” and Smaller: 1/32 inch.
   b. Size 2-½” and Larger: 1/16 inch.

D. Blow-down Valve: Provide valve for strainers 2-½” and larger.

E. All strainers in steam lines, shall be Y-pattern, set in a horizontal (or vertical downward) run of the pipe. Where this is not feasible, strainers may be of enlarged-cross-section type. Strainers shall be so arranged as not to "trap" pipes, and to facilitate disconnection and opening-up for cleaning. Unless otherwise indicated, strainers shall be line size.

F. All strainers, 2-1/2" and above, shall have semi-steel bodies of ample strength for the pressure to which they shall be subjected, removable cylindrical or conical screens of monel or stainless steel and suitable flanges or tappings to connect with the piping they serve. They shall be of such a design as to allow blowing out of accumulated dirt, and to facilitate removal and replacement of a strainer screen, without disconnections of the main piping.

G. Strainer screen perforations shall be 1/32" for steam and mixture of steam and condensate. Strainers of the "Y" type similar to Sarco Bulletin 1220 type IF and AF or approved equal.

H. All strainers shall be provided with flanged covers for screen removal in lieu of screwed covers wherever obtainable.

I. All strainer screens 8" and above shall be reinforced for the operating conditions.

2.4 GASKETS (<400 PSI & 475 F)

A. All gaskets shall be compatible with operating pressure, temperatures, and all components of the system.

B. Manufacturers:

1. Design Basis: Garlock HTC-9800
2. Other Acceptable Manufacturers:
    a. Flexitallic

C. Gasket Material Requirements:

1. Contain no asbestos.
2. Be comprised of carbon fibers bound with synthetic rubber.
3. Be thoroughly and evenly mixed and compressed into a sheet having compact and uniform texture, either cross laminated or single ply with a finished thickness of ±10%.
4. Have a minimum density of 105 lb/ft^3
5. Be distinctively marked so that the manufacturer of pre-formed gaskets or gaskets cut from the standard sheet can be readily identified.
6. Manufacturer shall guarantee a shelf life of at least 3 years from date of manufacture.

D. Gasket Dimensions:

1. Dimensions of all gaskets used by Steam Distribution Field Operations must be in compliance with the ASME B16.21, Nonmetallic Flat Gaskets for Pipe Flanges. See table below for sizes.

Pipe Size (in)	Gasket I.D. (in)	Gasket O.D. (in)
1	1-5/16	2-7/8
2	2-3/8	4-3/8
3	3-1/2	5-7/8
4	4-1/2	7-1/8
6	6-5/8	9-7/8
8	8-5/8	12-1/8
10	10-3/4	14-1/4
12	12-3/4	16-5/8

E. Material Testing:

1. Seal ability properties, determined in accordance with Method B of ASTM F37-00, "Standard Test Methods for Sealability of Gasket Materials", as follows:
   a. A maximum leakage of 0.1 milliliters per hour when tested using ASTM Fuel A under a pressure of 9.8 psig as the test fluid and a flange load of 500 psi on the gasket specimen.
   b. A maximum of 0.1 milliliters per hour when tested with nitrogen under a pressure of 30 psig as the test fluid and a flange load of 3,000 psi on the gasket specimen.
2. An average compressibility not exceeding 17 percent and an average minimum recovery of 55 percent when tested in accordance with Procedure A of ASTM F36-99 (2003), "Standard Test Method for Compressibility and Recovery of Gasket Material".
3. An average minimum tensile strength of 1,500 pounds per square inch measured across the grain and 4,500 pounds per square inch measured with the grain when tested in accordance with Procedure A of ASTM F152-95 (2002), "Standard Test Methods of Tension Testing of Nonmetallic Gasket Materials".
4. An average maximum creep relaxation of 15 percent when tested with 3,000 pounds per square inch initial load in accordance with Method B of ASTM F38-00, "Standard Test Methods for Creep Relaxation of a Gasket Material".
5. An average maximum adhesion force of 200 lb and not exhibit any tearing or pickoff of fibers after being tested in accordance with ASTM F607-03, "Standard Test Method for Adhesion of Gasket Material to Metal Surfaces".
6. The flexibility, both with and across the grain, to bend around a mandrel having a diameter of twelve times the sheet thickness without any visible cracks, breaks or surface separations after being tested in accordance with the "original" and "aged" test methods outlined in ASTM F147-87 (2003), "Standard Test Method for Flexibility of Non Metallic Gasket Materials".

2.5 SAFETY VALVES

A. Manufacturers:

1. Design Basis: Consolidated
2. Other Acceptable Manufacturers:
    a. Crane
    b. Keckley
    c. Leslie
    d. Farris

B. Model: 1541

C. Body: Forged copper alloy steel.

D. Rating: ASME certified.

E. Accessories:

1. Lifting lever.
2. Drip pan elbow.

F. Steam safety valves shall be the semi-nozzle type, having extra heavy cast iron bodies and bronze trim. Safety valves shall have two separately adjustable controls; one to control "pop" action and the other to control blow-down. Adjusting spring shall be enclosed. A plain lifting level shall be furnished with each valve.

G. Safety valves shall be Lonergan 11W or 41W series, Kunkle Fig. 83 or 250 or approved equal.

2.6 VACUUM BREAKERS

A. Manufacturers

1. Design Basis: Johnson
2. Other Acceptable Manufacturers:
    a. Watts
    b. Durable check valve or approved equal.

B. Model: VB8-66, VB-75-SS-T, or approved equal.

C. Size: ¾”

D. Body: Stainless steel body with threaded outlet connections.

2.7 AIR VENTS

A. Air valves shall be No. 1A or No. 1B Vari-Vent as may by the Dole Valve Co. or approved equal.

B. Provide steam air valves on steam mains, returns, and unit heaters. Air vents shall be No. 5 air valve as made by the Dole Valve Co., or approved equal.

PART 3 - EXECUTION

3.1 GENERAL

A. Comply with ANSI B31.1 Power piping Code.

B. Steam piping shall be welded and x-rayed as per the minimum requirements of ANSI B31.1.

C. From the point of entry, up to and including the primary and secondary PRV station(s) outlet stop valve(s), and its associated bypass piping and valves(s); including branch connection upstream of the primary and secondary PRV that supplies high pressure steam shall be 100% x-rayed.

3.2 INSPECTION

A. Contractor shall examine location where the piping to be installed and determine space conditions and notify architect in writing of conditions detrimental to proper and timely completion of the work.

B. Do not proceed with the work until unsatisfactory conditions have been corrected.

3.3 INSTALLATION

A. Coordinate with other work as necessary to interface installation of piping with other system components of the system.

B. All steam piping shall be pitched (and shall remained pitched in the hot condition) such that there is contiguous drainage from any point in the system to a condensate removal location (steam trap).

C. Where the submissions (drawings and stress analysis) are required by the Owner, insurance provider and/or Steam Business Unit, the Contractor shall prepare all required documentation for approval. Upon completion of the high pressure steam installation, the Contractor shall coordinate with the Steam Business Unit to perform the necessary field inspection of the construction work to verify that requirements and specification have been adhered to.

D. All gaskets shall be made of resilient or pliable materials. The materials selected shall be compatible with fluid and suitable for the pressure-temperature conditions of the service.

3.4 STEAM PIPING

A. All pipe shall be new, free from scale or rust, of the material and weight specified under the various services. Each length of pipe shall be properly marked at the mill for proper identification with name or symbol of manufacturer.

B. All steel piping, except where otherwise rated, shall be standard or extra strong weight, in conformance with the ASTM A-53 Grade A seamless, for piping 2" and larger, as manufactured by National Tube Division, Republic Steel Corp., or approved equal. Piping shall be ASTM A-53 continuous butt weld, for piping less than 2".

C. Where possible, install piping with 1.0” minimum drop in 20’ pipe run in the direction of steam flow. Otherwise, pitch steam and condensate lines downward one inch per 40 feet in direction of flow to ensure adequate flow and prevent noise and water hammer. Steam and return run outs to risers and to elements shall pitch 1/2 inch per foot. At low points of steam lines provide traps adequately sized to collect condensate. Mains shall be dripped at least every 100 feet of run. All supply mains shall be dripped and trapped on any vertical lift, except where otherwise noted.

D. Install branch piping with 1.0” minimum drop in 10’ pipe run in the direction of flow.

E. Install branch piping at top of main, either in vertical direction or at 45 degrees from vertical and perpendicular to main. Branches two pipe sizes smaller than main may be installed as horizontal tees.

F. Provide capped dirt pockets at all traps, riser heels, and wherever dirt and scale may accumulate to meet job conditions, mains shall set up (with drip connections to return line) to maintain headroom, clear other pipes, etc. Steam mains are to be installed as high as possible. System is to be arranged to secure venting of air to the return line at all low points in steam mains, without permitting ingress of air. In any case, where return or drip piping, to meet job conditions, may have to set down under stoops, doors, etc., and again rise after passing these, the sets shall be made up with 45 deg. fittings and with Y-laterals at each end, with brass plugs to permit easy cleaning of trapped portions of pipe. At any points where return mains have to rise again, after being depressed, provide also approved overhead "air lines" (not smaller than 3/4" in size) with adjusting valves, and connect with two high sides. Any turns in water sealed lines shall be made with crosses, with brass plugs in unused outlets to facilitate cleaning. All apparatus subject to high temperature differentials and high steam demand loads such as heating coils and steam-water converters shall have a vacuum breaker.

G. General standards for sizing condensate piping indicate a maximum velocity of 50 fps where mixed phase flow exists.

H. Condensate mains over 2” (two inches) in diameter shall be of extra heavy wall pipe.

3.5 CONDENSATE PIPING

A. Comply with the applicable steam piping installation requirements, except install piping with 1.0” minimum drop in 40’ pipe run in the direction of flow.

B. All drain piping from condensate drain pans shall be properly trapped in accordance with the static pressures involved. Condensate drain piping sizes shall be not less than 1½ “.

3.6 STEAM TRAPS

A. Except as otherwise indicated, furnish and install steam traps of approved types and capacities for proper venting and draining of all piping and of all pieces of equipment:

1. In the return piping adjacent to each item of equipment utilizing steam.
2. At the end of each steam main.
3. At each low point on high pressure system.
4. Heels of risers
5. Any other point where condensate and/or air may collect, such as ahead of pressure and temperature regulating valves, lifts and drops in steam mains, etc.

B. Install with valve and Y-strainer on upstream side of trap.

C. Install float-and-thermostatic traps on low pressure system.

D. Install bypass piping around traps on low pressure system.

E. All traps shall be designed for the steam pressure and service for which they are to be used and shall pass all condensate and air automatically, without passing any steam. Traps shall be of the types as specified hereafter, as may be required for satisfactory operation. All steam traps shall be warranted to have been tested in the manufacturer's plant under steam to insure tight closure and satisfactory operation.

F. All equipment steam traps shall be sized for a minimum capacity of 300% of the steam loads indicted on the drawings, and at a maximum pressure drop of 1/2 psi.

1. Exception: For modulating control systems with less than 30 psi inlet pressure, traps shall be sized at 100% of the steam load with a maximum pressure drop of 1/2 psi. Drip legs shall be a minimum of 18”.

G. It shall be this Contractor's responsibility to install the entire system of return line piping so that all condensate will be returned without water hammer.

H. Each heating unit, regardless of type, shall be installed with shut off valve at inlet. Each radiator or convector shall have at its supply inlet, a bronze body valve of packless quick-opening type which shall pass sufficient steam when fully opened to fully heat the radiator surface with the lowest pressure carried in the mains.

I. The following schedule of trap types shall apply:

Schedule of Steam Trap Types

Drips for Low Pressure mains and risers.......................... FT
Drips for Low Pressure risers under 2 inches................... FT
Heating coils………………………………………............. FT
Unit heaters... FT
Heat Exchangers... FT

<u>CODE</u>:

FT - Float and Thermostatic Trap

J. All traps up to and including 2-1/2" size shall be provided with threaded connections. Traps over 2-1/2" size shall be provided with threaded flanged connection.

K. Traps 2" size or less shall be provided with union connections.

L. Provide high capacity steam traps on all heat exchanger.

M. On the low pressure system, trap selection shall be made based on the load type, amount of allowable piping noise during trap operation, and the possibility of high levels of superheat.

N. Float type traps shall be protected from water hammer where necessary.

3.7 COMBINATION FLOAT AND THERMOSTATIC STEAM TRAPS

A. A gate valve and strainer shall be installed ahead of all float and thermostatic traps.

3.8 HIGH CAPACITY FLOAT TRAPS

A. For high capacity, float traps with double ported, closely balanced stainless steel valves shall be used. These traps shall not require change of seat size with varying pressures. Thermostatic air vents shall be located on outside of trap body.

3.9 VACUUM BREAKER

A. Install vacuum breakers at:

1. Steam heating coils
2. Heat exchanger
3. Jacketed kettles
4. Closed tanks
5. Hot water generator coils
6. And where shown on drawings or details.

3.10 BYPASS PIPING

A. Except as otherwise indicated, fabricate and install bypass piping using the same materials and the same plane as connected piping, but one pipe size smaller.

B. Include globe valve in bypass piping.

3.11 DRIP LEGS

A. Except as otherwise indicated, fabricate drip legs from 2” pipe.

B. Install to direct steam vertically downward:

1. Include Tee-fitting in vertical pipe.
2. Install dirt leg pipe at 180 degrees outlet of tee-fitting.
3. Close dirt leg pipe with cap.
4. At 90 degrees outlet of Tee-fitting, connect valve, strainer, trap and second valve.

C. Provide trap with continuous flow capacity of 1.5 lbs. per hr. of condensate per sq. ft. of surface drained pipe.

D. Install drip legs:

1. At both ends of steam header.
2. At the low points.
3. At vertical offsets.
4. Elsewhere as indicated.

3.12 SYSTEM CLEANING

A. Before placing steam piping in service, blow out system with steam to remove foreign material.

B. Place system in operation and waste condensate for minimum of three hours.

3.13 SAFETY VALVES

A. Valves shall be sized in accordance with ASME Power Boiler Code where applicable and shall be ASME approved where necessary. Safety valves for unfired pressure vessels shall be in accordance with Section VIII of the ASME Boiler and Pressure Vessel Code.

3.14 STRAINERS FOR STEAM AND CONDENSATE

A. There shall be approved strainers in the inlet connections to each coil, control valve, steam trap, blow-off, and each diaphragm valve, and where else indicated on the drawings. The intention is to protect by strainers, all apparatus of an automatic character, whose proper functioning would be interfered with by dirt on the seat, or by scoring of the seat.

B. Provide approved valved dirt blow-out connections for each strainer (with the valve located 6" to 1'-0" below strainer, or as directed). The blow-out connection shall terminate with a valve, nipple and cap. Blow off shall be 4 pipe sizes smaller than straight pipe - 3/4" minimum size and shall be suitable for a hose connection with cap.

3.15 TESTING

A. The steam piping system shall be hydrostatically tested upon completion of the installation at 150 percent of the design pressure for all piping pressure unless higher pressure are required by specification section 230593 or elsewhere.

B. See additional requirements elsewhere in the specification.

END OF SECTION

SECTION 23 25 13

CLOSED SYSTEM WATER TREATMENT

PART 1 - GENERAL

1.1 SCOPE

A. Furnish and install chemical treatment systems for closed hydronic systems where shown on the Drawings and as specified in this section.

B. Work under this section shall include providing equipment, chemicals, and service related to water treatment for the brine/chilled water systems.

C. The Contractor shall engage the services of a water treatment contractor who shall provide a complete water treatment service. The service shall include furnishing and application of all chemicals, at least one visit a month to collect samples for chemical analysis at the water treatment company's laboratory, and all necessary inspection, adjustment, and maintenance of the chemical treating devices. Complete chemical control of the treatment shall be included. Reports shall be furnished to Architect after each visit.

D. Water treatment shall be applied concurrently with the operation of each circulating water system for a period of one year. An initial dose of treatment chemical shall also be applied immediately after each system is initially filled with water if operation is to be delayed after filling. In addition to the chemicals indicated, slimicides and algeacides shall be provided as necessary. Chromate and phosphate will not be acceptable. All chemicals shall be approved by local and state agencies having jurisdiction.

E. The firm's water treatment laboratory shall be equipped to analyze water in accordance with the statement methods of the American Public Health Association.

F. Water treatment contractor shall provide chemical feeding devices during the period of this contract. At the termination of the contract, the treatment equipment shall belong to the Owner.

G. Provide a water treatment program for the brine/chilled water closed loop system.

H. Provide a comprehensive program of cleaning and flushing for brine/chilledwater system.

I. All chemicals and formulations prescribed for the cleaning and treatment of process water systems must meet the following specified criteria:

1. They must be ecologically compatible so that any discharge will not create an environmental impact.

2. They must be industrial and toxicologically safe so as to minimize personnel and equipment exposure to hazardous conditions.
3. Every effort must be made to maintain a sense of uniformity in chemical formulation to insure a line of continuity.

J. Provide permanent signage on hydronic systems treated with chemicals that include the following information:

1. Chemical type, concentration, and system volume.
2. Direction to drain system to sanitary drain.

K. Chemical type, concentration and system volume shall be stenciled on the system expansion tank in a visible location.

1.2 RELATED WORK SPECIFIED ELSEWHERE

A. Section 23 21 13 Hydronic Piping And Accessories

1.3 QUALITY ASSURANCE

A. The chemical treatment program shall be administered by a firm regularly engaged in the field of water treatment with a minimum of five years experience in the immediate area of the job site location, and similar sized projects.

B. The water treatment contractor shall have laboratory facilities, both central and field, to service the Owner’s account.

C. The water treatment contractor shall have local warehousing and will not be allowed to overstock chemical on premises.

D. A single water treatment company shall be responsible for all products and services.

E. Approval Process: All materials proposed for application must have the prior approval of the Engineer and Owner. In order to thoroughly evaluate the products performance, it is recommended that the following be submitted at the time of proposal:

1. Material Safety Data Sheets for all products that are to be applied, which shall contain the complete formulation. Further documentation of qualitative composition must be included if Material Safety Data Sheets do not supply all product(s) components.
2. Product Data Sheets specifying overall product description and application guidelines.
3. Methods of analysis for determining product residuals. Proposals should specify specific qualitative and quantitative procedures of evaluating actual product levels. They should also include recommended parameters for all products, expressed in either terms of parts per million or milligrams per liter.
4. Expected performance levels of products; this should include expected corrosion rates, expressed in mils per year. If the product is of a biostatic nature, what

levels of biological growth should be expected if the product is applied at recommended dosages.

5. Provisions should be submitted for the removal for any unused chemicals. In addition, provisions must be provided for the disposal of all empty containers.

F. The above mentioned criteria will serve as a guide as to the minimum information required for approval of any chemical treatment. No water treatment shall be purchased, delivered, or applied without consideration of the previously mentioned guidelines.

1.4 SUBMITTALS

A. Provide product data for each piece of equipment installed the system and for each chemical used.

B. Provide shop drawings for control panel, including internal and external wiring diagrams, dimensions, etc.

C. Provide operation and maintenance manuals for all equipment.

D. Material Data Safety Sheets shall accompany all chemicals delivered to the job site.

PART 2 - PRODUCTS

2.1 PRE-STARTUP CLEANER

A. Furnish pre-startup liquid detergent dispersant cleaner for flushing and cleaning of water systems to remove oil and foreign matter from piping and equipment prior to final filling of systems. Chemical shall not be injurious to persons, piping, pipe joint compounds, packings, coils, valves, pumps, and their mechanical seals, tubes, or other parts of the system.

B. This work shall include the internal cleaning and protective coating of all distribution systems on this construction such as, but not limited to, steam piping, brine/chilledwater piping and condenser water systems and components.

C. This method of cleaning and treating is to be applied to all piping supply and return and then back to the source of equipment.

D. In all systems the process shall be completely circulated throughout, and afterwards the system is to be drained, flushed and protective coated. The Contractor shall engage the services of a cleaning firm, for the purpose of removing lime, oil, grease, oxides and other wastes therefrom. Strainers and all points of piping systems shall be effectively flushed. After the removal of these impurities, a protective coating shall be applied to all inner surfaces, which will inhibit oxidation as well as protect the metals against impurities that may be present in the water. This coating shall be guaranteed for five years from date of completion at no cost to the Owner, covering labor and materials.

Valve-off heat exchangers to avoid coating surfaces.

E. The cleaning and testing materials use for this purpose must have been in use successfully for at least five years in comparable systems. Building system pumps shall not be used in system cleaning procedures.

F. It shall be compounded of non-corrosive, non-toxic, non-alkaline and non-injurious ingredients that have been investigated and reported as a "Neutral Compound" by a recognized engineering firm or laboratory, other than the submitting company's own laboratory. Brochures and unbiased test reports shall be submitted to the Architects within 90 days from job acceptance for approval. This cleaning and treating firm shall show proof, that said firm has been established and accepted for this work, for a minimum of 10 years. The ingredients used shall have no deleterious effects on seals, O-rings, glands, packing, etc.

G. It shall be the sole responsibility of the approved firm for the application of this process. He shall supply all labor, materials, and equipment for this purpose. A competent supervisor and/or equipment operator shall be kept at the site from commence of his work until completion. None but experienced men shall operate this pumping equipment. Any repairs or servicing of components of these systems shall be done by the Contractor.

H. Cleaning procedures for newly installed systems shall be as follows:

1. Step 1: Adjust all control valves and balancing valves to full open position during the cleaning and treatment process.
2. Step 2: Fill system and add standard 12% hypochlorite bleach for a residual of 2-3 parts per million (ppm) chlorine. This should require approximately one quart of bleach per 10,000 gallons of water. Test for concentration. Circulate solution for a minimum of eight hours. Clean strainers and dead end piping legs, then drain to sanitary sewer
3. Step 3: Fill system and add a general dispersant for iron, mud, silt, and microbiological matter at a concentration of 500-1000 parts per million (ppm), or approximately seven gallons of product per 10,000 gallons of water. Test for concentration. Circulate solution for a minimum of eight hours. Flush system using bleed and feed until the bleed water pH and iron levels are consistent with the feed domestic water levels. Clean strainers and dead end piping legs.
4. Step 4: Arrange for inspection by a representative from the Facilities Management Pipe Shop before proceeding to chemical treatment.

I. For extensions to existing building systems, the above cleaning procedures shall be followed if the extension contains ferrous piping materials. Provide temporary piping, valving, and pumping system isolated from the existing building system as needed to perform cleaning procedures prior to final connection to the existing building system.

2.2 CHEMICALS

A. A buffered Molybdate and/or Nitrite based corrosion inhibitor shall be provided to initially treat the closed systems and added as required for 1 year from date of owner acceptance. This treatment must contain a copper inhibitor and a borate buffer.

B. Any treatment must be compatible with glycol installed in glycol/water systems.

C. Treatment chemicals for hydronic brine/chilledwater cooling systems shall be as follows:

1. Glycol Cooling Systems: After cleaning and inspection, drain system then refill with Metro PG#36 propylene glycol (PG) solution at a concentration in accordance with manufacturer's recommendations. The water to be added to glycol solutions shall meet manufacturer's standards for quality.

D. Arrange for inspection by a representative from the Facilities Management Pipe Shop prior to final acceptance.

2.3 POT FEEDER

A. Provide a five (5) gallon pot feeder piped around the main Brine/chilledWater circulating pumps as indicated on the drawings. The feeder shall consist of a steel tank with operating pressure of 200 psi. A 3½" quick open cap with "O" ring seal shall be provided to add water treatment chemicals.

2.4 COUPON HOLDER

A. Provide coupon rack with coupon holders, flow control and isolation valves. Coupon racks shall be installed in all closed and open systems that are being treated.

B. Coupon Holders shall be similar to Pulsafeeder, Inc. Model CCR-4.

C. The Water treatment contractor shall install the coupons in the coupon holders and submit a written report to the Owner at the end of each 90 days, during the one year warranty period as to the condition of each system being treated.

2.5 CHEMICAL FEED EQUIPMENT - BRINE/CHILLED WATER SYSTEMS

A. Provide a 5 gallon shot feeder including funnel, relief valve and air vent for intermittent feed of corrosion inhibitor across a suitable pressure drop in each closed system.

2.6 WATER TREATMENT CONTROL TESTING EQUIPMENT

A. Provide a test set complete with apparatus and chemical regents for the determination of phosphonate (ortho), ph (7.6 - 9.2), nitrite and any additional test as required by water treatment company.

PART 3 - EXECUTION

3.1 Provide a one year supply, from date of startup, of the recommended formulas for the prevention of scale, corrosion, and biological growth in the recirculating system.

3.2 All formulations must be compatible with system construction materials and meet or exceed all environmental requirements.

3.3 The water treatment company will supply all testing equipment and reagents, necessary to properly maintain the treatment program.

3.4 The water treatment company will provide a water treatment service program for a period of one year from system startup. This program shall include: startup assistance, plant personnel training, monthly service calls and inspection of system equipment. Provide owner with copy of field service report including performance test required levels vs. Field measurements.

3.5 Provide quarterly laboratory analysis and report of coupons.

END OF SECTION

SECTION 23 25 16

OPEN SYSTEM WATER TREATMENT

PART 1 - GENERAL

1.1 QUALITY CONTROL

A. Installer:

1. A firm with at least ten (10) years of successful installation experience on projects with water treating systems similar to that required for this project.

B. Electrical Standards:

1. Provide electrical products which have been tested, listed and labeled by U.L.
2. Comply with NEMA standards.

C. Chemical Standards:

1. Provide chemical products acceptable under state and local pollution control regulations.
2. Retain a chemical company to provide water treatment, feed equipment, testing equipment and chemicals for the systems as defined herein and as may be required to maintain the integrity of the piping systems and mechanical equipment.
3. The water treatment chemical and service supplier must be a recognized specialist, active in the field of industrial water treatment for at least ten (10) years in New York City, whose major business is in the field of water treatment, and who has full time service personnel within the trading area of the job site. Laboratory facilities must be available. Service personnel must be degreed specialists in the fields of mechanical, chemical, environmental engineering or chemistry.
4. Furnish and install all equipment and material on this project in accordance with the requirements of the authority having jurisdiction, suitable for its intended use on this project, approved by the U.S. Environmental Protection Agency (EPA), and local Department of Environmental Protection, and so certified by the manufacturer.
5. Analyze the water from the local water company to be used on the project, before establishing treatment procedures.
6. Supplier shall have all permits required to perform chemical application and disposal.

1.2 SUBMITTALS

A. Submit the following:

1. Manufacturer's data on materials and equipment.
2. Operating instructions for:
   a. The system
   b. The water test kits
3. Certified test reports for samples.
   a. Comply with ASTM D 596 for reporting.
   b. Indicate ASTM test method used for each test.
4. Shop drawings showing:
   a. Piping
   b. Valves
   c. Connections
5. Chemical explanation, MSDS, layouts of feeding equipment, equipment detail sheets. List of services shall be provided for all systems.
6. Complete procedure to commence cleaning, including circulator recirculation rate and chemicals to be used.

PART 2 - PRODUCTS

2.1 GENERAL

A. Except as otherwise indicated, provide condenser water treating system manufacturer's standard materials and components as indicated by his published product information, and as recommended by the manufacturer for the application indicated.

2.2 DESCRIPTION

A. Provide flushing, cleaning and chemical treatment programs for the condenser water system(s), in accordance with the contract documents.

1. Work includes:
   a. Pipe cleaning
   b. Cleaning chemicals
   c. Water treatment chemicals
   d. Chemical feed equipment
   e. Water treatment testing equipment
   f. Water treatment services

2.3 OPERATION

A. System shall automatically control chemical feed and bleed off.

B. Furnish all required pipe cleaning chemicals, chemical feed equipment, materials and labor necessary to clean the piping as herein specified.

C. Provide a pre-startup non-foaming, liquid detergent dispersant cleaner and designated corrosion inhibitor for cleaning of all systems to remove oil and foreign matter from the piping and equipment prior to the final filling of the systems. Use chemical that, when used in accordance to the procedure, is not injurious to persons, piping, pipe joint compounds, packings, coils, valves, pumps and their mechanical seals, tubes or other parts of the system.

D. Furnish instructions dictating the quantities of the cleaner and inhibitor to use, methods and duration of the operation.

E. Install temporary electrical connections if supplemental cleaning apparatus is necessary.

F. Provide and install an Automated Control System. As a minimum, this control system must accomplish the following:

1. Feed inhibitor chemicals in proportion to makeup water, flow measured by a contact head water meter.
2. Control bleed-off by conductivity in a preset range.
3. Feed two biocides on a programmed basis.

G. Additionally, at a minimum, the equipment furnished shall provide for the functions listed below and shall include all controls, tanks, pumps, sensors, probes, analyzers, water meters, valves, etc. necessary to perform the water treatment functions required. Functions to be performed include:

1. Automatic control of cooling tower bleed-off.
2. Automatic control of chemical treatment.
3. Water meter with contacting head in make-up line to measure water usage and control chemical feed in the cooling tower.

H. Chemical pumps shall be of heavy duty construction. The recommended pumps shall maintain an output 1.3 times the pressure of the system in which it is injecting chemical. (Supplier must choose pumps to efficiently feed chemicals into the system).

2.4 PERFORMANCE

A. Provide from start-up, one-year’s supply of necessary water treatment chemicals including the following:

1. Open Condenser Water Systems

Corrosion Rate- Mild Steel	Less than 2.0 MPY based on ASTM Std. D-26688
Corrosion Rate – Copper	Less than 0.2 MPY based on ASTM Std D-26688
Frequency of Coupon Test	Ninety (90) days
Pitting Attack	None
Scaling and Deposition	None

Biological Fouling	No Visible Deposits
No Health Hazards	
Planktonic less than 10,000 / ml	
No Sulfate Reducing Bacteria	
No Visible Algae	

2.5 CHEMICAL EQUIPMENT MANUFACTURERS

A. Design Basis: Tower Water Management

B. Acceptable Manufacturers:

1. Autorol
2. Aquatrac

2.6 EQUIPMENT

A. Controller:

1. Slim-Flex Model S4T or approved equal
2. Digital conductivity monitor with flow through electrode assembly.
3. Selector switch: 0-5000 Micro Ohms.
4. Provide visual readout of conductivity
5. Relay Operates bleed-off valve, water meter input, operates three (3) chemicals
6. NEMA 4X Enclosures
7. Flow Switch: Shutdown Controller when tower pumps stops.

B. Bleed-Off Valve:

1. Type: Slow closing Motorized Ball Valve with Spring Return
2. Bellimo Model B225+LF120
3. Size: 1 Inch

C. Prominent Pump
1. Model: Concept or Beta Series
2. Mounting: Wall bracket or shelf

D. Secondary Containment
1. Manufacturer: Peabody
2. Model: G 40 N (40 Gallon White, drum inside drum, containment)

E. Bypass Feeder:

1. Manufacturer: Vector or equal
2. Model #: FA 1000 AL
3. Size: Five gallon

F. Make-up Flow Meter:

1. Manufacturer: Advantage Controls
2. Type: Turbine with electric contact head
3. Sized to match makeup

G. Chemical Feed Timers (as part of the water treatment controller):

1. Type: Reset timer, 0-10 min. range minimum
2. Interlock with make-up flow meter to operate chemical feed pump.

H. Corrosion Coupon Rack

1. Four station type: 2 low carbon steel
   2 copper
2. Made to ASTM Guidelines.
3. Flow control device, regulating to 10 GPM, with strainer.
4. Rack will be made of mild steel.

2.7 CHEMICALS

A. Scale and Corrosion Control

1. Type: Non-acid, organophosphonate, multi-purpose liquid.
   a. Approved by local water pollution control authorities.
2. Furnish chemicals for first year of operation beginning at Owner acceptance.
3. Furnish chemicals in container suitable for use as solution reservoirs.

B. Algae Control

1. Provide two separate algaecides for alternate use.
   a. Furnish for first year of operation.

C. pH Adjustment Chemicals:

1. Provide suitable pH adjustment chemicals to control pH at the 7.5-8.8 level.

D. Corrosion Inhibitor:

1. Provide liquid non-polluting corrosion inhibitor which complies with all laws regulating wastewater discharge, and as permitted by the local authorities having jurisdiction.

E. Dispersant:

1. Provide non-polluting dispersant which complies with all laws regulating wastewater discharge, and as permitted by the local authorities having jurisdiction.

F. Biocide:

1. Provide 2 types of biocide
   a. Oxidizing
   b. Non-oxidizing
2. Provide non-polluting biocide, which complies with all laws regulating wastewater discharge, and as permitted by the local authorities having jurisdiction.

G. Recommend pH adjustment chemical, corrosion inhibitor, dispersant, and biocide for the local water characteristics.

Treatment and Chemical	Control Level
Phosphate	5-10 ppm as PO_4
Phosphonate	5-10 ppm as PO_4
Molybdate	1-3 ppm as MO
Tolytraizole	2-4 ppm as TTA
Polymer	4-8 ppm as Active
pH	7.5-8.5

H. Test Equipment:

1. Supply a one-year’s quantity of testing chemicals to properly analyze the treated water for hardness, pH, molybdate, chlorine, nitrite, alkalinities, sulfite, and phosphate. Furnish the necessary test kits complete with instruments, reagents, materials and supplies.
2. Provide a conductivity meter, 0-2500 range, MICRO OHMS/CM auto-temp compensation 50° - 160°F.
3. Furnish a supply of log sheets on which to record the test results.
4. Provide and install a corrosion coupon test rack as directed with four (4) insert positions for steel and copper coupons furnished by the water treatment company, and to be inspected every 30 days.
5. Provide a bound copy of all test instructions.
6. Provide a metal test cabinet with lock and acid-resistant enamel finish, suitable for wall mounting.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Conductivity Sensor: Mount in 1” line running between pump discharge and sump.

1. Provide ball valve upstream of sensor.

B. Flow Switch: Mount in pump discharge line.

1. Wire to stop conductivity monitor and chemical pump when tower pump stops.

C. Bleed-Off Motorized Ball Valve: Mount in bleed-off line.

D. Install all equipment, chemicals, water devices, etc., in accordance with water treatment specialist’s directions and drawings, for all systems previously noted. Contractor shall provide 1-inch taps to bring system water to desired locations.

1. Provide a minimum of 4 on both the supply and return mains.

E. pH adjustment, inhibitor and dispersant tanks shall be shipped in use containers. Pump suction assemblies previously specified will pump directly from these shipping drums.

F. Installation and startup shall be supervised by the water treatment company’s representative.

G. Shipping containers shall be disposed of or refilled off the premises at no extra cost.

H. Secondary containment shall be placed under use containers to prevent spills.

3.2 MAKE-UP WATER SEQUENCE

A. Setup system to maintain a cycle of concentration of 8-10 (adj.).

3.3 START-UP PROCEDURES

A. During condenser cooling water system start-up, operate condenser water treating system (after charging with specified chemicals) to maintain the required steady-state characteristics of cooling water.

B. All piping Systems

1. Provide temporary connections with valves to fill and drain the piping and equipment after completion of the chemical cleanout procedure. Provide temporary blind flanges and/or caps to isolate existing piping and equipment.

2. Provide temporary piping connections, strainers, bypasses, and blank connections where required to clean out systems.

a. Cleaning shall not take place more than 14 days prior to startup. Give the Owner at least 30 days notice prior to startup.
b. Cleaning shall be performed using the water treatment supplier labor, only with supervision by mechanical contractor.
c. Add chemical pipe cleaning compound and corrosion inhibitor/biocide, etc., as recommended by the water treatment company's representative to the system simultaneously with the filling of the system.
d. Circulate the cleaning compounds in the system for the appropriate times (3-8 ft/s):

System Volume	Time
50 - 500 gallons	0.5 – 1.5 hours
750 - 2000 gallons	1.5 – 3.0 hours
2000 - 3000 gallons	3.0 – 5.0 hours
3000 - 5000 gallons	5.0 – 8.0 hours

e. Flush the system at all low points.

f. Once system is drained, refill the system immediately and begin the system circulating. The system shall not be drained or untreated for more than 2 hours.

g. Fill the system again with fresh water and flush until clean water is obtained. Maintain continuous blow-down and make-up as required during flushing operation).

h. Once cleaning is completed fill system with 100% treated water.

i. The treatment company shall chemically treat the system to protect it from corrosion and continue the passivation process. At this point the system needs to circulate for a minimum of 8 hours to properly passivate all metal surfaces.

j. The cleaning and flushing procedure must be approved in writing by the water treatment company's representative. The water treatment company's representative shall supervise and certify in writing the cleaning and flushing of the piping systems.

C. Filling of Water Systems

1. After completion of chemical cleanout, fill each water system with fresh water, air vent , and immediately add chemical treatment at three (3) times the normal dosage to passivate metal.

3.4 TESTING

A. Sample condenser cooling water at one-week intervals after condenser start-up for a period of four weeks.

1. Prepare certified test report for each required water performance characteristics.
   a. Comply with the following ASTM standards, where applicable:
      1) D 859 - Tests for Silica in Water and Waste Water.
      2) D 1067 - Tests for Acidity or Alkalinity of Water.
      3) D 1068 - Tests for Iron in Water and Waste Water.
      4) D 1126 - Tests for Hardness in Water.
      5) D 1128 - Identification of Types of Microorganisms and Microscopic Matter in Water and Waste Water.
      6) D 3370 - Sampling Water.

3.5 PERSONNEL TRAINING

A. Operator Training

1. Train Owner's personnel in use and operation of condenser water treatment system, including:
   a. Preparation of chemical solution, if applicable.
   b. Charging of the chemical solution reservoir.
2. Provide a minimum of 8 hours training.

3.6 TECHNICAL SERVICE AND CONTROL

A. Wherever possible, all water treatment equipment is to be located in the mechanical equipment rooms.

B. Provide two times the normal dosage of corrosion protection if the system is in operation. If the system will not be operating at designed flow use a lay-up program provided by the water treatment company to properly protect the system until fulltime operation is achieved.

C. For a period of one year after final startup of system, testing contractor shall be on call at no additional cost to the Owner to make on-site inspections of equipment during scheduled or emergency outages in order to properly evaluate their effect on the water treatment program.

D. During the first 3 months, provide bi-monthly, on-site testing, adjusting, recommendations, and reports during operation. Provide testing for iron, copper, phosphate, inhibitor, pH, conductivity, and bacteria in all systems. Testing shall be monthly for months 3 – 12.

E. Servicing and calibration of pumps and control equipment shall be done monthly.

F. Corrosion coupon removal and replacement shall be performed monthly until system is passive, then on a quarterly basis. Photographed reports shall be required.

G. Bacterial analysis shall be performed monthly via dip slide analysis.

H. Provide annual training seminar to include:

1. Safety and Chemical Handling
2. Testing and Adjusting Procedures
3. Basic Water Treatment
4. Water Treatment for Management

I. Written chemical and testing inventory shall be performed monthly.

J. Testing equipment calibration shall be performed monthly.

K. Water meter readings are to be logged in manuals from both controller and meters.

L. Copies of all correspondence, testing, coupon studies, etc., shall be left on site in a manual used only for water treatment and sectioned accordingly.

M. The program should provide the following results:

Open Recirculation

Mild steel	2.0 mpy no pitting
Copper	0.1 mpy no pitting

N. Provide complete operation manual including sections:

1. Field Reports
2. Log Sheets
3. Analytical
4. Testing/Training
5. Correspondence

O. Material safety data sheets shall be posted at each drum.

P. December pesticide reporting of all biocides.

3.7 ELECTRICAL

A. All control wiring or interlocks shall be provided by this division.

END OF SECTION

SECTION 23 31 13

DUCTWORK

PART 1 - GENERAL

1.1 INDUSTRY STANDARDS

A. Fabrication and installation shall be by a single firm specializing and experienced in metal ductwork for not less than 10 years.

B. Comply with SMACNA (Sheet Metal and Air Conditioning Contractors National Association) recommendations for fabrication, construction and details, and installation procedures, except as otherwise indicated.

C. Comply with American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE), except as otherwise indicated.

D. Compliance with SMACNA and ASHRAE is a minimum requirement. In case of disagreement between sheet metal work described in this Section and SMACNA or ASHRAE, the specification shall govern, unless the requirements of SMACNA or ASHRAE are of greater value.

E. Comply with SMACNA "HVAC Air Duct Leakage Test Manual" for testing of duct systems.

F. Comply with New York State Energy Conservation Code for UL Listing of products.

G. Comply with NFPA 90A.

1.2 SUBMITTALS

A. Detailed ductwork shop drawings, which include sizes, layouts, and pressure classifications, must be properly submitted. Any ductwork installed without prior written approval by the engineer of record shall be replaced at the expense of the contractor.

B. Shop Drawings: Submit shop drawings for:

1. Transition elbows.
2. Seal and reinforcing schedule for all ductwork fabrication types.
3. Turning vane and turning vane installation.
4. Coordinated duct routing and sizes.

C. Product Data: Submit manufacturer's product data including VOC content on the following:

1. Duct lining.
2. Duct lining adhesive.
3. Duct sealant

1.3 PRODUCT HANDLING

A. Protect shop fabricated ductwork, accessories and purchased products from damage during shipping, storage and handling. Protect ends of ductwork and prevent dirt and moisture from entering ducts and fittings.
B. Where possible, store ductwork inside and protect from weather. Where necessary to store outside, store above grade and enclosed with waterproof wrapping.

1.4 QUALITY ASSURANCE

A. The contractor must comply with the specification in its entirety. If on inspection, the engineer of record finds changes have been made without prior written approval, the contractor will make the applicable changes to comply with this specification at the contractor's expense.

B. At the discretion of the engineer of record, sheet metal gauges and reinforcing may be randomly checked to verify all duct construction is in compliance.

C. All ductwork and fittings must have a computer generated label affixed to each section detailing all applicable information including the duct dimensions, gage, reinforcement type/class, and connector type of systems manufacturer. In addition, galvanizing thickness and country of origin must be clearly displayed on each duct section.

D. Duct sealing shall be sealed as per requirements of SMACNA Air Duct Leakage Test Manual.

1.5 GUARANTEE

A. Contractor will guarantee all work for one year from the date of acceptance against all defects in material, equipment and workmanship. This guarantee shall include repair of damage to any part of the premises resulting from leaks or other defects in material, equipment or workmanship.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR DUCTWORK

A. Construct ductwork to meet the functional criteria defined in Section VII of the 2005 SMACNA "HVAC Duct Construction Standards, Metal and Flexible," Second Edition.

B. All ductwork must comply with any applicable local, state, and federal code requirements.

C. Furnish and install the size, connections and run of ducts as indicated on the Drawings. All dimensions represent inside clear dimensions.

D. While the drawings shall be adhered to as closely as possible, the Engineer reserves the right to vary the run and size of ducts during the progress of the work if required to meet structural conditions.

E. Install all ductwork in strict adherence to the ceiling height schedule indicated on the Architect's Drawings. Consult with the Electric and Plumbing Contractors, and in conjunction with the above Contractors, establish the necessary space requirements for each trade.

F. The sheet metal ductwork shall, whether indicated or not, rise and/or drop and/or change in shape to clear any and all conduits, lighting fixtures, plumbing and heating mains to maintain the desired ceiling heights.

G. The ductwork shall be continuous, with airtight joints and seams presenting a smooth surface on the inside and neatly finished on the outside. Ducts shall be constructed with curves shown on the Drawings, the inside radius of all curves and bends shall be not less than width of ducts in plane of bend.

H. All outside air intake ducts between intake point and air handling unit or mixed air duct or plenum shall be aluminum construction with all joints sealed with Foster 32-19, Childers CP-146 or Ductmate PROseal UL 181B-M listed sealer.

I. All air ducts exposed to the weather and not insulated shall be constructed of aluminum and shall be properly braced and supported and secured to the building construction. All seams shall be sealed with Foster 32-19, Childers CP-146 or Ductmate PROseal UL 181B-M listed sealer.

1. The construction of ductwork shall be same as conventional ductwork except where transverse reinforcing angles not required, provide 1" x 1" x 1/8" black iron bracing angles matched angles at joint and 1" x 1" x 1/8" black iron between joints 4'-0" from joints.
2. Provide 1/8" thick gasket (3M EC-1202 or equal) for all matched angles.
3. Edge of ducts shall be bent 1/2" over matched angles to obtain watertight seal.
4. Rivet angles to duct and seal with Foster 32-19, Childers CP-146 or Ductmate PROseal UL 181B-M listed sealer.
5. Paint bare steel iron angles black after installation.

J. Where dimensions, sizes, and arrangements of elements of duct assembly and support systems are not provided in these standards the contractor shall select configurations suitable for the service.

K. The contractor shall follow the application recommendations of the manufacturer of all hardware and accessory items and select them to be consistent with the duct classification and services.

L. Where sealing is required it means the following:

1. The use of adhesives, gaskets, tape systems, or combinations of these to close openings in the surface of the ductwork and field-erected plenums and casings through which air leakage would occur or the use of continuous welds.
2. The prudent selection and application of sealing methods by fabricators and installers, giving due consideration to the designated pressure class, pressure mode (positive or negative), chemical compatibility of the closure system, potential movement of mating parts, workmanship, amount and type of handling, cleanliness of surfaces, product shelf life, curing time, and manufacturer-identified exposure limitations.
3. That these provisions apply to duct connections to equipment and to apparatus.

M. Transverse joints for all supply, return, make-up air and outside air ducts serving an application that requires ductwork to be inspected and cleaned periodically shall be gasketed flanged Vanstone joints with minimum 1.5 inch flanges fastened 6 inches on center or “Ductmate” transverse sheet metal duct connection system with manufacturer-furnished gasketing system. Gasket shall be “440 Gasket Tape” by Ductmate Industries, inc. or approved equal.

N. Duct transverse and longitudinal joints (except for the above requirements) shall be selected and used consistent with the static pressure class, applicable sealing requirements, materials involved, duct support intervals and other provisions for proper assembly of ductwork outlined in the SMACNA HVAC Duct Construction Standards – Metal and Flexible. Transverse joints T-15 through T-24, shown in Figure 2-1 are acceptable construction. Type L-2 (button punch snap lock) or Type L-3 (grooved seam) longitudinal seams, shown in Figure 2-2, are not acceptable.

O. Seal all ductwork seams, joints, fastener penetrations and fitting connections with sealants in accordance with SMACNA Seal Classification as required by SMACNA Duct Pressure Classification. All ductwork, regardless of pressure classification, shall have a minimum Seal Class A. Where ducts are not continuously welded, provide liquid, mastic, and embedded fabric tape type sealants or combination, and gaskets as required to meet the specified duct leakage allowance. Sealant composite fire and smoke rating, when tested in accordance with ASTM E 84, NFPA 255 or UL 723, shall not exceed Flame Spread of 25 and Smoke Developed of 50.

P. The aspect ratio (ratio of width to height) of rectangular ducts should be minimized to reduce pressure losses and initial costs. Duct aspect ratios should not exceed 4:1.

2.2 DUCT PENETRATIONS THRU FLOOR

A. Provide 4” high and 4” wide concrete pad all around opening at duct penetrations thru floors. Fill in space between duct and floor construction with mineral wool and fire rated sealant.

2.3 DUCTWORK MATERIALS

A. All interior ducts shall be constructed with G-90 or better galvanized steel (ASTM A653/653M) LFQ, chem treat. Exterior ductwork or duct exposed to high humidity conditions (i.e. kitchen exhausts) shall also be G-90 or better galvanized steel LFP, chem treat.

B. Stainless steel duct shall be fabricated from lock forming grade, 300 series, ASTM-AI67, No. 4 general purpose finish. Protect finish with mill applied adhesive protective plastic/paper throughout construction.

C. Flexible Duct shall be factory constructed and listed in accordance with UL 181. Integral fiberglass or mineral fiber insulation shall provide a U value of .25.

2.4 PERMITTED DEFLECTION

A. Joints

1. Up to 48” wide – ¼”
2. 49” – 120” – W/200

B. Sheet

1. 12” and less – 3/8”
2. 13” – 18” – ½”
3. 19” – 24” – 5/8”
4. 25” – 84” – ¾”
5. 85 and larger – 1”

C. Reinforcement

1. Provide mid-panel tie rod, reinforcement and /or where required to control deflection within indicated limits. Details of construction and attachment shall be per SMACNA.

2.5 RECTANGULAR DUCT

A. Construct rectangular ductwork in accordance with Section II and to meet all functional criteria defined in Section VII, of the SMACNA “HVAC Duct Construction Standards Metal and Flexible”, 2005 Edition. All ductwork must comply with all local, state and federal code requirements.

B. All rectangular ductwork, unless otherwise noted, shall be built from galvanized sheet steel and thoroughly braced and stiffened

C. Where the standard allows the choice of external reinforcing or internal tie rods, only the external reinforcing options shall be used.

D. Pittsburgh lock shall be used on all “rectangular” duct longitudinal seams. All longitudinal seams shall be sealed with an approved sealant or pre-sealed with an encapsulated mastic or butyl E.P.D.M. rubber on all rectangular duct.

E. Pittsburgh lock shall be used on all longitudinal seams. All longitudinal seams will be sealed with mastic sealant. Snaplock is not acceptable.

F. Ductmate or W.D.C.I. proprietary duct connection systems will be accepted. Duct constructed using these systems will refer to the manufacturers guidelines for sheet gauge, intermediate reinforcement size and spacing, and joint reinforcements.

G. Formed on flanges (T.D.C./T.D.F./T-25A/T-25B) shall be constructed as SMACNA T-25 flanges, whose limits are defined on Page 1.36 1995 SMACNA Manual, Second Edition. No other construction pertaining to formed on flanges, will be accepted. Formed on flanges shall be accepted for use on ductwork 42” wide or less, 2” static (positive) or less and must include the use of corners, bolts and cleat.

H. Ductmate type systems that use a butyl Rubber Gasket which meets Mil-C 18969B, Type II Class A, TT-C-1796 A, Type II Class A, and TTS-S-001657 must also pass UL-723. This material, in addition to the above, shall not contain vegetable oils, fish oils, or any other type vehicle that will support fungal and/or bacterial growth (as defined in 21CFR 177, 1210 closures with sealing gaskets for food containers).

I. Aluminum duct shall be fabricated using the aluminum thickness equivalence table in the standard. Simply increasing the thickness by two gauges is not acceptable.

J. Fittings shall be constructed and reinforced as ductwork according to the longest span.

K. For duct construction pressure 2” w.g. or below based on external static pressure of fan:

1. Flat areas of duct over 18 in. wide shall be stiffened by cross breaking or beading.
2. All joints to have corner closures.
3. All joints shall be sealed with Foster 32-19, Childers CP-146 or Ductmate PROseal UL 181B-M listed mastic.

2.6 ROUND AND OVAL DUCT

A. Round and oval duct shall be galvanized steel, constructed in accordance with SMACNA “Duct Construction Standards, Metal and Flexible”, except as noted. Duct shall be minimum 22 gauge. Submit product data sustaining the equivalency of such duct into SMACNA standard duct.

B. Provide flat side reinforcement of oval ducts as recommended by SMACNA standards. Do not use internal tie rod reinforcement unless specifically approved by Engineer.

C. Round ductwork shall be spiral lock seam for round ductwork systems higher than 2”. Example: Ductmate, Greenseam or approved equal. Gauges shall be in accordance with

SMACNA Duct Construction Standard and fittings in accordance with SMACNA Duct Construction Standard, except as noted.

1. Joints 0”-20” diameter, interior slip coupling beaded at center, fastened to duct with sealing compound applied continuously around joint before assembling and after fastening. Wrap joints with 3-inch wide duct tape.
2. Joints 21”-72” diameter, use 3 piece, gasketed, flanged joints consisting of 2 internal flanges (with integral mastic sealant) split to accommodate minor differences in duct diameter, and one external closure band designed to compress gasketing between internal flanges. Example: Ductmate Spiralmate or equal.
3. Companion angles shall be bolted to each other with 1/4 in. x 3/4 in. stove bolts, spaced not more than 6 inches apart.
4. Hangers shall be as described for conventional ducts, except that they shall be fastened to the reinforcing angles, or angle connections. Where this is not feasible cradle hangers with a bottom angle shall be used; angle shall be suspended by angles or rods. Piercing of ducts by hangers, pipes, fasteners, etc., will not be permitted.

D. Fittings shall be continuously welded, standing seam, or spot welded and sealed. Metal thickness and reinforcing shall be equivalent to the requirements of the largest span.

1. All elbows greater than 45” shall be radius type, R=1.5 times duct diameter.
2. Elbows less than 12” shall be of die stamped construction. Elbows 12” or greater shall be 5-piece construction.
3. Diverging and converging flow fittings shall be constructed with no excess material projecting from the body into the branch tap entrance. All such fittings shall be 45° “shoe” entrance, wye plus elbow, or 45° lateral branch. Special fittings such as heel tapped elbows and bullhead tees may be used only where shown on drawings. Adjustable elbows and straight saddle taps shall not be used. Low pressure adjustable elbows acceptable.
4. Provide bell mouth, conical tees or taps, laterals, reducers, and other low loss fittings as shown in SMACNA standard.
5. Coat galvanized areas of fitting damaged by welding with corrosion resistant aluminum paint or galvanized repair compound.

E. For duct construction pressure 2” w.g. or below:

1. Longitudinal seam sealed, self-locking snaplock duct is acceptable for round ductwork systems of 2” w.g. and lower.
2. All round snaplock pipe longitudinal seams shall be sealed with an E.P.D.M. rubber on all round self-locking longitudinal round pipe. Approved Manufacturer: Ductmate Industries “Green Seam” self-locking longitudinal round pipe or approved equal.

2.7 ALUMINUM DUCTWORK

A. Where transverse reinforcing angles are not required provide 1”x1”x1/8” black iron matched angles at joints and between joints at a maximum spacing of 4 feet.

B. Provide 1/8” thick gasket at all matched angles. Edge of duct shall be bent ½” over matched angle to obtain watertight seal. Rivet angle to duct and seal with listed sealer. Paint black iron angles prior to installation.

C. Aluminum ductwork shall be fabricated using the aluminum thickness specified in the standard. Increasing galvanized gauge by 2 gauges is not acceptable.

D. Aluminum duct shall be fabricated from lock forming grade, ally 3003-HI4, ASTM B209. Reinforcing angles, bars, tie rods, and other structural members shall be alloy 6061-T6. Hangers shall be 6061-T6 aluminum, or galvanized or painted steel with a dielectric isolation pad between the dissimilar metals.

2.8 EXTERIOR UNINSULATED DUCTWORK

A. Top of duct shall be sloped to drain at 1/4” per foot.

B. Any ductwork observed to pond water shall be replaced by contractor at his expense.

2.9 SOUND LINED DUCTWORK

A. Sound lined ductwork shall be constructed with an exterior layer suitable for environment and a perforated inner wall constructed of the same material as the duct. Inner lining shall be 3/32” diameter holes approximately 22% open area.

B. Sound lining shall be installed in a minimum 2” interstitial space between layers.

2.10 FLEXIBLE DUCTWORK

A. Duct shall conform to NFPA 90 and be UL listed.

B. Insulation shall be on the exterior of duct.

C. Maximum length shall be 6 feet or less.

D. Flexible ducts shall be listed by Underwriters Laboratories, Inc., complying with UL 181. Ducts larger than 200 mm (8 inches) in diameter shall be Class 1. Ducts 200 mm (8 inches) in diameter and smaller may be Class 1 or Class 2.

E. Factory made including mineral fiber insulation with maximum C factor of 0.25 at 24 degrees C (75 degrees F) mean temperature, encased with a low permeability moisture barrier outer jacket, having a puncture resistance of not less than 50 Beach Units. Acoustic insertion loss shall not be less than 3 dB per 300 mm (foot) of straight duct, at 500 Hz, based on 150 mm (6 inch) duct, of 750 m/min (2500 fpm).

2.11 MISCELLANEOUS DUCTWORK MATERIALS

A. General: Provide miscellaneous materials and products of the types and sizes indicated, and where not otherwise indicated, provide type and size required to comply with ductwork system requirements including proper connection of ductwork and equipment.

B. Double wall turning vanes shall be Harper double wall turning vanes fabricated from the same material as the duct. Tab spacing shall be SMACNA standard. Rail systems with non-standard tab spacings shall not be accepted. All tabs shall be used, do not skip tabs. Mounting rails shall have friction insert table, which align the vanes automatically. Vanes shall be subjected to tensile loading and be capable of supporting 250 lbs. when fastened per the manufacturers instructions. Approved Systems: Ductmate PRO-Rail.

C. Single wall splitter and turning vanes shall be custom fabricated as specified below.

D. Ductwork Support Materials: Except as otherwise indicated, provide galvanized steel fasteners, anchors, rods, straps, trim and angles for support of ductwork.

E. Duct Sealant:

1. Products:

a. United McGill
b. Ductmate Industries, Inc., PROSeal
c. Hardcast, Versa-grip 181
d. Precision
e. Uni-Mastic 181 Duct Sealer, UL Listed - Indoor
f. Unicast, PROseal - Outdoor

2. Description: Non-hardening, liquid or mastic elastic sealant.
3. Fire Rating: UL 289U listed and NFC 220(b).
4. UL listed: UL 181A/B listed

2.12 DUCT TAPE ROLLED SEALANT SEALING SYSTEM:

A. Manufacturers:

1. Design Basis: Hardcast. Foil-Grip 1402 181B-FX, UL listed.

B. Model:
1. Tape: DT
2. Indoor Adhesive: FTA-20
3. Outdoor Adhesive: RTA-50

2.13 FIBERGLASS DUCTBOARD

A. Fiberglass ductboard is not accepted without prior written approval from the specifier.

2.14 ACCESS DOORS

A. Wherever necessary in ductwork, casings or sheet metal partitions, provide suitable access doors and frames to permit inspections, operation and maintenance of all valves, coils, humidifiers, controls, smoke dampers, smoke detectors, fire dampers, filters, bearings, traps, or other apparatus concealed behind the sheet metal work. All such doors shall be of double construction of not less than No. 20 gauge sheet metal and shall have sponge rubber gaskets around their entire perimeter. Doors in insulated ducts of insulated casings shall have rigid fiberglass insulation between the metal panels.

B. All access doors in sheet metal ducts shall be hung on heavy flat hinges and shall be secured in the closed position by means of cast zinc clinching type latches. Where space conditions preclude hinges, use four heavy window type latches.

C. Doors into ducts shall in general not be smaller than 18" x 18" except for access door to fire dampers which will depend on size of fire damper.

D. Provide insulated or acoustically lined doors to prevent condensation where applicable.

E. Systems 3” w.g. or less shall utilize a hinged, cam, or hinged & cam square-framed access door.

2.15 FLEXIBLE DUCT CONNECTOR

A. Flexible duct connector shall be used where ductwork connects to fans of apparatus, or apparatus casing to fans so as to prohibit the transfer of vibration from fans to ductwork connecting thereto. Connectors will meet NFPA 90A and 90B specifications and provide an airtight and waterproof seal. Indoor installations shall be Neoprene or vinyl coated fabrics. Outdoor installations shall use Hypalon coated fabric. Connector shall be Ductmate PROFlex or approved equal.

B. The flexible connections shall be a minimum of 12" long including bands using extra wide fabric as specified and held in place with heavy metal bands, securely attached, to prevent any leakage at the connection points. The fabric shall have a maximum length of 10”.

C. Flexible connections shall be fabricated from an approved flame retardant fabric each having a maximum flame spread index/rating of 25 and a maximum smoke developed ration of 50.

Range hood exhaust Installations shall be Flame-Proof Silvaseal by Duro Dyne, Ductmate PROflex Neoprene, or equal.

Low Pressure Systems - neoprene coated glass fabric
- 30 ounce/sq. yd.

D. Flexible connections shall not be painted.

E. Flexible connections shall be installed between all rigid ductwork or casing and all air handling equipment.

2.16 ROOF MOUNTED DUCT SUPPORTS

A. Duct on roof shall be supported by an engineered prefabricated system specifically designed to be installed on the roof without roof penetrations, flashing or damage to the roofing material. The system shall consist of linear curbs with spread bases located along the length of the duct with a trapeze constructed to support the underside of the duct. The system shall be custom designed to fit the duct to be installed and the actual conditions of service. Loading shall not exceed 15 PSF of bearing surface.

B. Duct finishes shall be constructed independently of the support system and shall not be enveloped in the support system.

C. Curbs shall be located to bear on structural elements of the roof deck, not the roof deck itself.

2.17 SEISMIC RESTRAINTS

A. Provide seismic restraints as required for seismic zone.

2.18 HANGER AND SUPPORT MATERIALS

A. Hang and support ductwork as defined in Section 5 of the 2005 SMACNA Manual, “HVAC Duct Construction Standards, Metal & Flexible” Third Edition or as defined within.

B. Aircraft cable hanging system with easy lightweight mechanical adjustment system shall not be used for hanging HVAC and other mechanical applications.

C. Supports, bar / angle reinforcements, and other products that are not part of the duct that are manufactured of uncoated mild steel shall either be painted with two coats of primer or shall be manufactured of a galvanized equivalent material.

D. Hanger spacing not to exceed 8 feet.

2.19 FABRICATION

A. Construct rectangular ductwork to meet all functional criteria defined in Section VII, of the SMACNA “HVAC Duct Construction Standards Metal and Flexible” 2005 Edition. This shall be subsequently referred to as the SMACNA Manual. All ductwork must comply with all local, state and federal code requirements.

B. Ducts shall be neatly finished on the outside with all sharp edges removed.

C. Inside surfaces shall be smooth with no projections into the air stream except where otherwise indicated.

D. Transverse joints shall be made airtight with all laps in the directions of air flow.

E. All fasteners and attachments shall be made of the same material as the ducts.

F. Furnish test wells 12" on the center horizontally and vertically in the suction and discharge duct of each fan. Test wells shall consist of a 1" x 3/4", 125 lb., bronze, screwed hex bushing, secured to the duct with a bronze hex locknut on the inside of the duct. A 3/4" x 2" long standard weight bronze, screwed nipple and cap shall be fitted to the housing on the outside of the duct. Test wells shall be no. 699 as made by Ventlok or approved equal.

G. Make all changes in direction using 1.5 radius elbows where possible. Use splitter vanes or mitered rectangular elbows with turning vanes otherwise.

1. Use single thickness splitter vanes for all radius elbows less than 1.5 D = r.
   a. D = diameter of duct or width of duct (in plane of change-in-direction).
   b. r = radius of duct at duct center-line.
   c. Use “Curve Ratios” of 0.45 or greater (as defined by figure 3-7 of the 1989 ASHRAE Fundamentals Handbook).
2. Use single thickness turning vanes with no trailing edges in accordance with SMACNA Standards.
   a. All mitered, rectangular elbows in series.
   b. All mitered, rectangular elbows less than 36” in width (in plane of change-of-direction).
3. Use double width, airfoil type turning vanes with no trailing edges for all, rectangular elbows greater than 36” in width (in plane of change-of-direction).
   a. Isolated elbows have a minimum of 3D straight duct upstream and downstream of the change-in-direction.

H. Fabricate transition elbows with turning vanes at correct angle so entering and leaving edges are parallel or tangent to air flow.

I. All square elbows shall have factory-designed and built turning vanes with hollow vanes having different inside and outside curvature, similar to Tuttle and Bailey, Inc., "Ducturns". Shop fabrication vanes will not be approved. Where turning vanes are in conflict with the access doors to fire dampers. They shall be made movable, so that fire dampers shall be accessible.

J. All branch duct take-offs shall use 45° laterals or 45° “pants-leg” type fittings.

K. Dissimilar metals shall be connected with flanged joints made up with fiber or neoprene gaskets to prevent contact between dissimilar metals. Flanges shall be fastened with bolts protected by ferrules and washers made of the same materials as the gaskets. Where an aluminum duct is to be connected to a galvanized steel duct, the end of the galvanized steel duct shall be coated with heavy black asphaltum paint before connecting it to the aluminum duct.

L. Changes in shape and dimension shall conform to the following: Except where otherwise noted, for increases, in cross-sectional area, the shape of the transformation shall not exceed 1" in 7". Except where otherwise noted, for reductions in area, the slope shall not be less than 1" in 4" but 1" in 7" preferred.

M. Wherever it may be necessary to make provisions for vertical hangers of the ceiling construction passing through ducts, provide streamlined shaped sleeves around such ceiling construction hangers as to fully protect the duct from being punched with holes for the passage of such hangers. Any such streamlined sleeves shall be made air tight at top and bottom of ducts. In no case shall there be more than two rods in any 9 sq. ft. area. No rods shall pierce ducts smaller than 12" in horizontal area.

N. Fastener material shall match duct material.

2.20 DUCT CONSTRUCTION SCHEDULE

	Material	Gauge	Joints	Pressure Class	Seal Class
Round and oval supply air duct upstream of VAV	Galv	SMACNA	SMACNA	10”	A
Return air duct	Galv	SMACNA	SMACNA	-4”	A
Rectangular and round constant volume supply duct	Galv	SMACNA	SMACNA	6”	A
Outside air duct	Aluminum	SMACNA	SMACNA	2”	A
General Exhaust	Galv	SMACNA, 18 Ga. Min.	SMACNA	-6”	A
Toilet exhaust	Galv	SMACNA	SMACNA	-4”	A
Fan coil supply	Galv	SMACNA	SMACNA	2”	A
Exterior exhaust duct unless SST	Aluminum	SMACNA	SMACNA Watertight	-6”	A

2.21 FIRE DAMPERS

A. Galvanized steel, interlocking blade type, UL listing and label, 1-1/2 hour rating, 70 degrees C (160 degrees F) fusible line, 100 percent free opening with no part of the blade stack or damper frame in the air stream.

B. Fire dampers in wet air exhaust shall be of stainless steel construction, all others may be galvanized steel.

C. Minimum requirements for fire dampers:

1. The damper frame may be of design and length as to function as the mounting sleeve, thus eliminating the need for a separate sleeve, as allowed by UL 555. Otherwise provide sleeves and mounting angles, minimum 1.9 mm (14 gage), required to provide installation equivalent to the damper manufacturer’s UL test installation.
2. Submit manufacturer’s installation instructions conforming to UL rating test.

2.22 SMOKE DAMPERS

A. Maximum air velocity, through free area of open damper, and pressure loss: Low pressure and medium pressure duct (supply, return, exhaust, outside air): 450 m/min (1500 fpm). Maximum static pressure loss: 32 Pa (0.113 inch W.G.).

B. Maximum air leakage, closed damper: 0.32 cubic meters/min/square meter (4.0 CFM per square foot) at 750 Pa (3 inch W.G.) differential pressure.

C. Minimum requirements for dampers:

1. Shall comply with requirements of Table 6-1 of UL 555S, except for the Fire Endurance and Hose Stream Test.
2. Frame: Galvanized steel channel with side, top and bottom stops or seals.
3. Blades; Galvanized steel, parallel type preferable, 300 mm (12 inch) maximum width, edges sealed with neoprene, rubber or felt, if required to meet minimum leakage. Airfoil (streamlined) type for minimum noise generation and pressure drop are preferred for duct mounted dampers.
4. Shafts: Galvanized steel.
5. Bearings: Nylon, bronze sleeve or ball type.
6. Hardware: Zinc plated.
7. Operation: Automatic open/close. No smoke damper that requires manual reset or link replacement after actuation is acceptable. See drawings for required control operation.

D. Motor operator (actuator): Provide pneumatic or electric as required by the automatic control system, externally mounted on stand-offs to allow complete insulation coverage.

2.23 COMBINATION FIRE AND SMOKE DAMPER

A. Combination fire and smoke dampers: Multi-blade type units meeting all requirements of both fire dampers and smoke dampers shall be used where shown and may be used at the Contractor’s option where applicable.

2.24 INSTRUMENT TEST FITTINGS

A. Manufactured type with a minimum 50 mm (two inch) length for insulated duct, and a minimum 25 mm (one inch) length for duct not insulated. Test hole shall have a flat gasket for rectangular ducts and a concave gasket for round ducts at the base, and a screw cap to prevent air leakage.

B. Provide instrument test holes at each duct or casing mounted temperature sensor or transmitter, and at entering and leaving side of each heating coil, cooling coil, and heat recovery unit.

PART 3 - EXECUTION

3.1 INSPECTION

A. Contractor shall examine location where ductwork is to be installed and determine space conditions and notify Architect in writing of conditions detrimental to proper and timely completion of the work.

B. Do not proceed with the work until unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF DUCTWORK

A. Assemble and install ductwork in accordance with recognized industry practices, which will achieve air-tight and noiseless systems, capable of performing each indicated service.

B. Duct sizes shown on the Drawings at connection to fans or other equipment may vary in actual installation. Contractor shall provide transition pieces as required.

C. Fittings shall be configured to provide the least possible pressure drop.

D. Install each run with a minimum of joints.

E. Align ductwork accurately at connections, within 1/8” misalignment tolerance and with internal surfaces smooth.

F. Support ducts rigidly with suitable ties, braces, hangers and anchors of the type, which will hold ducts true-to-shape to prevent buckling. Supports shall be placed at each joint and change in direction up to a maximum spacing of 8 feet on centers.

G. Seal ducts in accordance with SMACNA requirements for pressure class indicated.

1. Indoor Ducts: Use liquid or mastic sealant, or tape system.
2. Outdoor Ducts: Use tape system.
3. Approved manufactured joining systems with gaskets may be used in lieu of transverse sealing.

H. Locate ductwork runs, except as otherwise indicated, vertically and horizontally and avoid diagonal runs wherever possible. Casing and hangers shall be installed straight and level and all shall be free of vibration and noise when fans are operating.

I. Hold ducts close to walls, overhead construction, columns, and other structural and permanent-enclosure elements of the building.

1. Limit clearance to 0.5” where furring is shown for enclosure or concealment of ducts, but allow for insulation thickness, if any.
2. Where possible, locate insulated ductwork for 1.0” clearance outside of insulation.

J. Ducts at ceilings shall be suspended from inserts in concrete slabs except where otherwise indicated. Inserts shall be Grinnel Fig. 279, 282, or 152 as required. Each duct shall be independently supported and shall not be hung from or supported by another duct, pipe, conduit or equipment of any trade. Duct hung below slabs less than 4” thick shall be supported from supplemental steel.

K. All fastenings to building structure shall be adequate to insure permanent stability of sheet metal work and shall be capable of resisting all applied forces.

L. Vertical ducts in shafts or passing through floors shall be supported by steel angles or channels, welded, riveted, screwed or bolted to ducts and fastened to building structural members at each floor level. Provide safeing to close all floor openings around ductwork - pack annular space with rockwool and 18 gauge sheet metal safeing. Floor openings in plenums shall have 1/2 inch diameter steel bars constructed in a 6”x6” grid.

M. Rigid connections between ductwork and non-rotating equipment shall be 12 inch on centers and shall be made with flanged joints, sealed with fireproof material (Fiber or Neoprene gaskets).

N. In finished spaces, conceal ductwork by locating in mechanical shafts, hollow wall construction or above suspended ceilings.

O. Where possible, avoid locating ducts on or near floor.

1. Where ducts must be located low, provide metal trestle to protect duct at places where duct will be climbed over.
2. Ducts at floor shall be supported by steel angles suitably anchored to floor construction.

P. Coordinate the layout with suspended ceiling and lighting layouts and similar finished work as well as other components of systems.

Q. Install access doors where necessary for inspection and maintenance.

1. Provide additional 12” x 12” access door at each low leakage damper.
2. Arrange access doors so that:

a. They open against the system air pressure wherever feasible.
b. Their latches are operable from either side, except where the duct is too small to be entered.

R. Where ducts pass through non-fire-rated interior partitions below ceiling and exterior walls:

1. Conceal the space between the construction opening and the duct or duct-plus-insulation with sheet metal flanges of the same gauge as the duct.
2. Overlap the opening on all sides by at least 1-1½”.

S. Provide volume dampers at all branch take-offs.

T. Provide conical or tapered taps with balancing dampers on all round ductwork takeoffs.

U. Where space permits, round or oval ductwork of equivalent diameter may be substituted for unlined rectangular ductwork.

V. Provide 22-gauge aluminum ductwork for the first 20 feet downstream of any aluminum grille. Slope duct towards grille at 1/8” /ft.

W. It is the intent to obtain ductwork construction with minimum leakage. The construction noted in Specifications can produce low or high leakage rates, depending upon the workmanship, particularly with regard to the connection at the top of the ducts. Guarantee that total diffuser volume, measured by means of velometer, shall be at least 95% of actual fan supply (measured by means of a duct traverse tank with a Pitot tube and water manometer). Seal the ductwork at joints with suitable sealers Ductmate PROseal sealant and tape. Use of "HARDCAST" or any other material is subject to Architect's approval.

X. Provide duct transitions, offsets and connections to dampers, coils, and other equipment in accordance with SMACNA Standards, Section II. Provide streamliner, when an obstruction cannot be avoided and must be taken in by a duct. Repair galvanized areas with galvanizing repair compound.

Y. Provide bolted construction and tie-rod reinforcement in accordance with SMACNA Standards.

Z. Construct casing, eliminators, and pipe penetrations in accordance with SMACNA Standards.

AA. Install fire dampers, smoke dampers and combination fire/smoke dampers in accordance with the manufacturer’s instructions to conform to the installation used for the rating test. Install fire dampers, smoke dampers and combination fire/smoke dampers at locations indicated and where ducts penetrate fire rated and/or smoke rated walls, shafts and where required by the Resident Engineer. Install with required perimeter mounting angles, sleeves, breakaway duct connections, corrosion resistant springs, bearings, bushings and hinges per UL and NFPA. Demonstrate re-setting of fire dampers and operation of smoke dampers to the Resident Engineer.

BB. Seal openings around duct penetrations of floors and fire rated partitions with fire stop material as required by NFPA 90A.

CC. Flexible ducts shall not penetrate any fire or smoke barrier which is required to have a fire resistance rating of one hour or more. Flexible duct length shall not exceed 1.5 (5 feet). Provide insulated acoustical air duct connectors in supply air duct systems and elsewhere as shown.

DD. Temperature range: -18 to 93 degrees C (0 to 20 degrees F) internal.

EE. Maximum working velocity: 1200 m/min (4000 feet per minute)

FF. Minimum working pressure, inches of water gage: 2500 Pa (10 inches) positive, 500 Pa (2 inches) negative.

GG. Duct Clamps: 100 percent nylon strap, 80 kg (175 pounds) minimum loop tensile strength manufactured for this purpose or stainless steel strap with cadmium plated worm gear tightening device. Apply clamps with sealant and as approved for UL 181, Class 1 installation.

HH. Flexible duct installation: Refer to SMACNA Standards, Chapter 3. Ducts shall be continuous, single pieces not over 4 feet long (NFPA 90A), as straight and short as feasible, adequately supported. Centerline radius of bends shall be not less than two duct diameters. Make connections with clamps as recommended by SMACNA. Clamp per SMACNA with one clamp on the core duct and one on the insulation jacket. Flexible ducts shall not penetrate floors, or any chase or partition designated as a fire or smoke barrier, including corridor partitions fire rated on hour or two hour. Support ducts SMACNA Standards.

II. Where diffusers, registers and grilles cannot be installed to avoid seeing inside the duct, paint the inside of the duct with flat black paint to reduce visibility.

JJ. Control Damper Installation:

1. Provide necessary blank-off plates required to install dampers that are smaller than duct size. Provide necessary transitions required to install dampers larger than duct size.
2. Assemble multiple sections dampers with required interconnecting linkage and extend required number of shafts through duct for external mounting of damper motors.
3. Provide necessary sheet metal baffle plates to eliminate stratification and provide air volumes specified. Locate baffles by experimentation, and affix and seal permanently in place, only after stratification problem has been eliminated.
4. Install all damper control/adjustment devices on stand-offs to allow complete coverage of insulation.

3.3 DUCT HANGERS

A. Low pressure ducts up to 24" on a side or up to 20" diameter shall be suspended with 16 gauge, galvanized strap hangers, 1" wide.

B. Low pressure ducts 25" to 40" on a side or 21" to 40" diameter shall be suspended with galvanized strap hangers 1" wide by 1/8" thick.

C. Strap hangers shall be bent 90˚, extended down sides of ducts and turned under bottom of ducts a minimum of 2". Strap hangers shall be fastened at ceiling with nuts, bolts and lock washers and to sides and bottom of ducts with sheet metal screws.

D. Rod type hangers shall be 3/8" diameter black steel rods threaded at both ends and bottom bracing angles on ducts, with nuts and lock washers.

E. Angle type hangers shall be extensions of side bracing angles on ducts, bent 90° at ceiling and fastened with nuts, bolts and lock washers.

F. Hangers for vertical ducts shall be as per SMACNA Duct Manual.

G. Stainless steel ductwork shall be supported with rod or angle type hangers, so that there will be no penetration of the stainless steel ducts.

H. Provide supplemental steel to span structure in areas where duct cannot be otherwise supported from primary structure.

I. Do not support ductwork from pipe, other ducts, ceiling system, metal deck, metal roof deck or furring.

J. Do not hang lighting or pipes from ductwork.

K. Do not use perforated hanger straps to support ductwork.

3.4 DUCT LEAKAGE TESTING

A. Installed ductwork shall be pretested prior to installation of access doors, take-offs, etc.

B. All leak testing shall be witnessed by the Engineer or representative of the Engineer. The Contractor shall give the Engineer 72 hours notice prior to testing. Any testing not witnessed by the Engineer or his/her representative, shall be considered invalid and will be redone.

C. Test the ductwork leakage for each system (air handler, exhaust fan, return fan, etc.) and totalize leakage on a per system basis.

D. Use the leakage formula from section 4 of the SMACNA HVAC Air Duct Leakage Testing Manual, 1st edition, for calculating the allowable leakage for each section of ductwork based on the leakage classifications listed below:

1. Pressure classification 4" and over- Leakage Class 6
2. Pressure classification 3" - Leakage Class 12
3. Pressure classification 2" - Leakage Class 24

E. All volume dampers, fire and fire smoke dampers, and duct access doors shall be installed prior to the testing; no additional leakage rates will be allowed for these components. In-duct coils and VAV boxes are not to be included in the leakage testing.

F. Provide summary reports for each system on a single table which list each section tested, surface area of tested section, allowable leakage, and measure leakage. Include the measured velocity pressure from the testing rig and a legible copy of the nomegraph used to determine the actual flowrate.

G. The final testing shall be performed as follows:

1. Perform testing in accordance with HVAC Air Duct Leakage Test Manual.
2. Use a certified orifice tube for measuring the leakage.
3. Define section of system to be tested and blank off.
4. Determine the percentage of the system being tested.
5. Using the percentage, determine the allowable leakage (cfm) for that section being tested.
6. Pressurize to 1.5 times operating pressure and repair any significant or audible leaks.
7. Repressurize and measure leakage.
8. Repeat steps 6 and 7 until the leakage measured is less than the allowable defined in step 5.

NOTE: It is recommended that the first 100'-300' of ductwork installed be tested to insure the quality of the workmanship at an early stage.

H. All transverse joints and longitudinal seams shall conform to SMACNA's Class A sealing requirements.

I. Constant Volume Systems/Supply Ductwork
Allowable Leakage 1% of design cfm

J. Constant Volume Systems/Return Ductwork
Allowable Leakage 2% of design cfm

K. Exhaust Systems 1% of design cfm

3.5 DUCTWORK STORAGE AND CLEANING

A. Cleaning:

1. Clean ductwork internally, unit-by-unit as it is installed, of dust and debris.

2. Clean external surfaces of foreign substances which might cause corrosion of metal or deterioration of paint.

B. Protection:

1. Store duct a minimum of 4” above ground or floor to avoid damage from weather or spills.
2. When internally cleaning duct work prior to installation or shipment to the jobsite,
all duct ends and openings must be covered prior to transporting with a dual Polyethylene protective film. Film must be securely affixed to protect against dirt and debris and must be translucent to facilitate inspection of interior surfaces without removing film. Film must have a minimum elongation of 600%, contain no VOC and leave no residue on duct after removal. Approved Manufacturer: Ductmate Industries ProGuard or approved equal.
3. Cleaning of new and existing supply ductwork in existing buildings. After completion of ductwork installation purge ductwork as follows:

a. Cover all supply registers and diffusers with oil cheese cloth.
b. Use supply fan and install temporary fan to provide air to the system for twelve (12) hours at 200% design flow.
c. Remove oil cheese cloth.

C. Ductwork contaminated or damaged above “shop” or “mill” conditions shall be cleaned, repaired or replaced to the Engineer’s satisfaction.

1. Ductliner pre-installed in stored duct which has become wet may be installed if first allowed to completely dry out.
2. Ductliner in installed ductwork, which has become wet must be completely removed and replaced.
3. Torn ductliner may be replaced by coating with adhesive if damaged is minor and isolated. Extensively damaged liner shall be replaced back to a straight cut joint.

3.6 ACCESS DOORS

A. Install access doors where necessary for inspection, adjustment or servicing. In no case shall access to any items of equipment requiring inspection, adjustment, or servicing require the removal of nuts, bolts, screws, wing nuts, wedges, or any other screwed or loose device. Access doors shall be minimum 18”x 18” unless duct size requires a smaller door.

B. Arrange access doors so that:

1. They open against the system air pressure, wherever feasible.
2. Their latches are operable from either side, except where the duct is too small to be entered.

C. Provide access doors as follows:

1. Downstream and upstream side of coils within 3'-0" of coil.
2. Upstream and downstream of each humidifier.
3. Every 50’ along length of duct requiring cleaning.
4. At each automatically controlled damper, fire damper, smoke damper or fire/smoke damper.
5. In paint spray booth exhaust, provide access door at each sprinkler head.
6. Every 12” along length of kitchen exhaust duct.
7. On actuator side of each motorized damper.
8. At the base of all risers.
9. At all intake plenums.
10. At all smoke detectors.
11. At all valves, controls, filters, bearings, traps, drains, etc.

D. Hinges shall be Ventlok No. 150 or 260 with or without screw holes or approved equal. Latch for walk-in access doors shall be No. 260 as made by Ventlok Co. or approved equal. Latch for access door in ductwork shall be Ventlok No. 100 or approved equal.

E. Provide 4” high and 4” wide concrete pad all around opening at duct penetrations thru floors. Fill in space between duct and floor construction with mineral wool and fire rated sealant.

END OF SECTION

SECTION 23 33 00

DUCTWORK ACCESSORIES

PART 1 - GENERAL

1.1 INDUSTRY STANDARDS

A. Comply with SMACNA (Sheet Metal and Air Conditioning Contractors' National Association) latest recommendations for fabrication, construction and details, and installation procedures, except as otherwise indicated.

1.2 SUBMITTALS

A. Product Data: Submit manufacturer's product data on the following:

1. Flexible duct
2. Fire dampers
3. Smoke dampers

PART 2 - PRODUCTS

2.1 INSULATING AND SOUND REDUCING DUCT LINING FOR LOW PRESSURE DUCTWORK

A. Furnish and install all soundproofing material specified, indicated or necessary to that all systems will comply with requirement of quiet operation. In general, noise level in any part of building (except in machinery rooms), due to air conditioning or ventilating equipment, ducts, and outlets, shall not exceed 40 decibels at 1200-2400 cycles per second, except as otherwise hereinafter specified.

B. Furnish and install sound-absorptive lining in ductwork for locations and lengths as indicated and/or hereinafter specified. All soundproofing material, installation and arrangement, shall be as approved. Where ducts are acoustically lined, insulation shall be omitted for extent of acoustic lining. Dimensions noted for lined ducts are inside clear dimensions. Duct sizes shall be increased for liner.

C. Sound Absorbent Duct Lining for Low Pressure Ductwork - furnish and install as herein specified and/or shown on the drawings (except where otherwise noted) 1-1/2 lb. density, fibrous glass or polyester duct lining meeting the requirements of NFPA 90A.

1. 1" thick when installed in conditioned space
2. 1.5" thick, R-6 when installed in unconditioned space
3. 2" thick, R-8 when installed outside.

D. Liner shall be adhered to all interior sides of duct with minimum 100% coverage of fire-retardant adhesive similar to Benjamin Foster4 or PROtack spray by Ductmate Industries and with weld pins and washers or equivalent mechanical fastening starting 3" from edges and sides, 12" on center all sides. Minimum one row per side for duct size of 12" or less. Mechanical fasteners shall cause quilting of surface. Coated surface or FSK facing shall be toward air stream. Before installing liner, seal all butting edges and final edges with heavy coat of adhesive to seal off air between lining and duct. All exposed edges of lining shall be installed with sheet metal nosing 1-1/2" wide, two gauges heavier than duct. Installation shall be suitable for duct velocities up to 5,000 fpm. Low pressure duct lining shall be provided where specified and/or where shown and noted on the drawings. Liner support pins on aluminum duct shall be riveted to duct wall with closed end rivits.

E. Duct sizes indicated on drawings are clear inside dimensions. Increase sheet metal sizes as required to install acoustic lining.

F. The following ductwork shall be acoustically lined whether or not shown on Drawings.

1. Ductwork 10’ downstream of mixing box and terminal units.
2. Single wall built-up casing walls and ceiling except that lining shall be 2" thick 4 lb. density, and inner liner of perforated galvanized sheet metal (7/64" dia. holes on 3/16" staggered centers) shall be used for all systems.
3. All supply air ductwork within 20' of fan discharge.
4. All return and exhaust ductwork within 20' of fan intake.
5. Return air fan and toilet exhaust plenum walls and ceiling, except lining shall be 2 inch thick 4 lb. density, and inner liner of perforated galvanized sheet metal (7/64" dia. holes on 3/16" staggered centers) shall be used.
6. Outside air duct to air handling units.
7. All supply, return and exhaust ductwork installed exposed to conditioned space.

G. All ductwork not indicated to be lined shall be externally insulated.

2.2 ACOUSTICAL PERFORMANCE WITHIN EQUIPMENT SPACES

A. Equipment room noise levels and noise transmission to adjacent buildings shall comply with all Federal, State, and City Noise Ordinances.

B. Motor Acoustical Performance:

1. Motor drives for pumps and refrigerator machine when installed per plans and specifications shall operate with noise levels not to exceed 80 decibels.

2. Noise levels shall be determined in accordance with IEEE Standard #85 test "procedure for Air-Borne Noise Measurements on Rotating Electric Equipment".

2.3 BALANCING DAMPERS

A. At each main branch take-off and in such other locations where required to properly balance the low pressure system, furnish and install volume dampers of the opposed blade, multi-louvered type, which shall be operated by indicating quadrants and set screws, for adjusting the system.

B. Volume dampers shall be constructed as follows: Damper blades shall not be wider than 12", shall be complete with heavy angle iron frames, connecting and operating links, brass trunnions, and bronze bearings. Dampers, unless otherwise noted, shall be fabricated with not less than No. 16 gauge sheet steel. Blades shall overlap and shall be provided with continuous stops on all four sides of dampers to prevent leakage. Blades shall be galvanized. Blades of dampers shall be set into a flat steel frame with frame securely bolted to the duct. All dampers shall be fitted with a hexagonal brass spindle which shall extend through the exterior of duct and be fitted with an indicating self-locking regulator. Regulator shall be similar to Ventlok 641 or approved equal. All hardware shall be Ventlock or approved equal. For insulated ductwork provide No. 644 self-locking regulator as made by Ventlok or approved equal.

C. Maximum of two blades without a frame: Over two blades, use a manufactured 16 gauge galvanized stiffened, opposed blade damper in a 14 gauge galvanized steel frame. All hardware shall be galvanized except bronze iolite bearings; Pottorff Model MD-42 or approved equal.

D. All automatic dampers shall be furnished as a part of the automatic temperature control system by the automatic temperature control manufacturer. Install dampers and provide safeing in ductwork for automatic dampers smaller than duct size.

E. Movable splitter dampers shall be provided at each and every supply take-off and wherever else indicated. Dampers shall be airfoil, double-wall type. Splitter damper assembly shall be Ventlok 603 Ball Joint Bracket and 600 Blade Bracket or approved equal. All hardware shall be Ventlok or approved equal. Blades to be spot welded or pivoted to shafts. Elevated regulators shall be provided for insulated ductwork.

F. For stainless steel and aluminum ductwork provide dampers of same material as ductwork.

G. All dampers shall be made accessible from building construction. Access doors in building structure shall be furnished or provided as herein before specified.

H. Maximum pressure drop in full open position (@3000 fpm): 0.55

I. Maximum leakage: 32 cfm/sf at 4” W.C.

J. Provide cable operated dampers for all balancing dampers located above hard/inaccessible ceilings. Manufactured by Young Regulator or approved equal. Termination options are subject to Architect’s approval.

2.4 FIRE DAMPERS

A. Manufacturers:

1. Design Basis: Ruskin
2. Other Acceptable Manufacturers:
   a. Prefco
   b. Air Balance
   c. Safe-Air
   d. United Air
   e. United Sheetmetal
   f. National Controlled Air
   g. Air Control Products
   h. Greenheck

B. Rating: UL555 dynamic 1-½ hours (2 hour wall), or 3 hours (3 or 4 hour wall), UL555S Class II leakage rated. Match construction penetrated. FM approved.

C. Size: Metal-to-metal for lined and unlined ducts.

D. Fusible link only. Use Type B "Top Hat" wherever possible.

E. Clearly indicate damper location on shop drawings. Provide access doors in the ducts and furnish access doors or panels at building construction at each damper of sufficient size and type to permit inspection and replacement of linkage. Assume responsibility to coordinate all locations of duct access doors with the <u>General Contractor</u> to conform with whatever architectural openings may be necessary and furnish access doors or panels in building construction. Provide shop drawings indicating location of access panels or doors for Architect's approval.

F. It is the intention of these plans and specifications to be complete. However, it is the responsibility of this Division, as being completely cognizant of local regulations, to determine where fire dampers are required and to advise the Architect prior to bid as to any discrepancies or questions in the plans or specifications.

G. Fire dampers shall be enclosed in integral UL/FM approved sleeve of fourteen gauge metal set and grouted into fire partitions. Sleeve shall be secured at both sides of fire partitions with 1-1/2 x 1-1/2 x 1/4 ga. mounting angles secured to sleeves only. Provide duct breakaway connections, see detail on drawings. Sleeves shall be continuously welded with the transverse joint sealed. Flanged duct/sleeve connection shall be UL listed.

H. Dampers shall be steel plate, mounted to turn freely, in steelplate frame inserted in duct. Dampers shall be proportioned and weighted to close at once, if released from link with spring catches to hold closed, until manually reset. Dampers and frames to have suitable eyes, standard fusible-links, normally holding them open, but releasing upon contact with fire. Damper blades shall be mounted on corrosion resisting bearings. Damper shall close by gravity, moving with the air stream to full closed position against one-eighth (1/8) inch angle stop. Steel spring catch shall hold damper closed. Radius arm on shaft shall show position of damper. Submit details for approval. Dampers shall be outside of air stream where space permits.

I. In stainless steel ductwork, provide stainless steel construction fire dampers similar to Fire Seal Model 119D.

2.5 FIRE/SMOKE DAMPERS AND DAMPER OPERATORS

A. Manufacturers:

1. Design Basis: Ruskin
2. Other Acceptable Manufacturers:
    a. National Controlled Air
    b. Johnson Controls
    c. Safe Air
    d. Prefco
    e. Air Balance
    f. Greenheck

B. Fire Damper Rating: UL Standard 555 Dynamic, 1-½ hour or 3 hours. FM approved.

C. Smoke Damper Rating: UL Standard 555S, Class II.

D. Each combination fire/smoke damper shall be 1-1/2 or 3 hour fire rated under UL Standard 555, and shall further be classified by Underwriters Laboratories as a Leakage Rated Damper for use in smoke control systems under the latest version of UL555S, and bear a UL label attesting to same. Damper manufacturer shall have tested, and qualified with UL, a complete range of damper sizes covering all dampers required by this specification. Testing and UL qualifying a single damper size is not acceptable. The leakage rating under UL555S shall be leakage Class 2 (10 cfm/ft. at 1" w.g.).

E. Jackshaft penetrations shall be provided with a factory installed shaft seal, field sealing of the shaft is not acceptable.

F. Damper Assembly:

1. Type: 120 volt.
2. Listing: UL 555S, UL555.
3. Rating: Match wall rating.
4. Failure Position: Fail closed.
5. Fusible Link: 165°F fusible link.
6. Blade: Air foil.
7. Seals: Mechanically fastened, rated up to 450°F.
8. Smoke Detector: Duct mounted within 4’ of damper. Activation of detector shall close damper and alarm fire alarm system.

G. Clearly indicate damper location on shop drawings. Provide access doors in the ducts and furnish access doors or panels at building construction at each damper of sufficient size and type to permit inspection and replacement of linkage. Assume responsibility to coordinate all locations of duct access doors with the General Contractor to conform with whatever architectural openings may be necessary and furnish access doors or panels in building construction. Provide shop drawings indicating location of access panels or doors for Architect's approval.

H. Where part of Smoke Control System.

1. Provide end switch for positive indication of damper position.
2. Provide means to re-open damper remotely in the event thermal link trips. Allow for re-open up to elevated rating of 350°F, after which the elevated temperature high-limit override shall close the damper.

I. Combination fire/smoke dampers shall meet or exceed the following specifications. Frame shall be a minimum of 16 gage galvanized steel formed into a structural hat channel shape with tabbed corners for reinforcement. Bearings shall be stainless steel sleeve turning in an extruded hole in the frame. The blades shall be airfoil shaped double skin construction with 14 gage equivalent thickness. Blade edge seals shall be silicone rubber designed to withstand 450˚F and jamb seals shall be stainless steel flexible metal compression type. Blade action must be parallel blade or opposed as required.

J. As part of the UL qualification, dampers shall have demonstrated a capacity to operate (to open and close) under HVAC system operating conditions, with pressures of at least 4" w.g. in the closed position, and 2000 fpm air velocity in the open position.

K. In addition to the leakage ratings already specified herein, the combination fire smoke dampers and their operators shall be qualified under UL555S to an elevated temperature of 250˚F, 350˚F, or 450˚F depending upon the operator. Appropriate electric operators shall be installed by the damper manufacturer at time of damper fabrication. Damper and operator shall be supplied as a single entity which meets all applicable UL555 and UL555S qualifications for both dampers and operators. Manufacturer shall provide factory assembled sleeve of 16" minimum length (contractor to verify requirement). Sleeve shall be 20 gage for dampers through 36" x 48" and 18 gage above 36" x 48". Sleeve shall be continuously welded or sealed and the transverse joint shall be sealed. Flanged duct sleeve connection shall be UL approved. Damper and operator assembly shall be factory cycled 10 times to assure operation.

L. Each combination fire/smoke damper shall be equipped with a UL Classified Firestat equal to Ruskin model TS150. Firestat shall electrically and mechanically lock damper in a closed position when duct temperatures exceed 212˚F and still allow appropriate authority to override Firestat and operate damper as may be required for smoke control functions. Damper must be operable while temperature is above 250˚F. Firestat package shall include two damper position indicator switches linked directly to damper blade to provide capability of remotely indicating damper position. One switch shall close when damper is fully open; the other switch shall close when the damper is fully closed. Firestat and position indicator switches shall be capable of interfacing electrically with smoke detectors, building fire alarm systems, and remote indicating/control stations. Provide damper test switch and remote annunciation indicator. Dampers shall be Ruskin Model FSD36 with TS150 Firestat package.

M. Provide 3-function actuators where dampers are used to modulate air flow during normal operation.

1. Fire function
2. Smoke function
3. Modulating position control function

PART 3 - EXECUTION

3.1 INSTALLATION OF ACCESSORIES

A. Install fire, smoke and ceiling dampers in accordance with manufacturer's instructions and the latest version of the Fire, Smoke and Radiation Damper Guide for HVAC Systems, published by SMACNA.

B. Notify fire alarm provider of smoke damper control requirements and fire alarm interlocks.

C. Install flexible ductwork without tight bends and free of kinks.

1. Flexible ductwork shall not exceed 6' in length.
2. Flexible ductwork shall be installed with a "minimum length of straight duct" upstream of the diffuser neck inlet. "A minimum length" shall mean a length equal to three (3) duct diameters. "Straight duct" shall mean the center-line of the duct shall be aligned with a line perpendicular to the plane of the diffuser neck opening at the center point of the opening.
3. Conform to the detail on the drawings.

D. Install all dampers, including those furnished by control contractor.

1. Caulk damper frames to ductwork.
2. Make sure dampers are free to operate properly.
3. Install parallel blade mixing dampers to two streams impinge on each other to facilitate mixing.

E. Provide balance dampers at all branch take-off and where required to minimize balancing performed at diffuser face.

F. Provide all balance dampers as shown on plans and any additional dampers necessary to provide a balanced system meeting all sound requirements.

G. Fire and smoke dampers shall be provided with an approved means of access, large enough to permit inspection and maintenance. The access shall not reduce the fire-resistance rating of the assembly. Access point shall be permanently identified on the exterior by a label having letters not less than ½” in height reading: SMOKE DAMPER, FIRE DAMPER or FIRE SMOKE DAMPER.

END OF SECTION

SECTION 23 34 00

FANS

PART 1 - GENERAL

1.1 QUALITY CONTROL

A. Provide fans with AMCA performance certification and label.

1.2 MOTOR HORSEPOWER

A. Do not increase or decrease motor horsepower from that specified without written approval from Architect/Engineer. See Section 23 05 01.

1.3 SUBMITTALS

A. Manufacturer’s Data: Submit manufacturer’s product data including:

1. Performance
2. Size
3. Type
4. Options provided
5. Fan curves
6. Indicate Compliance with Section 1.1 where applicable.

PART 2 - PRODUCTS

2.1 IN-LINE CENTRIFUGAL FAN

A. Manufacturers:

1. Design Basis: As scheduled
2. Acceptable Manufacturers:
   a. Greenheck
   b. Cook
   c. Trane
   d. Aerovent
   e. Carrier
   f. Jenn Air
   g. Penn
   h. American Coolair
   i. Powerline
   j. Twin City
   k. Carnes

B. Cabinet: Steel, insulated, baked enamel finish with access panel.

C. Wheel: Cast aluminum Airfoil, statically and dynamically balanced. Cast aluminum hub.

D. Bearings: Heavy duty pillow black in enclosed duct with external grease fittings.

E. Guards: Belt.

F. Drive: See Schedule.

G. The fans shall be the square shaped and of heavy gauge formed steel. One of the sides shall be hinged and shall support the entire drive assembly (motor only for direct drive fans) and wheel allowing the assembly to swing out for cleaning, inspection or service without dismantling the unit in any way.

H. For direct drive fans, the motor shall be isolated from the air stream by a motor enclosure and shall draw cooling air from outside the fan housing.

I. For belt drive fans, the motor shall be mounted on the hinged side exterior isolated from air stream. The belt and pillow block ball bearings shall be protected from air stream by an enclosure. The shaft shall be keyed to both the wheel and pulley.

J. The fan inlet shall be spun Venturi throat overlapped by a backward curved centrifugal wheel with spun cone for maximum performance.

K. Air and sound shall be A.M.C.A. certified.

L. Install fan with spring type vibration isolators, threaded rods and expansion shields.

PART 3 - EXECUTION

3.1 NOISE AND VIBRATION

A. Insure that fans are properly supported on vibration isolators. Reference Section 23 05 48 for Vibration Isolation Requirements.

B. Insure that flexible duct connections are properly made.

C. Check fan for improper balance and have fan re-balanced if necessary.

D. Check for proper rotation.

E. Check for unusual noise or vibration and correct as necessary.

3.2 ACCESS

A. Provide for proper access to all parts of fan needing inspection or service with access doors in fan or ductwork.

3.3 INSTALLATION

A. Install units level and plumb.

B. Provide necessary auxiliary supporting steel.

C. Mount motor and drives so belts run true.

D. Provide necessary lubrication.

E. Provide flexible duct connections on inlet and discharge.

F. Provide 460v/120v transfer to serve controls and convenience outlet at all 460v fans.

G. Provide unfused disconnect of suitable capacity. Disconnect shall be weatherproof where installed outside or in a location subject to wetness.

H. Provide vibration isolators as recommended by manufacturer and other sections of this specification.

END OF SECTION

SECTION 23 37 00

AIR INLETS AND OUTLETS

PART 1 - GENERAL

1.1 CEILING CONSTRUCTION

A. Provide products compatible with ceiling construction.

1.2 SUBMITTALS

A. Submit catalog data including throw, sound, pressure drop, physical dimensions and color.

1.3 INDUSTRY STANDARDS

A. Provide products tested in accordance with ASHRAE 70-1991 150 Standard 5219, 150 Standard 3741.

PART 2 - PRODUCTS

2.1 GRILLES AND RECTANGULAR DIFFUSERS

A. Manufacturers:

1. Design Basis: As scheduled
2. Other Acceptable Manufacturers:
   a. Titus
   b. Carnes
   c. Anemostat
   d. Metal Aire

B. Material: Steel or aluminum except:

1. Where noted otherwise.
2. Where required otherwise for fire rating.
3. Grilles and diffusers in locker rooms, showers and toilet rooms to be aluminum.

C. Finish: Baked enamel with color selected by Architect.

D. Refer to Drawings for required performance.

E. Match frame and border types to ceiling system.

2.2 SQUARE CEILING DIFFUSERS:

A. Manufacturers:

1. Design Basis: Titus OMNI
2. Other Acceptable Manufacturers:
    a. Carnes Series SK or SE
    b. Krueger Series S
    c. Metal Aire Series 5000
    d. Anemostat
    e. EH Price Model AMD

B. Material: Steel or aluminum, louvered face furnished with frame type appropriate to installation, except:

1. Where noted otherwise.
2. Where required otherwise for fire rating.
3. Grilles and diffusers in locker rooms, showers and toilet rooms to be aluminum.

C. Finish: Baked enamel except where noted, color by Architect.

D. Louver cones shall be one-piece construction with no corner joints.

E. Directional blow pattern as shown on the drawings and/or as scheduled.

F. Refer to the Drawings for required performance.

G. Match frame and border types to ceiling system.

2.3 SIDE –WALL REGISTERS AND GRILLES:

A. Manufacturers:

1. Design Basis: Titus series 300(supply) and series 350(return/exhaust)
2. Other Acceptable Manufacturers:
    a. Carnes model R series
    b. Krueger series 880
    c. Metal Aire series V4000 or H4000
    d. Anemostat
    e. EH Price model NM22S/T or C22S/3

B. Material: Steel or aluminum except:

1. Where noted otherwise.
2. Where required otherwise for fire rating.
3. Grilles and diffusers in locker rooms, showers and toilet rooms to be aluminum.

C. Finish: Baked enamel except where noted, color by Architect.

D. Double deflection type blade supply registers and supply grilles allow deflection adjustment in all direction.

E. Opposed blade volume control damper supply registers, operable from face.

F. Fixed blade (0°, 45°) core return and exhaust registers and grilles.

G. Opposed blade volume control damper return registers, operable from face.

H. Register and grille sizes as shown on drawings and/or as scheduled.

I. Screw holes on surface counter sunk to accept recessed type screws.

J. Refer to the Drawings for required performance.

PART 3 – EXECUTION

3.1 GENERAL

A. Refer to architectural reflected ceiling plan for exact locations and ceiling types.

B. Install grilles, registers and diffusers as shown on drawings, in accordance with manufacturer's written instructions, and with recognized industry practices, to ensure that equipment complies with requirements and serve intended purposes.

C. Coordinate with other work as necessary to interface installation of equipment with other components of systems.

D. Furnish diffusers with equalizing grids where it is not possible to maintain minimum 2 duct diameter straight duct into diffuser. Equalizing grids shall consist of individually adjustable vanes designed for equalizing airflow into diffuser neck and providing directional control of airflow.

E. Unless otherwise indicated, size ductwork drops to diffusers or grilles to match unit collar size.

F. Seal connections between ductwork drops and diffusers/grilles airtight.

G. Where diffusers, registers and grilles cannot be installed to avoid seeing inside duct, paint inside of duct with flat black paint to reduce visibility.

H. Where registers and/or grilles cannot be installed to avoid seeing above the ceiling, paint the above the ceiling in the area of the register and/or grille with flat black paint to reduce visibility.

I. In clean rooms and animal holding rooms, caulk space between diffuser or grille and ceiling or wall to be air and watertight. User clear, non-hardening silicone sealant compatible with ceiling or wall surfaces. Sealant shall be resistant to microbiological growth.

J. Exposed mounting screws:

1. Use tamper proof screws in countersunk holes.
2. Point screws to match frame.

K. Fire Rated Ceilings:

1. Provide ceiling fire or fire/smoke damper that meets all applicable requirements of Section 23 33 00.
2. Provide insulation equivalent to ceiling construction above diffuser between ceiling opening and ceiling damper.

L. Install security type devices in accordance with manufacturer’s directions.

3.2 INSPECTION

A. Contractor shall examine location where this equipment is to be installed and determine space conditions and notify architect in writing of conditions detrimental to proper and timely completion of the Work.

B. Do not proceed with the work until unsatisfactory conditions have been corrected.

3.3 FIELD QUALITY CONTROL

A. Upon completion of installation of equipment, energized with normal power source, test equipment to demonstrate compliance with requirement. When possible, field correct malfunctioning units, then, retest to demonstrate compliance. Replace units which cannot be satisfactorily corrected. Refer to Testing and Balancing.

END OF SECTION

SECTION 23 40 00

AIR CLEANING

PART 1 - GENERAL

1.1 SUBMITTALS

A. Submit manufacturer's product data including:

1. Media:
    a. Description
    b. Efficiency
    c. Test method
2. Support requirements
3. Weight
4. Electrical data
5. Drawings showing dimensions

1.2 QUALITY CONTROL

A. All filters shall be listed as class II per UL Standard 900.

PART 2 - PRODUCTS

2.1 GENERAL

A. Furnish and install the air filters shown on the Drawings. The filters shall be component sections of air handling units or shall be installed in ductwork as indicated on the drawings.

B. Filters shall be as manufactured by: CamFill Farr Filtration Group Viledon Tri-Dim Corp.

C. The filter arrangements shall be as indicated in the schedule on the Drawings.

D. Fans and systems shall not be operated until protective filters have been installed. Filters which are required for operation before the Owner's acceptance of the systems shall be provided by this Contractor.

E. At the time of acceptance by the Owner, the Contractor shall install new filtering media in the high efficiency sections and shall provide new filter media rolls for all of the automatic roll type filter in which the rolls have been operated fifty percent or more of the rated capacity.

F. Air filters for built-up air handling systems shall be a combination of prefilter and after filters made by the same manufacturer and are to be so designed that the holding frames for the cartridge type after filters are installed in the structural frame of the automatic type prefilter.

G. When systems are operated during construction and balancing, prior to turning the installation over to the Owner, the after filter shall be of the dry type having an efficiently of not less than 40% an atmospheric dust by the National Bureau of Standards Dust Spot Test Method.

H. After balancing and prior to acceptance by the Owner each 40% efficient after filter cell shall be replaced with filter of the efficiency specified.

2.2 MEDIUM CAPACITY MERV 8 PLEATED AIR FILTER

A. Filters shall be medium capacity extended surface pleated air filters.

B. Filters shall be available in standard nominal depth of 2".

C. Filter shall be the Camfil Farr 30/30, or an approved equal.

D. This type of filter is employed as a pre-filter in dry environments.

E. Media shall be 100% synthetic or polyester/cotton blend, mechanical media that does not support microbial growth.

F. Frame shall be a heavy duty, high strength, moisture resistant paperboard with a cross member design that increases filter rigidity and prevents breaching. Frame shall be made with 100% recycled paperboard with an average of 35% post-consumer content. Frame shall be recyclable.

G. Filters shall have a paperboard or expanded metal support grid bonded to the air-exiting side of the filter to maintain pleat uniformity and prevent fluttering. Paperboard and metal support grid shall be recyclable and contain a significant amount of post-consumer and pre-consumer content.

H. Filters shall be MERV 8 in a medium capacity configuration when fully tested in accordance with the ASHRAE 52.2-2007 Test Standard.

I. Initial resistance of filters shall not exceed the following, based on the following face velocities:

Filter Depth	Airflow Velocity	Init Pressure Drop
2”	500 fpm	0.31” w.g

J. Filters shall have a recommended maximum final resistance of 1.0" w.g.

2.3 FILTER GAUGES

A. Provide draft gauges for each after-filter and pre-filter for measuring the resistance of the air through the filters.

B. Dwyer Mangehelic Series 2000.

C. Provide mounting bracket, tubing, static pressure tips and vent valves.

D. Gauges shall be neatly mounted on the side of the filter housing.

PART 3 – EXECUTION

3.1 INSPECTION

A. Contractor shall examine location where this equipment is to be installed and determine space conditions and notify architect in writing of conditions detrimental to proper and timely completion of the work.

B. Do not proceed with the work until unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install filters and hosings where shown, in accordance with manufacturer's written instructions, and with recognized industry practices, to ensure that equipment comply with requirements and service intended purposes.

B. Coordinate with other work as necessary to interface installation of equipment with other components of systems.

C. Provide vertical and horizontal stiffening bars, blank offs, angle flashing as necessary to install built up filter banks in plenum. Gasket or caulk between frame members, flashings, and blank offs.

D. Provide filter gauges to measure pressure drop of all filter banks.

E. Electric filters shall be field tested by the filter manufacturer. Filter manufacturer shall provide start up for the filters.

F. Contractor shall provide a filter replacement matrix schedule for each unit indicating size and filter type.

G. Provide and install a clean set of filters in all equipment prior to turn over to owner and one spare filter for each unit. For units with multiple filters provide a spare filter for each type.

END OF SECTION

SECTION 23 55 22

HEATING CABLES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. The requirements of the General Conditions, Supplementary Conditions and Division 26 Materials and Methods, Grounding, and Wires and Cables.

1.2 SUMMARY

A. Furnish and install all electric heating cable systems as specified herein and as required for freeze protection, and heating of piping, valves, fittings, drains, etc., as indicated on the Drawings. Division of work shall be as follows:
   1. Plumbing and HVAC Contractors shall provide the heating cables and power distribution panels with alarm breakers, and ground fault protection.
   2. The Electrical Contractor shall receive the power distribution panels and heating cables from the plumbing Contractor and install and provide power wiring to the heat trace cables.
   3. The Temperature Controls Contractor shall provide and install low voltage wiring to the BMS system and assign alarm points for each panel.

1.3 CODES, APPROVALS, AND STANDARDS

A. The electric heat-tracing system shall conform to the specification. It shall be designed, manufactured, and tested in accordance with the applicable requirements of the latest edition of the following codes and standards:

FM	Factory Mutual Research Corporation
EEE 515	Institute of Electrical and Electronics Engineers
NEC	U.S. National Electric Code (NFPA 70)
NEMA	National Electrical Manufacturers Association
UL 746B	Underwriters' Laboratories, Inc.
ANSI	American National Standards Institute
CSA	Canadian Standards Association

B. Each electric heating cable system and all components shall be designed, manufactured and tested in accordance with the latest applicable UL, NEMA, and ANSI Standards as well as NFPA 70 - National Electrical Code (NEC) UL508A.

C. All equipment and material to be furnished and installed on this Project shall be UL or ETL listed in accordance with the requirements of the authorities having jurisdiction, and suitable for its intended use on this Project.

1.4 ENGINEERING

A. The vendor shall be given a line list from which to design and estimate a complete heat-tracing system. The bid package shall also include area layout and orthographic drawings.

B. The vendor shall provide a detailed design utilizing standard heat-tracing design software, such as Chromatrace. At minimum, the design must provide the following:

1. Circuit identification number.
2. Maintain temperature.
3. Line size and insulation.
4. Heat loss for pipe, valves, and supports.
5. Amount and type of heating cable required.
6. Spiral requirements.
7. Heating cable service voltage.
8. Heating cable power output at the maintain temperature.
9. Uncontrolled pipe temperature at maximum ambient.

1.5 FIELD SUPPORT AND TRAINING

A. The material shipments shall include a detailed installation and maintenance manual for all products included in shipment.

B. The local vendor (Faber Industrial Technologies, Inc. – Clifton, NJ 973-546-7900) shall maintain qualified field service personnel to assist in installer training, system commissioning and basic troubleshooting.

1.6 REFERENCE STANDARDS

A. Each electric heating cable system and all components shall be designed, manufactured and tested in accordance with the latest applicable UL, NEMA, and ANSI Standards as well as NFPA 70 - National Electrical Code (NEC) UL508A, with City of New York Amendments.

B. All equipment and material to be furnished and installed on this Project shall be UL or ETL listed and bear an MEA listing as necessary for the City of New York in accordance with the requirements of the authorities having jurisdiction, and suitable for its intended use on this Project.

1.7 SUBMITTALS

A. The following submittal data shall be furnished according to the General Conditions and shall include, but not be limited to:
   1. <u>Electric Heat Tracing System</u> including cables, fittings, thermostats, installation details, circuit capacities, operational details, power distribution panel for group control, etc.

B. Submit Shop Drawings for review prior to installation. Shop Drawings shall show the overall system and each circuit, control locations, cable lengths, current required for each circuit and feed points. Provide a summary sheet of the entire system with capacity data for each line, valve, etc. See Section 26 05 02 for Shop Drawing requirements.

1.8 WARRANTY

A. Comply with the requirements of the General Conditions and Section 26 05 02.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Manufacturers:

1. Design Basis: Raychem.
   a. Model: XL-Trace for freeze protection applied between pipe and insulation.
   b. Model: Ice stop for freeze protection applied inside storm drain leaders and down spouts.
2. Other acceptable manufacturers:
   a. Thermon
   b. Nelson
   c. Chromalox

2.2 ELECTRIC HEAT TRACING SYSTEM FOR WATER PIPING

A. Heat tracing system shall be designed to maintain the water temperature within the piping to at least 40ºF, but not greater that 80 ºF, with an ambient temperature of 0ºF The piping will be insulated as specified in Division 22 in Section titled “Plumbing Insulation”.

B. Heating cables shall be UL listed electrical heating strips. The electric heat tracing may be a self regulating type of parallel circuit construction consisting of a continuous inner core of self regulating conductive material between two parallel copper bus wires suitable for operation on 120, 208 or 277 Volts, 60 hertz, single phase power. The heat tracing strips shall be capable of being cut to the desired length in the field. Operating energy shall be conserved by the self regulating feature of the heater materials, which automatically controls heat output in proportion to the heat requirement.

1. Self regulating at all points along its length.
2. 90% power reduction from 40ºF pipe temperature to 150º pipe temperature.
3. No overheating if crossed.
4. Provide outer jacket and braided copper shield for use inside roof drain leaders or on piping without a ground path.
5. UL listed and approved for use in Hartford.

6. Provide tee, splice, and end seal kits as required by the manufacturer.
7. Provide ambient sensing thermostat in a NEMA 4x enclosure, with three (3) contacts rated at 22 amps each.

C. The heat trace cabling shall be controlled by power distribution panels specifically designed and built dedicated for heat trace systems. Confirm voltage and short circuit of main electric service with electrical drawings and provide a Panel which shall include a 100A main breaker, and branches fully rated for the available short circuit current, rated either 208 or 480 volt 3 phase, 4 wire with 120 or 277 volt branch breakers, 12 circuits with ground fault 30 mA trip, NEMA 4 panel with panel front H-O-A switch and status lights. Two sets of contacts shall be wired to the BMS, one to globally engage/disengage the heat tracing system and one alarm output.

PART 3 - EXECUTION

3.1 SCOPE AND REQUIREMENTS

A. Furnish and install a complete electric heating cable system, including but not limited to cable, panels, ambient air sensors, aquastats, and controls, on all water piping, fittings, drains, valves, and valve bonnets as indicated on the Drawings. The Electrical Subcontractor shall coordinate the cable installation with the Mechanical and Plumbing Subcontractors. See drawings for scope and locations.

B. All installation and materials furnished shall meet the NEC requirements and be Underwriters Laboratories listed for the application.

C. The installation and all materials, conductors, conduit, etc. utilized between the electric heating cable system, controls and distribution panels shall be as specified.

D. After the piping has been successfully pressure tested, heating cables shall be installed parallel to the pipe or by spiraling the strip to obtain the heating capacity required. All cables and components shall be installed as recommended by the manufacturer by properly trained personnel using the manufacturer specified tools and procedures and as specified herein. The heating cables shall be banded to the pipe with fiberglass tape per manufacturer recommendations. After the piping has been insulated, appropriate caution signs or markings shall be provided at frequent intervals along the pipeline in accordance with NEC requirements.

E. Heat trace cable shall be installed by a licensed electrician. HVAC or Plumbing contractor shall subcontract this work to a licensed electrician if HVAC contractor is not a licensed electrician.

F. Apply the heat trace cable on the pipe after pressure testing.

1. Do not spiral wrap on pipe.
2. Make one wrap at valves.
3. Secure to pipe with methods approved by manufacturer.

G. Apply “Electrically Traced” signs on outside of insulation.

H. Heat trace shall be sized as follows, based on 0ºF ambient, to maintain 40ºF pipe temperature:

PIPE SIZE	1” INSULATION	2” INSULATION
Less than 2”	3 w/ft.	3 w/ft
2”, 2½”, 3”	5 w/ft	3 w/ft
4”, 5”, 6”	8 w/ft	5 w/ft
8”, 10”, 12”	(2 cable circuits) 8 w/ft ea.	8 w/ft

I. Provide heat tracing on all pipes installed within the intake, relief and exhaust shafts.

J. Provide heat trace on all pipes installed in enclosed perimeter shafts where separated from the exterior only by precast panels.

K. After the piping has been successfully pressure tested, heating cables shall be installed parallel to the pipe or by spiraling the strip to obtain the heating capacity required. All cables and components shall be installed as recommended by the manufacturer by properly trained personnel using the manufacturer specified tools and procedures and as specified herein. The heating cables shall be banded to the pipe with fiberglass tape per manufacturer recommendations. After the piping has been insulated, appropriate caution signs or markings shall be provided at frequent intervals along the pipeline in accordance with NEC requirements.

L. The Electrical Subcontractor shall test all electric heating cable systems for short circuits, grounds and insulation resistance. Test with 1000 VDC to a minimum resistance of 20 mega ohms.

M. All heat trace circuits shall be monitored by the BMS system. Contractor shall provide all necessary hardware.

3.2 FIELD TESTING

A. Refer to Section 26 05 03 for additional testing requirements for electric heating cable systems.

END OF SECTION

SECTION 23 57 00

HEAT EXCHANGERS

PART 1 - GENERAL

1.1 QUALITY ASSURANCE

A. ASME construction:

1. Provide exchanger with ASME “U” stamp.
2. Provide inspection certificate.
3. Heat exchangers shall be designed, constructed, and tested in accordance with the latest version of Section VIII, Division I of the ASME Pressure Vessel Code, and shall be code stamped.

B. Submittals: Submit manufacturer’s product data.

1. Include the following:
   a. Materials.
   b. Design working pressure and temperature.
   c. Entering and leaving conditions.
   d. Fouling factors.
   e. Flow rates.
   f. Pressure drops.

C. The heat exchanger manufacturer shall have an established and on-going QA/QC program including manuals available for inspection at plant.

D. The heat exchanger manufacturer shall have extensive background and experience in the design and fabrication of heat exchangers. The manufacturer shall have fabricated heat exchangers for a minimum of twenty (20) years.

1.2 WARRANTY

A. The warranty period shall be 3 years from date of shipment for AHRI certified plate heat exchangers.

1.3 REFERENCES

A. ASME Section II - Material Specification
B. ASME Section V - Non-Destructive Testing
C. ASME Section IX - Welding and Brazing qualifications
D. ASME Section VIII - Pressure Vessel Code
E. AHRI Standard 400 - Liquid to Liquid Heat Exchangers

1.4 CERTIFICATION

A. Plate heat exchangers shall be certified according to AHRI Standard 400 and listed on the AHRI.org site http://www.ahridirectory.org/ahridirectory/pages/llhe/defaultSearch.aspx

PART 2 - PRODUCTS

2.1 SHELL AND TUBE HEAT EXCHANGERS

A. Manufacturers:

1. Design Basis: As scheduled.
2. Other Acceptable Manufacturers:
   a. Bell and Gossett
   b. Ace
   c. Adamson
   d. Patterson Kelley
   e. Taco
   f. Thrush

B. Construction:

1. Shell: Steel.
2. Heads: Cast iron.
3. Tube Sheet: Steel.
4. Tubes: Copper, 18 Gauge minimum
5. Type Supports: Steel

C. Steam to water heat exchangers shall be provided with steam in shell, water in tubes.

D. Construction: A manufacturer's test sheet report for unfired pressure vessels, form No. U-1, as required by the provisions of the ASME Code Rules, is to be furnished. This form must be signed by a qualified inspector holding a National Board commission certifying that construction conforms to the latest ASME Code for Unfired Pressure Vessels as detailed on form No. U-1. The ASME "U" symbol should also be stamped on the converter.

E. Shell and tubes shall have a minimum of 300 psig test pressure and 150 psig working pressure.

F. Fouling factor shall be 0.0005 unless otherwise scheduled on the Drawings.

G. Water velocity thru the tubes shall not exceed 7.5 feet per second.

H. Shell shall be provided with inlet and outlet tappings and tapping for pressure gauge and tapping for relief valve.

I. The heat exchanger manufacturer shall furnish (for installation by the Contractor) a one-inch brass mounted pop relief valve for connection to the water outlet pipe (between the heater exchanger and the shut-off valves). Valve to be set to discharge at a pressure of approximately 15 psi above the normal working pressure at the heat exchanger. Provide a brass mounted pop relief valve for connection to the exchanger shell. The relief valve shall be set to discharge at 5 psig pressure above the steam inlet pressure to exchanger and be of the size recommended by the exchanger manufacturer.

J. All heat exchangers shall have a pressure rating of at least 125 psig for both the shell and tube bundle, even if the operating pressures are less. For high pressure applications (above 15 psig), the shell and head shall be rated for the maximum steam temperature available at the building location.

K. Heat exchangers using low pressure steam shall be ASME rated for a minimum of 125 psig, with a 375˚F head and shell rating, and a 300˚F tube sheet rating.

L. Heat exchangers using high pressure steam shall also be ASME rated, and be piped and tested in accordance with the ASME Power Piping Code. Hydrostatic tests are required of all high pressure components, inclusive of tests across closed valves (leakage tests).

M. The operating pressure shall be established based on the type of pressure relief system required (see below).

N. The shell shall be provided with an ASME approved pressure/temperature relief device, piped appropriately.

O. For systems with redundant parallel heat exchangers, provide isolation on each exchanger.

PART 3 - EXECUTION

3.1 INSTALLATION OF SHELL AND TUBE HEAT EXCHANGERS

A. Support from floor. Provide all necessary steel.

B. Locate exchanger so tubes may be withdrawn.

1. Arrange piping so that tubes may be withdrawn without disturbing welded piping connections.

END OF SECTION

SECTION 23 64 16

ICE RINK REFRIGERATION AND PIPING

PART 1 - GENERAL

1.1 SCOPE OF WORK

A. This Section of the Contract includes all Ice Rink Equipment work called for or implied by the drawings and specification, together with all necessary incidentals whether referred to or not, as will be required to complete the work to the full intent and meaning of the drawings and specifications. The specification and drawings describe a complete and operational ice skating rink to be constructed as part of a performance based design-build contract. The work includes but is not limited to the following:

1. A central ice chiller plant to serve the arena ice sheet. The central plant will consist of one flooded evaporators (200 tons) and one evaporative condensers (200 tons). The evaporator and condenser are to be supplied by (2) nominal 100 ton reciprocating compressors. The condenser shall be supplied with condenser water via a separate two cell roof mounted cooling tower. The ice sheet will be served by a separate pumped brine loop including a respective brine pump and a 100% back-up pump.
2. Ammonia refrigerant.
3. Brine consisting of 40% ethylene glycol. Note, for these specifications, brine refers to the secondary fluid circulating through the ice slab.
4. All inter-connecting refrigerant piping.
5. Refrigerant charge and oil charge.
6. (2) Brine Pumps (1-100% standby).
7. (2) Condenser Pumps (1-100% standby) with 3-way control valve.
8. Brine balance tank.
9. Brine rink piping and floor is existing to remain.
10. Equipment housekeeping pads, with the exception of the ice chiller. The ice chiller shall be mounted directly on the slab. Level slab as required.
11. Insulation of cold brine piping and refrigerant piping.
12. Cutting and patching and sleeving by this Contractor for all condenser water, refrigerant water, brine piping, and relief piping.
13. Power and control wiring for all refrigeration equipment specified hereunder.
14. Grouting of all equipment.
15. Ammonia Refrigerant Detector.
16. Painting and Identification.
17. Start-up and testing.
18. Training.
19. Instruction and operating manuals and as-built drawings (6 copies).
20. Brine to building steam heat exchanger rated at 3,500 MBH for quick ice removal.
21. PLC Control System
22. Fire stopping.

23. NH3 steel absorption tank per code.
24. Evaporative Condenser.

1.2 QUALIFICATIONS FOR REFRIGERATION INSTALLER

A. Refrigeration Installer shall have installed a minimum of 5 artificial ice rinks of 10,000 seats or greater using ammonia and glycol within previous 10 years to be eligible to submit a bid on this work.

B. The Refrigeration Installer shall have adequate personnel and equipment, and shall be approved by the Architect and Engineer.

C. The Refrigeration Installer shall be able to satisfactorily service the equipment after installation, and shall provide 24 hour service for 1 year after acceptance of system by Owner.

D. The Refrigeration Installer shall employ only skilled welders, each holding a currently active certificate, dated within 12 months, from a recognized testing association, indicating satisfactory welding test results per the American Welding or ASME Boiler and Unfired Pressure Vessel Code, Section IX, Welding Qualifications. Retest is required if welder has not performed welding for a period of 90 days.

E. The refrigeration installer shall employ licensed electricians for electrical equipment installation and power wiring.

F. The Refrigeration Installer shall provide all product data, shop drawings, designs, daily logs, record documents and warranties. The Refrigeration Installer shall furnish, install and design a complete system including all engineering, shop drawings, submittals and design work, calculations, etc. All work (e.g. shop drawings, engineering, calculations, design work, etc.) to the extent required by applicable law, shall bear the seal of an engineer properly registered in the State of Connecticut. The Refrigeration Installer shall perform all work to obtain approval and permits of the ice floor system design and installed work from the local and State governing authorities and shall abide by all code requirements. The Refrigeration Installer shall include costs to pay for permits as necessary.

G. Basis of Design: Ice Builders

H. Other Acceptable Manufacturers:
1. Cimco Refrigeration
2. Pace Refrigeration
3. Frick

1.3 RELATED WORK GENERAL

A. The installation of all electrical work shall conform to the base building Division 26 Electrical specification.

1.4 RELATED WORK

A. Work by Other Subcontractor(s):

1. 1-1/2 inch cold water service to Mechanical Room.
2. Floor drains in mechanical room piped to a dedicated ejector pump.
3. 120V temporary power in equipment room for test and lighting purposes.
4. Steam to quick ice removal heat exchanger in the refrigeration room.
5. Domestic hot and cold water supply.
6. Condenser water treatment if dedicated ice cooling tower or evaporative condenser is utilized.
7. Condenser water piping routed to ice chiller room skid by Division 23.

1.5 REFERENCED STANDARDS

A. ANSI/ASHRAE 15 Safety Code for Mechanical Refrigeration. ASME Boiler and Pressure Vessel Code, Section VIII, Division 1.

B. BSR/IIAR 2 – Latest Addition - Standard for Safe Design of Closed-Circuit Ammonia Refrigeration systems.

C. All State and local code compliance to the current edition.

1.6 SHOP DRAWINGS

A. Provide 6 copies of shop drawings for the entire ice system. Shop drawings shall include all equipment specifications, ice floor layout, piping layout, piping schematic flow diagrams, motor control centers, electrical power diagrams, control diagrams and wiring and details of construction. Complete shop drawings shall be provided. No part of ice system will be released for construction until entire submittal is accepted by Engineer.

1.7 WARRANTY

A. The contractor shall warranty all parts and labor of the ice rink system for a period after the acceptance of the Owner and when they have assumed operation of the facility. Warranty on equipment shall be in effect for the duration of the time offered by the manufacturer of the equipment. The chiller package shall have full 2 year warranty.

B. The Refrigeration and Rink Piping Installer guarantees that he shall repair, replace, and install any or all parts, materials, or workmanship found to be defective or lacking in specified capacity as stipulated in foregoing specifications and/or shown on drawings. Guarantee includes necessary labor, as well as material and refrigerant required for repair, replacement, and/or 24 hour per day service for a year referred to above.

PART 2 - EQUIPMENT

2.1 GENERAL

A. Manufacturers and equipment specified below are for the purpose of setting a minimum standard of capacity and quality of equipment for the performance of the ice rink system.

Provide a complete and automatic flooded ammonia and 40% ethylene glycol brine refrigeration system capable of producing and maintaining ice conditions year round under the following specified design criteria.

1. Refrigeration Capacity of the system is a total of 200 tons. 5ºF Sat. Evap. Temp. and 105ºF Cond. Temp.
2. Rink design conditions:
   a. Dry Bulb: 65 ºF
   b. Wet Bulb: 43 ºF
3. Ambient:
   a. Wet Bulb: 78ºF
4. Primary Refrigerant: NH3 – Anhydrous Ammonia
5. Secondary Refrigerant: 40% Ethylene Glycol
6. Number of Evaporators: (1) @ 200 Tons
   a. Entering Fluid 17ºF / Leaving Fluid 14ºF
7. Number of Condensers: (1) @ 200 Tons
   a. Entering Water 85ºF / Leaving Water 95ºF
8. Number of Compressors: (2) @ 100 Ton (Total 200 Ton)
9. Electrical Supply (Power): 480V/3Ph/60 HZ.
   (Control) 120V/1Ph/60 HZ.
   a. All equipment shall be mechanically braced for an available fault of no less than 65,000 amps.
   b. Power supply will be divided into two feeds:
      1) Main Power #1(400 Amp Disconnect)
         a) (1) Compressor Motor 200 H.P.
         b) (1) Ice Slab Pump Motor – 40 H.P.
         c) (1) Condenser Pump Motor – 15 H.P.
      2) Main Power #2 (400 Amp Disconnect)
         a) (1) Compressor Motor - 200 H.P.
         b) (1) Ice Slab Pump Motor – 40 H.P.
         c) (1) Condenser Pump Motor – 15 H.P.
         d) (1) Control System (120/1/60)
10. Condenser:
   a. CWS = 85 ºF
   b. CWR = 95 ºF

2.2 REFRGERATION SKID

A. The refrigeration skid must be self-contained on a single factory fabricated, structural steel constructed and designed for the stresses associated with equipment transportation.

All major components must be factory mounted, assembled with all sub-assemblies (ie: refrigerant level control column, etc.) to provide a fully functional refrigeration "Chiller". The skid must also include a single power point, fully integrated control system including all power components (See controls section) factory wired control and power wiring. On site assembly will not be acceptable

B. The equipment specified shall be mounted "Skid" type construction and shall include:
1. Qty: 2 Compressors (200 Tons Total)
    a. Open drive screw type
    b. 200 H.P. High Eff. Motor (0.94)
2. Qty: 1 Condenser (200 Tons)
    a. Water-Cooled,
    b. Shell and Tube
    c. Dual relief valve
3. Qty: 1 Evaporator (200 Tons)
    a. Shell and Tube type
    b. 2" Factory Insulated
    c. Liquid Level control equipment. Danfoss, Hanson or Equal
    d. Dual relief valve
4. Qty: 1 Oil Separator
    a. Two Stage
    b. Coalescing Element
    c. Dual relief valve
    d. Oil Separator Heater
    e. Oil level, low level sight glass
    f. Oil level, low level safety switch
5. Qty: 1 Oil Pot
    a. Oil / Liquid feed line solenoid valve
    b. Oil / Liquid feed line isolation valve
    c. Oil / Liquid feed line hand expansion valve
    d. Oil / Liquid feed line sight glass
    e. Oil Pot heater

C. The skid frame shall be constructed of enough strength to not require concrete poured to absorb system vibration.

D. The skid frame shall be constructed of sufficient strength as to not require addition support during transportation and rigging into place on the job site.

E. The chiller skid shall be complete factory:
1. Refrigeration Pipe –
    a. Up to and including ½" shall be threaded Sch-80 pipe
    b. ¾" up to and including 1-1/2" shall be Sch-80 Socket weld
    c. 2" and over shall be Sch-40 Butt welded.
2. Control System –
    a. Single Power Point connection (See Special Instructions)
    b. ¾" up to and including 1-1/2" shall be Sch-80 Socket weld
    c. 2" and over shall be Sch-40 Butt welded.

2.3 BRINE EVAPORATOR

A. Dual refrigerant circuit, with Section VIII of the A.S.M.E. coded carbon steel shell and carbon steel tube insulated chiller vessel complete with:

1. Flow switch,
2. flow control valve

B. Flooded chiller shall be two parts all steel shell and tube type construction arranged for ammonia operation.

C. Design flow is approximately 1,200 gpm for 40% ethylene glycol, to maintain ice surface temperature of 20ºF with a 14ºF supply fluid, approximately 3ºF temperature difference and a capacity of approximately 200 Tons

D. Chiller to be constructed to ASME code and registered by the National Board for 300 psi working pressure.

E. Chiller to be equipped with dual pressure relief valves and bulls-eye (reflex type) sight glasses (min. 2) to establish operating level of refrigerant.

F. Chiller and surge drum to be factory insulated with 2” of foamed in place urethane insulation covered with a PVC or fiberglass jacket to protect against damage. Head covers (insulated) shall be removable without damage.

2.4 WATER-COOLED CONDENSER

A. Indoor Water-Cooled-High efficiency, shell and tube, water-cooled condensers manufactured in accordance with Section VIII of the A.S.M.E. Code complete with:

1. Pressure relief valve on our industrial units,
2. Water regulating valve(s) for head pressure control.

B. Water-Cooled Condenser shall be shell and tube type construction arranged for ammonia operation.

C. Design flow is water with 85ºF supply fluid, 95.0ºF leaving temperature and approximately 576 GPM.

D. Chiller to be constructed to ASME code and registered by the National Board for 300 psi working pressure.

E. Condenser to be equipped with dual pressure relief valves.

2.5 COMPRESSORS

A. Open Drive Screw Compressor

1. Compressor shall be of the heavy-duty, screw compressor open drive type design, and shall be capable of withstanding 250 psi pressure differential. Compressor shall be equipped with:
    a. Design driver 3,600 RPM
    b. Flanged at the shaft for direct motor mounting by means of coupling housing
    c. Solid tandem axial bearings with counter bearings.
    d. Pressure relief of the axial bearings
    e. High efficiency profile rotor with advanced geometry and high rigidity
    f. Dual capacity control
        1) Infinite slide valve capacity control
        2) 3-Stage
    g. Integral oil management system
        1) Automatic oil stop valve
        2) Oil filter
        3) Monitoring of oil flow, rotation direction
        4) Internal pressure relief valve
    h. Electronic protection devices
        1) Thermal monitoring of discharge gas temperature
    i. Each compressor shall or solid-state reduced voltage starter, 480/3/60 motor rated. Motor shall have 1.15 service factor. Compressor to be isolated from floor via isolation on skid framing.
    j. Each compressor shall have a capacity for operating at design conditions.

2. Compressor shall be Bitzer, Frascold or equal

3. Provide 24 month manufacturer’s warranty on chillers from time of first start-up or 30 months from delivery.

4. Provide factory start-up and adjustment, which shall be approved by the Engineer.

2.6 OIL SEPARATOR/RESERVOIR

A. The oil separator/reservoir will be a horizontal, two stage unit with integral sump. A coalescent separator element is provided for final gas/oil separation and manufactured in accordance with Section VIII of the A.S.M.E. Code complete with:
    1. pressure relief valve on our industrial units,

2.7 OIL RECEIVER / OIL POT

A. Supply and install Oil Receiver complete with dual relief valve assembly and stop valves. Heater designed for 300 psig.

B. Manufactured in accordance with Section VIII of the A.S.M.E. Code complete with:
    1. Pressure relief valve on our industrial units,
    2. Water regulating valve(s) for head pressure control.

C. Supply and install oil receiver complete with:
  1. Single relief valve assembly
  2. Stop valves
  3. Hand expansion valve
  4. Solenoid Valve
  5. Sight Glass on drain line
  6. Sight Glass on oil pot shell
  7. Heater designed for 300 psig.

2.8 REFRIGERANT PIPING

A. All ammonia piping shall conform to the ASME B31.5 Refrigeration Pressure piping code and the ASHRAE/ANSI 15 Safety Code for Mechanical Refrigeration.

2.9 REFRIGERANT VALVES AND CONTROLS

A. Supply and install all refrigerant stop and control valves as required. Valves to be Henry, Hubbel, Phillips, Hansen or approved equal. Supply and install two replaceable core driers complete with additional replacement cores and valves.

2.10 GAUGES AND THERMOMETERS

A. Supply and install min. 3½" diameter gauges, Marsh or equal complete with gauge stop valves and constructed of material compatible with fluid being measured.

Thermometers shall be Trerice 9" stem or equal and complete with thermometer wells.

2.11 BRINE VALVES AND FLEXIBLE CONNECTORS

A. Supply and install all cold brine valves as shown on the drawings. Valves shall be lug type butterfly, Keystone or approved equal. All valves 10" and larger shall have worm gear operators.

B. Provide flexible connectors at the chillers and pumps.

2.12 BRINE EXPANSION TANKS

A. Provide and install expansion tanks to allow for expansion and contraction of the brine charge. Tanks to be bladder type.

2.13 BRINE CHILLER REFRIGERANT CONTROLS

A. The chiller is to be complete with a float switch and isolating valves to protect the compressors against high liquid levels in the chiller. Chiller to also be complete with oil return system. Provide appropriate pressure regulating valves.

B. High pressure liquid feeding the chiller shall be controlled using a Phillips Series 701 control valve with a Series 275 pilot float valve. Valves shall be isolated with hand stop valves. A 2” Hand Expansion Valve bypass shall also be included.

2.14 WATER PIPING FOR OIL COOLERS AND COMPRESSORS

A. Refrigeration Installer shall furnish necessary water piping and interconnecting pipe, valves, controls and hangers to supply water to oil coolers and compressors. Water piping shall be type “L” hard copper tubing with sweat or brazed joints. Water will be picked up from condenser water supply and returned to the condenser return.

2.15 SAFETY RELIEF ABSORTION STEEL TANK - AMMONIA DILUTION TANK

A. System shall be furnished and installed by the Refrigeration Installer. Piping and valves to be designed in accordance with ASME and ASA B-9 codes. Safety line shall be run to atmosphere and extend 3’ 0” above roof line and equipped with suitable diffuser. Relief piping shall be galvanized Schedule 40 steel pipe with malleable 150 psi galvanized fittings. Relief line shall connect to all relief valves on refrigeration unit.

B. Tank shall be an above-grade steel vertical water storage tank for diffusion of ammonia discharges from pressure relief valves. Tank shall be manufactured from ASTM A-36/ASTM A569 stainless steel, minimum 1/8” (10 Gauge) thickness, or more if structurally required. Tank and coating shall be designed for containment of liquids up to 1.2 specific gravity, and suitable for non-potable water application and for temporary storage of an ammonia/water solution.

C. Manufacturer/Model: American Tank Company (americantankco.com, phone 877-655-1100), or approved equal, 1,500-gallon capacity (nominal) single–wall vertical tank.

D. Tank inside diameter shall not exceed 5’-10” and tank overall fill height shall not exceed 8’-4”.

E. Tank accessories to be provided include 24-inch diameter non-vented manway with bolt-on cover and confined space warning signage, internal sidewall mounted stainless steel sparger tube sized to match relief header size and in compliance with ASHRAE and IIAR2 requirements, vapor tight vent connection, drain connection with valve, make-up water inlet, target-type reverse liquid level indicator, anchor brackets for seismic hold-down connections and lifting lugs.

2.16 MOTOR CONTROL CENTER

A. For all refrigeration system equipment provide a separate motor control center. The motor controls centers shall have motor circuit protector breakers and starters (part winding) that serve the following equipment:

<u>Ice Chiller Plant Motor Control Center (MCC)</u>

1. Chiller compressors (2) (Provide part-winding compressor magnetic starters)
2. Brine pump (2)

3. Condenser water pump (2)
4. Controls

B. All starters shall be sized for 460V/3Ph/60 cycle power. Control power shall be 120V/1Ph/60 cycle. All starters to be part winding type starters.

C. MCC shall be complete with pilot lights to indicate run status of each motor, overload relays and resets, gauges to indicate system suction pressure & system discharge pressure. Oil pressure gauges shall be mounted at each machine using a steady mount.

All compressor safety controls shall be mounted, piped and wired to the panel. All relays, terminal strips, wiring to U/L, state, and local regulations.

D. Each motor starter shall be equipped with a H.O.A. selector switch.

E. All gauges, cutouts and selector switches shall be properly identified with engraved laminated nameplates.

F. Provide hour meters for each compressor in this panel.

2.17 PUMPS

A. Pumps shall be base mounted centrifugal type. Iron construction complete with mechanical shaft seals and stainless steel shaft sleeve. Motor shall be high efficiency.

2.18 BRINE HEATER (ICE DE-BONDING SYSTEM) – HX-ICE

A. Provide (1) 3,500 MBH brine heater heat exchanger.

B. Unit shall have suitable sized openings welded in shell as indicated and shall be built in accordance with ASME standards and shall be so stamped.

C. All necessary tube side piping including valves, fittings, and hangers required to connect into tie-in connection shall be provided by the Refrigeration and Rink Piping Contractor. Tie-in connections shall be as indicated on the drawings.

2.19 INSULATION

A. Piping insulation shall be installed on all:
1. Brine piping
2. low pressure liquid Lines
3. Low Pressure suction lines. Insulation shall be 2” thick polystyrene or equal with vapor barrier and PVC jacket.

B. Piping insulation shall be installed on all brine piping and low pressure liquid and suction lines. Insulation shall be 2” thick urethane or polyisocyanurate with vapor barrier and 30 mil. PVC jacket.

C. Hot water piping shall be insulated above grade insulated with 1” fiberglass with an all-purpose PVC jacket.

D. Cold water piping shall be insulated with 1” fiberglass with all-purpose PVC jacket.

E. Insulation shall be 2” Trymer 2000 XP, (or Approved Equal) complete with vapor barrier and color coded, 20 mil, PVC jacket.

F.

G. Brine heater and equipment shall be insulated with black urethane insulation and covered with aluminum or PVC jacket.

2.20 THERMOMETERS, PRESSURE GAUGES AND ACCESSORIES

A. Install 9” scale adjustable angle thermometers, 0 degrees to 100 degrees F., with separable sockets.

B. Gauges shall be installed in suction discharge line of all pumps. Suction side shall be scaled 30” vacuum to 60 lbs. Discharge pressure shall be scaled 0 lbs. to 100 lbs. Dials shall be 4-½” diameter. Each gauge shall be valved off. Provide gauges in condenser water inlet and outlets.

C. Furnish and install multi-purpose valves on discharge line of each brine pump. The valves shall combine a balancing valve, check valve, and shut-off valve in single body.

D. Provide compression type expansion tanks and accessories as shown on Flow Diagram.

E. Provide recording thermometer in discharge line of chillers.

F. Air release valves at high points of supply and return shall be APCO Air Vent #50, 1” size. Air release valve at air separator shall be APCO 200 A, 2” size. Provide stainless steel ball valve between vent and piping, full port, full size of air valve inlet. Provide an air release valve in floor at rink header return for both heating and cooling headers. Provide access panels. Valve shall be stainless steel, lever handle ball valve.

2.21 CONDENSER PIPING

A. All piping shall be Schedule 40 butt welded galvanized steel pipe.

2.22 PUMP SKID

A. The equipment specified shall be mounted “Skid” type construction and shall include:

1. (1) Ice Slab Pumps centrifugal (1,200 GPM @90 Ft.)
   a. Base mount centrifugal
   b. 40 H.P. High Eff. Motor (0.94)
   c. Operational range 0^{O}F to 100^{O}F

2. (1) Ice Slab Stand-By Pump (1,200 GPM @90 Ft.)
   a. Base mount centrifugal
   b. 40 H.P. High Eff. Motor (0.94)
   c. Operational range 0^{O}F to 100^{O}F

3. Future Ice Slab Pumps (1,200 GPM @90 Ft.)
   a. Base mount centrifugal
   b. 40 H.P. High Eff. Motor (0.94)
   c. Operational range 0^{O}F to 100^{O}F

4. (1) Condenser Pumps (576 GPM @90 Ft.)
   a. Base mount centrifugal
   b. 15 H.P. High Eff. Motor (0.94)
   c. Operational range 0^{O}F to 100^{O}F

5. (1) Condenser Stand-By Pump (1,200 GPM @90 Ft.)
   a. Base mount centrifugal
   b. 40 H.P. High Eff. Motor (0.94)
   c. Operational range 0^{O}F to 100^{O}F

6. Future Condenser Pumps (1,200 GPM @90 Ft.)
   a. Base mount centrifugal
   b. 40 H.P. High Eff. Motor (0.94)
   c. Operational range 0^{O}F to 100^{O}F

2.23 CONTROLS

A. Design/Commissioning: The refrigeration contractor shall provide a competent experienced technician for control system commissioning. Refrigeration contractor employees shall accomplish programming and commissioning and shall be directly employed by the refrigeration company. Subcontracting of automation work is not permitted.

B. Once the system is commissioned and operating the refrigeration contractor shall provide a minimum of sixteen (16) hours training at the project location for the operating staff. The control system contractor shall provide a system training video on the HMI PC.

C. The refrigeration contractor shall supply off site support for the Control system and for the refrigeration system for the duration of the first-year warranty period by the customer supplied Internet high speed connection and must offer this service as part of Refrigeration service contract after the warranty period. In case of an emergency, the refrigeration contractor must have available qualified personnel to offer off site technical support 24 / 7.

D. General

1. Enclosure will be manufactured with the following characteristics: NEMA 12, hinge doors. electrostatic factory paint of gray color, interior components such as transformer, fuses, circuit breakers, relays, Programmable Logic Controllers (PLC), soft starters, VFD's, cross-line starters will be assembled on a dismountable back plate; the installation of component directly on the panel will not be accepted. Each panel will be designed for a single power point connect and integral control circuit power supply of 120 volts AC, 15 amps' maximum and will be protected by a suitable integrated circuit breaker and will have a bobble service socket to power 115-volt laptop and router. Wiring connection of cables coming from outside the enclosure will have connections to a terminal block with the exception of the wires (ie: Temperature Sensors) connecting to the input side of the programmable controllers.
2. This panel is equipped with conveniently labelled run and fail lights, selector switches, as required by manufacturers design
3. Within (5) working days after the proposal closing and before award of contract the selected contractor shall submit preliminary design documentation and sequence of operation for review by the owner or consultant. This document shall contain the following information:
4. A copy of the control specification with a statement of compliance or non-compliance clearly identified for each item.
5. Description of the requirements for changing set-points, limits, schedules etc.
6. List of at least five (5) similar installations installed within the last year.

E. Control System Minimum Requirements

1. The operation of the cooling system, including ALL auxiliary equipment including circulation pumps, fans and safety equipment must function seamlessly and automatically without operator input and without direct or indirect monitoring. The control system must remain 100% function independent of the visual interface (HMI). The basic system must also include remote communication to the facilities BMS / BAS system over the site-specific protocol such as BacNET. Remote, offsite communications must be available and capable of performing diagnostics, setpoint changes, force shut-down and start-up, locking out failed components, etc.
2. The control program includes the system control parameters as well as, but not limited to:
   a. Complete system control including all associated systems, (Snow Melt. Sub-Soil, etc.)
   b. Complete electrical component monitoring,
   c. Calendar for event scheduling,
   d. 7-day scheduling flexibility is assured, “Game Day”, “Practice Day” and “Dark Building” events preloaded,
   e. Trending and logging of the temperature, pressure and motor function data. Trend logging enables the operators to detect slowly developing problems,
   f. Logs will be kept on all operating conditions and run times recorded on all motors to prompt the operators to carry out preventive maintenance.

g. Sensors are installed in the brine supply, brine return piping and the concrete ice slab.
h. "On the Fly" program changes and enhancements,
i. The operating conditions can be monitored and controlled from home or anywhere in the world via two-way communication ability.
j. Component live longevity and serviceability is increased by monitoring accumulative runtime and number of starts ie: compressors, fans, pumps and motors,

F. Compact Screw Compressor: The cooling capacity is precisely matched to the desired process fluid conditions in order to conserve energy and avoid over shooting demand. This is accomplished by tracking the cooling demand with the compact screw compressors, infinite capacity control slide valve. Compressor protections include compressor rotation (lead – Lag with multiple compressor arrangement), anti-cycle timer which optimizes compressor starting versus process demands, operating hours and real time clock.

G. Motors and Drives
1. All motors up to 50 H.P., unless otherwise noted, to be cross-line start
2. All motors, 75 H.P. and over, equipped with Soft Start
3. Soft Start communications back to controller over Modbus
4. All Evaporative Condensers / Cooling Tower fans equipped with Variable Speed Drives (VFD)
5. Condenser fan(s) are controlled by PLC to maintain refrigeration system head pressure
6. All ice slab circulation pump(s) equipped with Variable Frequency Drives (VFD)
7. All VFD communications back to controller over Modbus
8. All outputs to be equipped with H.O.A. selector switches
9. Where equipped with multiple or redundant compressors, fans and pumps, the control system will include automatic Lead / Lag as well as minimum and maximum run times
10. Control system to include compressor anti-cycle timers to prevent excessive motor starts
11. Control system will stage compressors for consistent ice slab temperature
12. All components to grounded

H. PLC Controller
1. Controller, software and hardware to be Non-proprietary,
2. System MUST include permanent hardware c/w software and program made available to owner and third party after the warranty period.
3. Control all the refrigeration equipment and associated components directly. The PLC controller shall not depend on any other CPU or computer to perform this function. Loss or failure of the operator workstation shall in no way affect the operation of the refrigeration equipment.
4. The PLC controllers must be able to support real-time programming
5. Full function touch screen Human Machine Interface (HMI)
6. User friendly, multi-functional / Programmable Logic Controller (PLC) to co-ordinate system operation.

7. Communications Baud (data) rates of 10/100 Mbit/s.
8. ETHERNET PLC can be used as a programmable controller within ETHERNET networks.
9. The PLC supports both MODBUS/TCP and ETHERNET/IP for use in industrial environments.
10. Native BacNET communications for facility BMS / BAS shall conform to ANSI/ASHRAE Standard 135-2001, BacNET.
11. Provide BacNET points list complete descriptive tag names and units,
12. Supports a wide variety of standard ETHERNET protocols for easy integration into IT environments e.g., HTTP, BootP, DHCP, DNS, SNTP, SNMP, FTP).
13. Interfaces support Auto-Negotiation and Auto-MDI(X).
14. Each controller must have a specific network address using Derived Network Addressing.
15. Available wireless capabilities
16. Ability to be remotely accessed and controlled off-site
17. Ability to continuously upgrade / update system programming
18. Controller to include compressor pressure transducers (High pressure, Low Pressure, Oil Pressure)
19. Temperature sensors to be NTC, RTD, Thermocouple.
20. The PLC system must be able to communicate with other peripheral controllers using BacNET, Modbus.
21. Include exhaust fan interlocks for control

I. Programing
1. Controller, software and hardware to be Non-proprietary,
2. “On the Fly” program changes and enhancements,
3. The refrigeration system will be designed with "Floating Head Technology", The head pressure control feature will incorporate this technology for maximum energy efficiency.
4. Available outdoor Dry Bulb / R.H. for best energy efficiency control,
5. The PLC controller shall be capable of being monitored remotely from any location via phone line, or Internet. Remote diagnostics, software maintenance, graphics updates and setpoint adjustments shall be possible with remote communications.
6. Multi-level LOGIN security access, Minimum 6 levels. Owner defined levels.
7. Multi-screen capabilities to clearly,
8. Two level alarm indication "Warning" (When conditions are outside of normal operation) and "Fault" (When conditions exceed safe operating limits and has shut down the system),
9. Upon an alarm condition, a message shall appear on the operator interface indicating what the alarm condition is and time it occurred. The alarm occurrence shall be recorded to the HMI hard drive as a permanent record.
10. Acknowledgment of the alarm will clear the alarm and the acknowledge occurrence shall be recorded to the HMI hard drive as a permanent record.
11. All compressors, pumps and fans shall have their own individual trend logs. The trends will show readings of equipment status, i.e. on/off or fault, and the associate control variable relevant to that equipment, i.e. temperature, pressure etc.

12. All "Warnings" and "Faults" must be held permanently on the hard drive.
13. Active alarms are shown on "Alarm" screen and can be deleted when cleared,
14. Seven day “Game Day”, “Practice Day” and “Dark Building” scheduling events,
15. Trending and logging of all temperature, pressure and motor function data must be held on the local hard drive. Outputs include graphic, xlsx as a minimum,
16. Where the facility has multiple ice surfaces, each ice surface shall have its own unique set of schedules,
17. Each ice surface shall have a trend log associated with it. As a minimum, the PLC system HMI shall store to hard drive, readings of temperature setpoint's, actual temperature, supply temperature and return temperature. All trend data shall have an unlimited number of samples stored on the hard drive of the work station.
18. The controller shall log run hours and # of starts for each pump, compressor and fan.
19. The controller shall monitor all temperatures, pressures and equipment status for alarm conditions. The alarm setpoint's shall be adjustable by the operator with the appropriate password.
20. Compressor cylinder head loading to closely control Ice Slab temperature,
21. Available Ice Surface IR temperature indication and control,
22. Control and sequence all auxiliary systems including but not limited to Snow Melt System, Sub-Soil System, De-Bonding System,
23. Linear refrigeration head pressure control,
24. Available integration of Leak Detector controller c/w values,
25. Available power supply, power monitor including: Line Voltage, Line Amperage, Power Factor, Efficiency, to determine actual kW.
26. Available Ice Slab Fluid circulation flow meter.
27. Available kW / Ton calculation to monitor system energy efficiency.
28. Auto change-over for head pressure control strategy (Summer / Winter)

J. Graphical Interface
1. Controller, software and hardware to be Non-proprietary,
2. “On the Fly” graphic changes and enhancements,
3. Full graphic software provided by SCADA
    a. SCADA is acronym for Supervisory Control And Data Acquisition. SCADA Systems consist of both hardware and software components. The hardware collects and feeds data into a computer with SCADA software installed in real time. The data is then processed by the computer before presenting it in a real timely manner. The function of SCADA is recording and logging all events in a file that is stored in a hard disk or sending them to a printer. If conditions become hazardous, SCADA sounds warning alarm. Input/output signal hardware, network, human machine interface, controllers, database, communication and software constitute a SCADA system.
    b. There are real time automated and integrated control systems like its cooling by the computer itself for quick responding to the process changes within the processes’ own time-frame. But SCADA is not critical to controlling real time process.
4. Navigation thru Multi-Screen by touch screen or mouse

5. Minimum graphic requirements are:
   a. Logon graphic
   b. Main project graphic
   c. Flow graphic
   d. One schedule graphic per ice surface
   e. One graphic for each trend log
   f. Setpoint graphic(s)
   g. Alarm graphic(s)
   h. Runtime data graphic(s)
6. Multi-level LOGIN security access, Minimum 6 levels. Owner defined levels.

K. Multiple Level Password to Access and Modify Controller and Settings:
1. Open – “user” – check status only,
2. Operator level
3. Service level
4. Factory level
5. Total six (6) levels available

L. Event Programing:
1. Special event (Non-Ice)
2. Game day – 1 Day Scheduler (Purchased Option)
3. Game Day / Practice schedule - 7 Day Scheduler (Purchased Option)
4. Dark building – Included in above
5. Ice Surface IR sensor override

M. Auxiliary I/O’s.
1. These I/O’s are to be used by remote systems or features for complete integration:
2. Leak detector, (Ethernet input for remote monitoring – Available)
3. Mechanical room exhaust fans
4. Mechanical room access door “E-stops” Minimum four (4)
5. Mechanical room dry bulb temperature
6. Outdoor dry bulb temperature / Outdoor R.H.

N. Alarm System:

In addition to the BMS / BAS based communications, the PLC is to provide a “Dry Contact” for local “Visual” and “Audible” indication complete time-based alarm silence.
1. Indicates all “Hard” faults
2. Indicates all “Warning” status (Used for diagnostics)
3. Selectable silence time of Audible alarm

O. Calibration:

1. The above is only representative of the screens and data available. Each project will have a complete list of I/O’s reflecting the project specific components. ALL

I/O's will be found on this screen as well as ALL setpoint's, differentials, timers, etc. and ALL points can be altered from this screen as well.

P. PLC Data provided:

Where the compressor selection is a reciprocating model, the central control, PLC takes total control of the entire system. The PLC control points are highlighted and explained in the following system I/O map. Including, but not limited to,

1. Compressor
    a. Stop / Start,
    b. Compressor loading, (Reciprocating Compressor Stages or Screw Compressor Slide Valve)
    c. Multiple compressor Lead / Lag and rotation,
    d. "Run" Indication
    e. "Warning" Indication - All critical operating points will include a normal operating range and when the system falls outside that range the PLC will provide indication that the system did fall outside normal operating range. This feature will be used for diagnostics.
    f. "Fault" Indication. Included but not limited to:
    g. Screw Compressor:
        1) Motor Amps,
        2) Soft Starter fault
        3) High Pressure Transducer
        4) Low Pressure Transducer
        5) Oil Pressure Transducer,
            a) Compressor Oil Pressure Differential will indicate net oil pressure
        6) Compressor Rotation
        7) Oil Filter
        8) Oil Flow Switch
        9) High Discharge Temperature
    h. Accumulative RUN time,
    i. Number of starts,
    j. Anti-cycle timer,
    k. Minimum "Run" and "Off" Timer
    l. Individual High Pressure electro-mechanical safety switch,
    m. Crankcase Temperature
    n. Crankcase heater control

2. Circulation Pumps
    The Ice Slab Circulation Pumps shall be equipped with VFD's and shall be controlled by the PLC.
    a. Automatic pump start sequence,
    b. Automatic pump shut-down sequence,
    c. Automatic spare pump rotation into service based on run time and "First in" (Lead-Lag)
    d. "Run" Indication

e. “Fault” Indication
f. Fluid Loop Flow switch indication
g. Run Status Resettable by Operator
    1) “Accumulative Run Time”
    2) “Number of Starts”

3. Cooling Tower / Evaporative Condenser / Fluid Cooler - The PLC must be able to take control of all related I/O’s including but not limited to:
    a. Fan Speed controlled by either system head pressure or tank temperature
    b. “Run” Indication
    c. “Fault” Indication
    d. Multiple fan automatic rotation (Lead / Lag)
    e. Local sump
        1) water level control
        2) Basin heaters
    f. Run Status Resettable by Operator
        1) “Accumulative Run Time”
        2) “Number of Starts”

Q. Process fluid temperature monitoring and Control, - Extend all existing sensors/circuits and/or provide new sensors/circuits to new chiller controller. These multiple existing temperature sensors shall be averaged in normal operation.
1. Ice Rink Surface Fluid Supply Temperature
2. Ice Rink Surface Fluid Return Temperature,
3. Ice Rink Slab Temperature (Available four (4) sensors)
4. Sub-Soil Temperature (Available four (4) sensors)
5. Compressor Cooling Jacket Loop
    a. Loop Supply Temperature,
    b. Loop Return Temperature
    c. Loop Temperature Control Actuator
6. De-Bonding System
    a. System Supply Temperature,
    b. System Return Temperature
    c. System “Flow Switch” indication
    d. System – Heating System Temperature Control – Modulating Signal

R. Cooling System (Chiller) Aux. sub-systems
1. Outside Ambient Temperature Sensor, Air-Cooled Only, or as requested,
2. High evaporator liquid refrigerant shut-down switch
3. Flooded chiller Oil Pot:
    a. Oil Pot heater
    b. Oil Pot feed solenoid c/w filter
    c. Oil Pot temperature sensor
4. Liquid Refrigerant Level Control – Stand Alone Device
    a. Position feed-back to PLC
    b. Controller “Fault”
    c. Electric Actuator
    d. Level control sensing rod

S. Motor Start/Stop and Run Status:

1. Cold Brine Pumps
2. Condenser Pumps
3. Jacket and Oil Cooling Pumps
4. Compressors

T. Temperature Readings:

1. The temperature sensors shall be RTDs, mounted in wells or conduit bodies.
2. The following temperatures shall be monitored and displayed through the operator terminal:
   a. Rink Slab Temperature, (4) locations, 2 in the rink floor and 2 infra-red.
   b. Rink Sub-Slab Temperature (2) locations.
   c. Cooling Brine Supply Temperature.
   d. Cooling Brine Return Temperature.
   e. Condenser Water Inlet Temperature.
   f. Condenser Water Outlet Temperature.
   g. Evaporative temperature.
   h. Condensing temperature.
3. For control purposes, the operator shall be able to select the average or all of the ice rink temperature transducers to control the operation of the compressors.
4. Each temperature shall have its' own discrete high and low alarm values which can be changed through the operator terminal.
5. Control set points shall be changeable through the operator terminal with optional password protection.
6. Conduit, wiring and installation shall be by this Contractor.
7. The printer shall provide hourly print-out of readings selected by the operator.
8. Provide three-way control valve to control the inlet condenser water temperature.

2.24 REFRIGERANT LEAK DETECTION SYSTEM

A. Provide a six-channel controller designed to accept industry standard 4/20 mA input signals. It provides a regulated 6.5 Amp, +24 VDC power supply to power all industry standard 4/20 mA gas transmitters, and connected audio/visual devices. System needs to provide continuous real-time monitoring of each sensor and a backlit LCD display to provide an at-a-glance status of gas concentrations and alarms.

B. The system shall be assembled into a wall mounted enclosure designed for non-classified locations. The gas sensors are installed at specific locations where gas is to be detected, up to 1,500 feet from the controller. They are electrically connected to the controller via three conductor cables. (Shielded)

C. Mechanical room shall be fitted with a minimum of two ammonia detection sensors> One located 60" from the floor with the second located within 18" of the highest point of the ceiling without being located in any ceiling cavities.

D. The programmable onboard relays have adjustable on/off time delays to prevent unnecessary cycling during a fault, warning or alarm condition. The internal buzzer and horn relay work in unison. Typically, the horn relay should be programmed to be silence able.

E. An analog output board provides an individual 4/20 mA output for each channel to be monitored by plant PLC or other analog input devices.

F. All operator functions are performed from the keypad on the front of the panel.

G. The TWA (8-hour) and STEL (15 minute) functions can be enabled through the menu, along with their corresponding alarm setpoints and relay output functions.

H. Refrigeration leak detection system shall be for NH3 (Ammonia) refrigerant.

I. System shall comply with ASHRAE Standard 15.

J. Provide calibration equipment and horn.

K. The leak detector shall be located just outside the Refrigeration Room doorway.

L. Provide each monitor with a filter.

M. Provide a 4 to 20 MA output signal for each channel outlet to start exhaust system.

N. Tie into BMS shall be by Division 23. Power wiring by Division 13. Provide relays to Refrigeration Room exhaust system.

2.25 CONDENSER WATER TREATMENT

A. Condenser water treatment per specification section 23 25 16 unless the following is more stringent.

B. This Contractor shall engage a “Water Treatment Contractor”, to provide a water treatment program for a period of one year from the date of initial treatment for the refrigeration condenser water system, this program to include cleanout chemicals, water treatment chemicals, feeding and testing equipment, and service.

C. The company’s laboratory shall be equipped to analyze samples in accordance with the standard methods of the American Water Works Association and the American Society for Testing Materials.

D. This Contractor shall install all feeding equipment, the equipment to become the property of the Owner. This Contractor shall be responsible for all piping, valves, fittings, switches, and miscellaneous equipment shown on the accompanying drawings but not supplied by the water treatment contractor.

E. The Water Treatment Contractor shall provide the following services:

1. Provide the Owner with complete written instructions for chemical feeding, bleed-off and testing procedures.
2. Demonstrate to Owner’s personnel the proper application of written instructions.
3. Provide all biocide and corrosion control chemicals, chemical feeding and testing equipment, as specified.
4. Install feed and bleed control devices.
5. Provide laboratory analythical facilities for regular testing of samples and furnish written reports and recommendations to Owner or Engineer.
6. Provide general technical consultation relating to his field of expertise.

F. Open Condenser Water Feeding System

1. Provide a controller to automatically control chemical feed and bleed-off from the condenser water system by synchronization of feed and bleed through accurate monitoring of conductivity. MORR system C-1 or equal.
2. Controller shall be factory prepiped and prewired and include the following:
    a. Control center of solid state electronic design consisting of dual calibrated scale, internal calibration check and lock-out timer that allows the chemical pump to operate for only a set time to protect against an overfeed of chemicals, all housed in NEMA 1 enclosure with hinged door, viewing window, padlocking hasp, power cord and duplex receptacle.
    b. Quick disconnect temperature compensated electrode in ¾” FNTP tee, pressure rating 100 psi, water temperature 140 degrees F. maximum.
    c. Mounted flow switch with back check valve, to inactivate controller when flow is less than 1 gpm.
    d. Indicator lamps indicating operating mode: power, time-out, control.
    e. Solenoid bleed valve, appropriately sized for system tonnage, ASCO, or equal.
    f. Chemical pumps (2 required: 1 for inhibitor, 1 for biocide) IMI A101-91T, 0.15-14.4 gpd, 75 psi, or equal and 50 gallon LMI poly tanks and agitators.
    g. Corporation stop and injection nozzle assembly, ½” PVC injection nozzle with ¾” NPT male connection to the main line for injecting inhibitor into condenser water return line downstream from bleed-off point.
    h. Companion 7 day pre-wired timer in NEMA 1 case to permit operation of biocide pump at pre-set internals, and with adjustable bleed lock-out capability to shut down controller during and immediately following the addition of biocide, MORR T11-A or equal.

G. Testing Equipment

1. Furnish all necessary portable drop test kits for maintaining control of recommended treatment residuals and cycles of concentration.
2. Corrosion coupon rack shall include 4 ports and shall be installed in accordance with NACE procedures. Coupons shall be exposed for 30 days and 90 days and corrosion rates reported in mils per year (MPY).

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install in accordance with manufacturer’s instructions.

B. Provide for connection of electrical wiring between starter and chiller control panel, oil pump, and purge unit.

C. Furnish and install necessary auxiliary water piping for oil cooling units and purge condensers.

D. Arrange piping for easy dismantling to permit tube cleaning without disturbing piping.

E. Install pressure relief system in compliance with governing regulations to vent refrigerant in case of over pressurization.

F. Provide piping from chiller relief valves to outdoors. Size as recommended by manufacturer and as required by ASHRAE 15.

G. The chiller will be located on a existing slab, no housekeeping pad is required. Manufacturer shall provide vibration isolation in accordance with requirements of this specification.

H. Provide emergency shutoff switch to shut down all equipment in chiller room in accordance with Code. Provide multiple break glass stations, one for each door, in rooms with multiple doors.

I. Install refrigerant monitors in accordance with code requirements and manufacturer’s recommendations.

J. Provide two self contained breathing apparatuses (SCBA), suitable for the refrigerant used, located outside, but closes to, the machinery room. Self contained breathing apparatuses shall be located within an protected enclosure. Final location of the enclosure shall be approved by the architect and engineer.

K. Coordinate electrical requirements with Division 26 prior to ordering. Report any discrepancies to the Engineer for resolution.

L. Provide chilled water and condenser water flow switches.

M. Field insulate any areas of chiller subject to heat loss or damaged due to delivery/rigging.

3.2 REFRIGERANT SYSTEM DEHYDRATION, LEAK TESTING AND CHARGING

A. Dehydrate system by “Double Dehydration” method.

B. Use a suitable vacuum pump. Evacuate system to a vacuum of 0.2” Hg absolute and operate pump for eight (8) hours when that pressure is reached.

C. After eight (8) hours, admit dry nitrogen directly to the system, and then evacuate system to a vacuum of 0.2” Hg absolute and operate pump for four (4) hours.

D. Test for leaks by use of carbon dioxide or nitrogen and a liquid soapsuds solution. Correct leaks found.

E. Evacuate system to 20” vacuum and charge with refrigerant until a pressure of 15 psig is reached. Then test for leaks using a Halide leak detector.

F. Pressurize system, with carbon dioxide or nitrogen, to 300 psig on the high side, and 200 psig on the low side, and test for leaks. Correct leaks found.

G. When system dehydration is complete and all leaks corrected, charge system with refrigerant.

3.3 OIL CHARGE

A. Contractor shall provide a complete initial charge of oil for the compressors plus one spare 50 gallon drum. Oil to be per compressor manufacturer’s recommendations. Provide a hand oil pump for charging of oil.

3.4 BRINE CHARGE

A. Provide, mix and charge into system a complete charge of 40% ethylene glycol. When system is fully charged, brine shall have a freezing point of -13 degrees F. Charge shall have factory mixed inhibitor or neutralizing agent and shall be completely stabilized. One (1) full drum (55 gallons) shall be furnished as spare.

B. Provide to Owner, at no additional cost, not less than one each three months after final acceptance of plant, for a period of one year, a chemical analysis of brine charge, together with recommendation for correction of brine, if necessary. Required corrective measures to brine for a period of one (1) year from final acceptance shall be paid by Refrigeration Installer.

C. Copies of report shall be sent to the Owner, Architect, and Ice Rink Design Engineer.

3.5 INSULATION AND PIPE COVERING

A. Equipment and piping shall be tested and approved before insulation is applied. Surfaces shall be clean and dry. Insulation shall be installed only by persons regularly employed and skilled in this trade. Insulation sections or segments shall be properly cut and fitted to each surface, tightly butted together and secured. Seams and joints shall be thoroughly sealed with an approved fire retardant joint sealer as recommended by manufacturer.

Provide vapor barrier on all cold temperature pipe.

Equipment to be insulated includes chiller (insulated at factory) brine piping, heating pipe, refrigerant pipe. (See Part 2 for insulation requirements).

3.6 IDENTIFICATION

A. All fabricated steel shall be primed and painted. All piping shall be painted in the mechanical room.

B. All refrigerant lines, brine lines, and water lines pertaining to the ice rink refrigeration system will be identified after painting and insulation as to the substance in the pipe, and the direction of flow. All lines penetrating a wall section must be immediately identified on either side of the wall. Markers shall be by Brady, IIAR, or equal.

3.7 CONTROL SEQUENCE OF OPERATION

A. A Motor Control Center (MCC) shall provide motor starter for all refrigeration compressors and pumps. Each starter shall be sized for 460V/3PH/60HZ power. Control power shall be 120V/1PH/60HZ. Each motor starter shall be equipped with a H.O.A. selector switch.

MCC shall be complete with pilot lights to indicate run status of each motor, overload relays and resets, and gauges to indicate suction pressure and discharge pressure. All compressor safety controls shall be mounted piped and wired to the control panel. Provide run time indication for each compressor at the control panel.

Provide an adjustable anti-recycle timer for each compressor wired to each compressor start circuit to prevent excessive motor starts.

Compressors shall be staged to maintain ice floor temperature and/or return cold brine temperature once one brine pump and one condenser pump are operating. Condenser water three-way valve shall modulate to maintain inlet water temperature to the condensers of 85 ºF (adj.).

Compressors shall not start unless at least one brine pump and one condenser pump are operating.

B. The ice temperature for rink shall be sensed by two (2) existing overhead infra-red sensors and (2) existing rink floor sensors. Software shall be capable of using a combination of temperature signals to cycle rink brine pumps to maintain a proper floor ice temperature. Contractor shall extend sensor signals to new chiller controller.

C. Condenser pump operates continuously whenever at least one compressor operates. Evaporative condenser operates continuously whenever at least one compressor operates.

D. Flooded evaporators controlled by a liquid level probe which controls feed of liquid refrigerant to each evaporator.

E. Provide to the building automation system (1) overall alarm indication relay contact and (1) relay contact to start/stop the refrigeration room exhaust system.

3.8 ERECTION AND TESTING AND TEST RUN

A. The above specified equipment, materials, and accessories shall be carefully installed and erected by skilled mechanics. Welders are to be experienced in type of welding they perform. Architect may demand a welding test if he deems it advisable.

B. After brine connections back to chiller room are completed, a 50# psi air and soap test shall be applied; after this test, a 50# psig hydrostatic test shall be put on system for a period of not less than twenty-four (24) hours, after all leaks have been repaired. This test must be witnessed and approved by the Architect. The 50 psig pressure shall be maintained on rink piping during the pouring of concrete floor. Brine system shall be thoroughly tested and flushed clean before brine is charged into system. This Contractor shall keep a welder on duty during the pouring of floor.

C. All new recirculating condenser water systems, both open and closed, shall be filled and flushed with an alkaline solution of a non-foaming chemical cleaner containing wetting agents, “Flush-Out Compound” or equal, to remove all foreign matter.

D. Solution shall be circulated for a minimum of 8 hours and drained as rapidly as possible to remove all suspended particulates sloughed off by cleaning compound.

E. The system shall be flushed with fresh water, drained a second time and then filled. After final filling, the pH of the water shall not exceed the pH of the fresh incoming water by more than 0.5 pH.

F. Refrigeration Installer shall be solely responsible for charging of brine and refrigerant into system.

G. Refrigeration Installer shall provide qualified engineers to supervise the operation of first run and test run of plant. Test run for freezing first sheet of ice shall be for three (3) days after pre-determined date. Refrigeration Installer shall furnish necessary help required to spray ice rink for purpose of making ice during three day test run. The Chiller Manufacturer shall provide factory start-up for the chillers.

H. Owner shall furnish a person who will be instructed by Refrigeration Installer’s supervising engineer regarding care and operation of system. Time for starting test shall be agreed upon by Architect, an operating log-form to record operating conditions during test run. This record shall be kept by Refrigeration Installer’s supervising engineer.

I. Refrigeration Installer shall furnish three (3) complete sets of operating instructions bound in stiff covers. These manuals shall contain bulletins describing parts of equipment in refrigeration and brine circulating system, repair parts bulletin, description of methods of starting plant, instruction for summer shut-down period, wiring diagram and other material pertinent to operating and maintenance of plant. These manuals shall be turned over to Architect.

J. The Refrigeration Contractor shall install the first slab of ice to ¼".

K. The first flood shall be made with deionized hot water at 160 degrees to seal the ice.

L. Fine spray, cold or hot, deionized water shall be sprayed until the ¼" thickness is achieved, to the approval of the Engineer.

M. After miscellaneous tests and mechanical work has been completed to satisfaction of Architect, Refrigeration Installer shall give notice in writing to the Architect that he is ready to commence a test run.

N. Upon conclusion of test run, the Architect and Engineer shall make a complete, thorough, and final inspection of the plant and will elaborate to the Refrigeration Installer in writing details that are to be corrected.

3.9 TESTING ADJUSTING AND BALANCING

A. Refrigeration contractor shall contract with a test and balance firm to test, adjust and balance the hydronic system. Also Contractor shall have a registered engineer responsible for the work and shall have prior approval by the Architect/Engineer. Testing shall be done by certified technicians.

B. References:

1. ASHRAE - Standard 111 - Practices for Measurement, Testing, Adjusting, and Balancing of Building Heating, Ventilation, Air Conditioning, and Refrigeration Systems.
2. ASHRAE - HVAC Systems and Applications Handbook: Chapter 57, Testing, Adjusting and Balancing.
3. NEBB - Procedural Standards for Testing, Balancing, and Adjusting of Environmental Systems.

C. Submittals:

1. Submit name of Adjusting and Balancing Firm for approval within thirty (30) days after award of contract.
2. Submit for review, prior to commencement of work, a list of equipment and procedures to be used in balancing the systems.
3. Submit reports of pre-construction plan check and periodic mechanical construction review.

4. Submit draft copies of report for review prior to final acceptance of project. Provide final copies for Architect/Engineer and for inclusion in operating and maintenance manuals.

D. Procedures and Report:

1. Hydronic Systems shall be balanced using a procedure which results in minimum restrictions being imposed. At completion of balancing provide a report with the following information.
   a. Instrument List:
      1) Instrument
      2) Manufacturer
      3) Model
      4) Serial number
      5) Range
      6) Calibration date
   b. Electric Motors:
      1) Manufacturer
      2) HP
      3) Phase, voltage, amperage, nameplate, actual
      4) RPM
      5) Service factor
      6) Starter size, rating, heater elements
   c. V-Belt Drive:
      1) Identification
      2) Driven sheave, diameter
      3) Belt, size and quantity
      4) Motor sheave, diameter
      5) Center to center distance, maximum, minimum, and actual
      6) Final components
   d. Pump Data:
      1) Identification/number
      2) Manufacturer
      3) Size/model
      4) Impeller diameter
      5) Service
      6) Design flow rate, pressure drop
      7) Actual flow rate, pressure drop
      8) Discharge pressure
      9) Suction pressure
      10) Total operating head pressure
      11) Shut off, discharge and suction pressures
      12) Shut off, total head pressure
   e. Evaporator and Condenser:
      1) Identification/number
      2) Manufacturer
      3) Capacity
      4) Model

5) Evaporator entering glycol temperature, design and actual
6) Evaporator leaving glycol temperature, design and actual
7) Evaporator pressure drop, design and actual
8) Evaporator glycol flow rate, design and actual
9) Condenser entering water temperature, design and actual (including heat recovery side)
10) Condenser leaving water temperature, design and actual (including heat recovery side)
11) Condenser pressure drop, design and actual
12) Condenser water flow rate, design and actual

f. Heat Exchanger: (Ice Melting)
1) Identification/number
2) Location
3) Service
4) Manufacturer
5) Model
6) Primary glycol entering temperature, design and actual
7) Primary glycol leaving temperature, design and actual
8) Primary glycol flow, design and actual
9) Primary glycol pressure drop, design and actual
10) Secondary water entering temperature, design and actual
11) Secondary water leaving temperature, design and actual
12) Secondary water flow, design and actual
13) Secondary water pressure drop, design and actual

g. Brine Flow Measuring Station:
1) Identification/number
2) Location
3) Size
4) Manufacturer
5) Model
6) Design flow rate
7) Design pressure drop
8) Actual/final pressure drop
9) Actual/final flow rate
10) Station calibrated setting

h. Sound Level Report:
1) Location
2) Octave bands - equipment off
3) Octave bands - equipment on

i. Vibration Test:
1) Location of Points:
a) Fan bearing, drive end
b) Fan bearing, opposite end
c) Motor bearing, center (if applicable)
d) Motor bearing, drive end
e) Motor bearing, opposite end
f) Casing (bottom or top)
g) Casing (side)

2) Test Readings:
   a) Horizontal, velocity and displacement
   b) Vertical, velocity and displacement
   c) Axial, velocity and displacement
3) Normally acceptable readings, velocity and acceleration
4) Unusual conditions at time of test
5) Vibration source (if non-complying)

j. Existing Rink Sensor Temperatures: (Sub Floor and Rink Floor)
   1) Description of sensor under test

k. Rink Brine Temperature:
   1) Temperature leaving rink
   2) Temperature entering rink

2. Report is to include a listing of any abnormal or notable conditions not contained in above.
3. Provide four (4) copies of reports in soft cover, letter size, 3-ring binder manuals, complete with index page and indexing tabs, with cover identification at front and side. Include set of reduced drawings with air outlets and equipment identified to correspond with data sheets, and indicating thermostat locations.

E. Contractor Responsibilities:

1. Prepare each system for testing and balancing.
2. Cooperate with testing organization, provided access to equipment and systems. Operate systems at designated times, and under conditions required for proper testing, adjusting and balancing.
3. Notify testing organization seven (7) days prior to time system will be ready for testing, adjusting and balancing.

F. Examination:

1. Before commencing work, verify that systems are complete and operable. Ensure the following:
   a. Equipment is operable and in safe normal condition.
   b. Temperature control systems and rink dehumidification system are installed complete and operable.
   c. Proper strainer baskets are clean and in place.
   d. Correct pump rotation.
   e. Proper strainer baskets are clean and in place.
   f. Service and balance valves are open.

G. Installation Tolerances:

1. Adjust Hydronic Systems to the following tolerances:
   a. Heating System:
      1) Supply glycol temperature 60 degrees - 90 degrees F: 0% to +10% of design value.
      2) Supply water temperature 120 degrees to 160 degrees F: 5% to +10% of design value.

3) Supply water temperature above 160 degrees F: -10% to +10% of design value.

b. Chilled Ethylene Glycol System:

1) Supply 40% ethylene glycol temperature below 45 degrees F: -5% to +5% of design value.

H. Adjusting:

1. Recorded data shall represent actually measured, or observed condition.
2. Permanently mark settings of valves, dampers, and other adjustment devices, allowing settings to be restored.
3. After adjustment, take measurements to verify balance has not been disrupted or that such disruption has been rectified.
4. Leave systems in proper working order, replacing belt guards, closing access doors, closing doors to electrical switch boxes, and restoring thermostats to specified settings.

END OF SECTION

SECTION 23 65 00

COOLING TOWERS

PART 1 - GENERAL

1.1 SUBMITTALS

A. Submit manufacturer's data including:

1. Overall dimensions with maintenance and operation clearances.
2. Operating weights.
3. Support loading points and loads.
4. Fan cfm and brake horsepower.
5. Motor data.
6. Sizes and locations of connections.
7. Installation instructions.
8. Maintenance manuals.
9. Sound power levels.

1.2 TESTING

A. Tower shall be capable of passing a capacity test conducted in accordance with the Cooling Tower Institute's Acceptance Test Code for Water Cooling Towers. CTI STD. 201.

B. Testing will be done at the discretion of the Owner, and it is not part of the work of this Section.

1.3 APPROVALS

A. Tower to be Factory Mutual (FM) approved.

B. All cooling towers, access platforms, railings and ladders shall comply with all O.S.H.A. regulations.

1.4 SOUND POWER LEVEL

A. The following shall serve as a guide for maximum sound power levels (dB):

Distance from Tower	Octave Band (Air Inlet)							
	63	125	250	500	1000	2000	4000	8000
5'	68	70	69	67	61	60	60	57
50'	58	57	54	54	48	46	47	43

Distance from Tower	Octave Band (Top of Tower)							
	63	125	250	500	1000	2000	4000	8000
5’	66	66	66	63	58	55	58	48
50’	54	54	54	50	45	43	45	34

Distance from Tower	Octave Band (End)							
	63	125	250	500	1000	2000	4000	8000
5’	62	62	58	54	47	42	42	32
50’	53	50	48	46	39	35	34	24

1.5 QUALITY ASSURANCE

A. The cooling tower manufacturer shall have a Management System certified by an accredited registrar as complying with the requirements of ISO9001:2008 to ensure consistent quality of products and services. Manufacturers that are not ISO9001 Certified shall not be acceptable.

B. The structure shall be designed, tested and certified in accordance with IBC 2009 regulations for wind and seismic forces. The unit shall be certified by the manufacturer for operation after an event and verify that such rating is based on actual shake-table testing. Experience or calculation data is not acceptable to verify operation. Units not provided with a certificate of IBC 2009 compliance shall not be an acceptable alternative.

1.6 WARRANTY

A. The fan(s), fan shaft(s), sheaves, bearings, mechanical equipment support and fan motor shall be warranted against defects in materials and workmanship for a period of five (5) years from date of shipment.

B. The basin shall be warranted against leaks for five (5) years.

PART 2 - PRODUCTS

2.1 INDUCED DRAFT CROSS FLOW TOWERS

A. Manufacturers:

1. Design Basis: As scheduled.
2. Other Acceptable Manufacturers:
    a. Baltimore Air Coil
    b. Marley.
    c. Evapco

B. The thermal performance shall be certified by the Cooling Technology Institute (CTI) in accordance with CTI Certification Standard STD-201. Lacking such certification, a field acceptance test shall be conducted within the warranty period in accordance with CTI Acceptance Test Code ATC-105, by the Cooling Technology Institute or other qualified independent third party testing agency. Manufacturers' performance guarantees or performance bonds without CTI Certification or independent field thermal performance test shall not be accepted. The cooling tower(s) shall comply with the energy efficiency requirements of ASHRAE Standard 90.1.

C. The tower shall be guaranteed to perform as scheduled.

D. All panels and structural members, including casing panels, fan deck and fan cylinder shall be constructed of 304 stainless steel. All fasteners shall be 304 stainless steel. Type 301 stainless steel will not be accepted.

E. Collecting Basin:

1. Material: Heavy-gauge 304 Stainless Steel.
   a. All factory seams in the cold water basin shall be welded to ensure watertight assembly and welded seams shall be warranted against leaks for five (5) years. Stainless steel basins with bolted seams are not acceptable. The entire cooling tower, including fan motor, drive system, bearings, and structure, shall be backed by a comprehensive Louver-to-Louver^{SM} Five-Year warranty. Type 301 Stainless Steel shall not be an acceptable alternative.
   b. Basin shall include a depressed center section with drain/clean-out connection. The basin area under the fill shall be sloped toward the depressed center section to facilitate cleaning.
   c. Water Connections:
      1) As shown on plans.
   d. Provide removable anti-vortexing device to prevent air entrainment, and large area lift out strainers with perforated openings sized smaller than the water distribution sysem nozzles. The strainers shall be constructed from the type 304 stainless steel.
   e. A welded Type 316 stainless steel basin shall be an acceptable alternative; provided the basin is warranted against leaks and corrosion for a period of at least 5 years. A bolted basin shall not be an acceptable alternative.
   f. All factory seams shall be welded to ensure watertight assembly. Bolted seams are not acceptable.

2. Bottom: Sloped

F. Fill:

1. Fill eliminator and louver shall be lightweight, non-combustible, polyvinyl chloride and of non-corrosive inert construction. Fill, eliminator and louvers shall be guaranteed against corrosion for the life of the cooling tower. Fill shall be hung from top to tower by galvanized steel pipe and fill shall be raised 1-1/2"

above cold water basin floor to offer adequate cleaning ability to remove silt, dirt and other foreign debris. Drift eliminators shall be three pass, non-corrosive, non-combustible integral with fill and louvers. Maximum allowable drift loss shall be .005 of 1% of the water circulated.

2. Fire Rating: Comply with NFPA 220.
3. Flame spread rating of 5 per ASTM E84.

G. Louvers: Air inlet louvers shall be separate from the fill and removable to provide easy access for inspection of the air/water interface at the louver face. Louvers shall prevent water splash out during fan cycling and be constructed of 304 stainless steel.

H. Water Distribution System: Stainless steel open basin with plastic metering orifices.

1. The hot water distribution basins shall be open and gravity fed for easy cleaning, and constructed of Type 304 or 316 stainless steel. The basins must be accessible from outside the unit and serviceable during tower operation. Basin weirs and plastic metering devices shall be provided to assure the even distribution of water over the fill. Weir dams shall accommodate a flow range of 50% to 100% of the design flow rate. Lift-off distribution covers shall be constructed of heavy-gauge Type 304 stainless steel and designed to withstand 50 psf (244 kg/m^2) live load or a 200 pound (90.7 kg) concentrated load. Gravity flow nozzles shall be snap-in type for easy removal. Should pressurized nozzles be used, they shall utilize grommets, which ensure easy removal.
2. Each tower cell shall be furnished with a single water inlet connection, complete with the means to automatically balance flow rates to the hot water basins.

I. Basin Covers:

1. Material: 304 Stainless Steel.
2. Type: Removable.

J. Casing Panels:

1. Casing panels shall be constructed of corrosion and UV-resistant fiberglass reinforced polyester (FRP) to minimize maintenance requirements and prolong equipment life. Casing panels shall not provide structural support, since the sturdy, structural frame of the tower transfers all loads to the equipment anchorage. Corrosion resistant Type 304 stainless steel casing panels may be used in lieu of FRP panels.

K. Water Outlet:

1. The water outlet connection shall be beveled for welding and grooved for mechanical coupling or bolt hole circle designed to accept an ASME Class 150 flat face flange. The outlet shall be provided with large-area lift out strainers with perforated openings sized smaller than the water distribution nozzles and an anti-vortexing device to prevent air entrainment. The strainer and vortex device shall

be constructed of the same materials as the cold water basin to prevent dissimilar metal corrosion.

L. Guards:

1. Provide guards for exposed parts of belt or gear drives.
2. Refer to Section 23 05 02, Article 2.05.

M. Framework:
1. All framework shall be ¼” thick galvanized steel.

N. Handrails and Ladders:

1. Material: Aluminum.
2. Railing around top working surfaces, and ladder to them with safety cage.
3. Provide access door platform with rail.

O. Fan: Fan cylinders shall be heavy galvanized steel consisting of four segments.

1. Fan(s) shall be heavy-duty, axial flow with aluminum alloy blades selected to provide optimum cooling tower thermal performance with minimal sound levels. Air shall discharge through a fan cylinder designed for streamlined air entry and minimum tip clearance for maximum fan efficiency. The top of the fan cylinder shall be equipped with a conical, non-sagging removable fan guard.
2. Bearings: Fan(s) and shaft(s) shall be supported by heavy-duty, self-aligning, grease-packed ball bearings with moisture proof seals and integral slinger collars, designed for a minimum L10 life of 80,000 hours.
3. Fan Drive: The fan(s) shall be driven by a one-piece, multi-groove, solid back V-type powerband with taper lock sheaves designed for 150% of the motor nameplate horsepower. The powerband shall be constructed of neoprene reinforced polyester cord and be specifically designed for cooling tower service.
4. Sheaves: Fan and motor sheave(s) shall be fabricated from corrosion-resistant materials to minimize maintenance and ensure maximum drive and powerband operating life.
5. Capacity Adjustment:
   a. Variable Speed Drive.
6. Variable frequency drive(s) shall be provided by manufacturer and designed specifically for cooling tower motor(s). The drive enclosure shall be provided with NEMA 3R outdoor rated enclosure.

P. Motor:

1. Tower shall be equipped with fan motors as scheduled. Service factor of 1.15 of the protected type enclosure. If fans are cycled for capacity control, temperature limits shall be set to prevent motor cycling of no more than 6 times per hour.
2. Location: Out of humid airstream.
3. Fan motor(s) shall be totally enclosed fan cooled (TEFC) and mounted outside the airstream. The motor shall be furnished with special moisture protection on

windings, shafts and bearings. Fan motors shall be premium efficient/inverter duty type designed per NEMA standard MG1, Section IV Part 31.

Q. Access and Safety

1. Access panels shall be 16 gauge galvanized steel and be provided on both end walls for access to the eliminator and plenum area by a sliding access door. A heavy duty galvanized steel wire grille-type fan guard shall be provided over each fan cylinder. Provide an aluminum ladder from a point 1'-0" above the (roof/grade) to the top of the handrail. 1-1/4" diameter galvanized steel pipe handrails shall be provided around the top of the cooling deck to insure the safety of operating personnel. Tower safety features shall meet OSHA requirements.

R. Accessories:

1. Air inlet screen.
2. Hot water basin cover.
3. Basin Heater(s): The cooling tower cold water basin shall be provided with electric heater(s) to prevent freezing in low ambient conditions. The heater shall be sized per manufacturer’s recommendation based on sump capacity to maintain 40°F basin water temperatures at -20 °F ambient. The heater(s) shall be provided with low water cutout and thermostat.
4. Vibration switch mounted by Tower manufacturer.
5. Basin Water Level Control: The cooling tower manufacturer shall provide an electric water level control (EWLC) system. The system shall consist of water level sensing and control units in quantities and locations as indicated on the drawings. Each water level sensing and control unit shall be hermetically sealed and consist of the following: solid state controls including all necessary relays and contacts to achieve the specified sequence of operation; status code L. E. D which illuminates to indicate status: stainless steel water level sensing electrodes with brass holder; Schedule 40 PVC standpipe assembly with vent holes, and all necessary stainless steel mounting hardware. Provide PVC union directly below the control enclosure to facilitate the removal and access of electrodes and control enclosure. The number and position of water level sensing electrodes shall be provided to sense the following: high water level, low water level, high water alarm level, low water alarm level, and heater safety cutout.
6. Internal Walkway: An internal walkway shall be provided in the plenum section to provide for inspection and maintenance. All working surfaces shall be able to withstand 50 psf (244 kg/m2) live load or 200 pound (90.7 kg) concentrated load. Other components of the cooling tower, i.e. basin and fill/drift eliminators, shall not be considered an internal working surface. Cooling tower manufacturers that promote these surfaces to be used as a working platform shall provide a two-year extended warranty to the Owner to repair any damage to these surfaces caused during routine maintenance.
7. Winterization: (Electric) Each cold water basin shall be provided with electric heater components consisting of heater(s), stainless steel electric float switch, aquastat and contractor/circuit breaker to maintain 40˚F. in cold water basin at

minus 20˚F. ambient and wired by the cooling tower manufacturer, including control transformer for 120V.

S. Control Panel (one per cell) with the following:

1. NEMA 3R construction with fused disconnect switch that may be padlocked.
2. VFD with internal heater and fan.
3. Control power transformer (120 V control power).
4. Auto-Off-Low-High selector switch.
5. Pilot lights for low or high speed running.
6. PENN A-28 thermostat for two speed fan control *[if no B MS on job].*
7. Automatic decelerating timing relay for two speed operation.
8. PENN A-19 thermostat for basin heater control.
9. Interlock switch which will prevent the basin heater and fan from operating simultaneously.
10. Automatic sensor switch to turn off the heater when there is no water in the basin.
11. Provide 120V interlock wiring between the control panel(s) for each cell to allow a single CWS sensor to stage each cell as necessary to maintain leaving condenser water temperature.
12. Provide dry electrical contacts for on/off control of system from BMS.

T. The tower shall be warranted against defects in materials and workmanship for a period of five (5) years.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install units level and plumb.

B. Provide necessary auxiliary supporting steel.

C. Mount motors and drives so belts run true.

D. Wire vibration switch to de-energize fan when excessive vibration is experienced.

E. Pipe all drains to nearest roof drain or standpipe waste. Provide daylight at connection so flow can be observed.

3.2 ADJUSTMENTS

A. Adjust drive for speed shown in submittal.

B. Check motor amps. Do not overload motor.

C. Check for unusual noise or vibration.

D. Provide necessary lubrication.

E. Adjust make-up water control.

F. Adjust sump water thermostat.

END OF SECTION

SECTION 23 73 24

AIR HANDLING UNITS

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Packaged Air Handling Units.

1.2 RELATED WORK

A. Section 23 05 13 – Motors and Starters

B. Section 23 05 30 – Electronic Speed Controllers

C. Section 23 82 16 – Air Coils

D. Section 23 40 00 – Air Cleaning

E. Section 23 09 00 – Building Automation and Automatic Temperature Control Systems

1.3 REFERENCES

A. ARI 430 - Standard for Central Station Air Handling Units.

B. NFPA 90A - Installation of Air Conditioning and Ventilation Systems.

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

D. SMACNA - HVAC Duct Construction Standards.

E. ARI 410 - Standard for Forced Circulation Air-Cooling and Air-Heating Coils.

F. ANSI/UL 900 - Test Performance of Air Filter Units.

G. AMCA 301 - Method for Publishing Sound Ratings for Air Moving Devices.

H. ASHRAE 90.1 - Energy Efficiency.

1.4 QUALITY ASSURANCE

A. Air Handling Units: Product of manufacturer regularly engaged in production of components who issues complete catalog data on total product offering.

B. Air Handling Units: Certify capacity, static pressure, fan speed, brake horsepower and selection procedures in accordance with ARI 430-89.

C. Air Coils: Certify capacities, pressure drops and selection procedures in accordance with ARI 410-87.

D. Manufacturer Qualifications:

1. Company specializing in manufacturing the products specified in this section with minimum of five years documented experience.
2. Units shall be manufactured in a facility registered to ISO 9001 manufacturing quality standard.
3. Air-handling unit assembly shall have UL 1995 certification for safety, including use with electric heat.
4. Products requiring electric connection shall be listed and classified by ETL and CSA as suitable for the purpose specified and indicated.
5. Coil performance shall be certified in accordance with AHRI Standard 410, latest edition.
6. Air-handling unit shall be AHRI 430 listed and meet NFPA 90A requirements.

1.5 SUBMITTALS

A. Submit as-built drawings and product data under provisions of Division 1.

B. As-built drawings shall show unit configuration in direction of airflow, and shall indicate assembly and unit dimensions.

C. Product data shall indicate dimensions, weights, capacities, fan performance, motor electrical characteristics, and finishes of materials.

D. Submit product data of filter sizes and quantities, filter performance, and filter frames.

E. Submit manufacturer’s installation instructions under provisions of Division 1.

F. Provide fan curves with specified operating point clearly plotted.

G. Submit sound power levels for air handling unit(s) at scheduled conditions. If unit exceeds sound power levels at scheduled conditions, manufacturer must provide sound attenuators.

1.6 OPERATION AND MAINTENANCE DATA

A. Submit operation and maintenance data under provisions of Division 1.

B. Include instructions for lubrication, filter replacement, motor and drive replacement, spare parts lists, and wiring diagrams.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Do not operate units for any purpose, temporary or permanent, until ductwork is clean, filters are in place, bearings lubricated, and fan has been test run under observation.

B. All indoor units, painted or unpainted, shall be completely shrink-wrapped from the factory for protection during shipment. Tarping of bare units is unacceptable.

C. Inspect for transportation damage, store in clean, dry place, and protect from weather and construction traffic. Handle carefully to avoid damage to components, enclosures, and finish.

1.8 START-UP REQUIREMENTS

A. Do not operate units until ductwork is clean, filters are in place, bearings lubricated, condensate properly trapped, piping connections verified and leak tested, belts aligned and tensioned, all shipping braces have been removed, and fan has been test run under observation.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Design Basis: As Scheduled

1. Carrier Model Number:
   a. 39L — Indoor Unit

B. Other acceptable manufacturers:

1. Carrier
2. York
3. McQuay
4. Thermal Corp
5. Trane

2.2 GENERAL

A. Any exceptions to the specifications must be clearly defined. The contractor shall be responsible for any additional expenses that may occur due to any exception made.

B. Factory fabricate draw-thru type air handling units suitable for the scheduled air pressure operation.

C. Factory fabricate units with fan section, coil sections, mixing box, filter sections, access sections, as called for on the drawings and in accordance with this specification.

D. Factory fabricate and test air handling units of sizes, capacities, and configuration as indicated and specified. Units shall be fully assembled up to practical shipping limitations. On units not shipped fully assembled, manufacturer shall tag each section to indicate location in direction of airflow to facilitate assembly at the job site.

E. Base performance on elevations shown on drawings.

2.3 CASING

A. Construction:

1. Unit shall be constructed of a complete frame with easily removable panels. Removal of any panel shall not affect the structural integrity of the unit.
2. All units shall be supplied with 14-gage or heavier, G-90 galvanized steel base rails. Bolton legs are NOT acceptable. Perimeter lifting lugs for overhead lifting shall be provided on each section. Slinging units in place of lifting lugs shall not be acceptable.

3. Unit shall be thermally broken to minimize the conduction path from the inside of the casing to the outside.
4. Casing panels (top, sides, and bottom) shall be constructed of galvanized steel, and shall have one of the following exterior finishes as specified:
   a. Unpainted G-90 galvanized steel.
5. Casing panels (top, sides, and bottom) shall be one piece, double-wall construction with insulation sealed between the inner and outer panels. Panel assemblies shall not carry an R-value of less than 13.
6. Casing deflection shall not exceed a 1:200 ratio when subject to an internal pressure of ± 8-in. wg. Casing leakage rate shall be less than 1% at 8 in. wg of nominal unit airflow or 50 cfm, whichever is greater. Leakage rate shall be tested and documented on a routine basis on random production units. Optionally, factory witness leak testing and/or test reports shall be available.
7. Side panels shall be easily removable for access to unit and shall seal against a full perimeter automotive style gasket to ensure a tight seal.
8. The panel retention system shall comply with UL 1995 which states all moving parts (for example, fan blades, blower wheels, pulleys, and belts) that, if accidentally contacted, could cause bodily injury, shall be guarded against accidental contact by an enclosure requiring tools for removal.
9. Accessibility options shall be as follows:
   a. Hinged double-wall access door on either side with removable access panel(s) on the other side.
   b. Hinged double-wall access doors on both sides.
   c. Removable double-wall access panels on both sides.
10. Depending on the options selected and the remaining available space inside each section, the following options may be available:
   a. Thermal pane reinforced glass viewports shall be factory-installed on the access panel(s) or door(s) of the section.
   b. Marine lights shall be factory installed with GFCI (ground fault circuit interrupter) convenience outlets.
11. Fan supports, structural members, panels, or flooring shall not be welded, unless aluminum, stainless steel, or other corrosion-resistant material is used. Painted welds on unit exterior steel or galvanized steel are not acceptable.
12. All coil sections shall be double-wall construction with insulation sealed between the inner and outer panels. Panel assemblies shall not carry an R-value of less than 13. Single height coil sections shall have removable frame sections to facilitate vertical coil extraction.

B. Access Doors:

1. Access doors shall be one piece, minimum of 2” thick, double-wall construction with insulation sealed between the inner and outer panels. Panel assemblies shall not carry an R-value of less than 13.
2. Access doors shall be included between each air handler component.
3. Each access door shall have a minimum of two securing latches which also are operable from inside the unit.
4. Positive pressured section shall have inward swinging doors, negative pressurized doors shall have outward swinging doors.
5. Access doors shall include view ports for every section.
6. Coil sections shall be separated by a minimum space of 18”. Each coil section shall have full size access door(s). Coil casing shall be fabricated from 16 gage 304 stainless steel. Removable panels shall be located on both side of the air handling unit.

C. Drain Pans:

1. Drain pans shall be insulated double-wall stainless steel construction and shall extend the entire length of the coil section and extend as possible in the direction of airflow. The pan shall be sloped toward the drain connection. Drain pan shall have 11/2-in. MPT connection exiting through the hand side or opposite side of the casing as specified. One drain outlet shall be supplied for each cooling coil section. Drain pan shall allow no standing water and comply with ASHRAE Standard 62.1-2010. Where 2 or more coils are stacked in a coil bank, intermediate drain pans shall be provided and the condensate shall be piped to the bottom drain pan. The bottom coil shall not serve as a drain path for the upper coil. Drain pans shall be insulated.

2.4 FANS

A. General:

1. Fan assembly vibration shall not exceed 0.248 in. per second when mounted on active isolators. Vibration shall be measured in both vertical and horizontal directions at the specified fan operating speed using specified motor. Accelerometers shall be mounted on the motor near the bearing locations.
2. All fan sled components shall provide corrosion protection to pass 100-hour salt spray test per ASTM B-117.
3. Fan wheels shall be keyed to the shaft and shall be designed for continuous operation at maximum rated fan speed and motor horsepower. Fan wheels and shafts shall be selected with a maximum operating speed 25% below the first critical.
4. Belt drive fan motor shall be mounted within the fan section casing on slide rails equipped with adjusting screws. Motor shall be premium efficiency, open drip-proof or totally enclosed fan cooled NEMA Design A or B with size and electrical characteristics as shown on the equipment schedule. Motor shall be mounted on a horizontal flat surface and shall not be supported by the fan or its structural members. All three-phase motors shall have a ± 10% voltage utilization range and a 1.15 minimum service factor. Motor shall be compliant with the Energy Independence and Security Act (EISA) of 2007 where applicable. Single-phase motors shall be available up to and including 5 hp.
5. Fan section to have viewport & light.

B. Performance Ratings:

1. Fan performance shall be rated and certified in accordance with AHRI Standard 430, latest edition.

C. Sound Ratings:

1. Manufacturer shall submit first through eighth octave sound power for fan discharge and casing radiated sound.

D. Mounting:

1. Fan scroll, wheel, shaft, bearings, drives, and motor shall be mounted on a common base assembly. The base assembly is isolated from the outer casing with factory-installed isolators and rubber vibration absorbent fan discharge seal. A canvas style duct connection between fan discharge and cabinet is not acceptable. Units shall use 2-in. deflection spring isolators.

E. Flexible Connection:

1. The base assembly is isolated from the outer casing with factory-installed isolators and rubber vibration absorbent fan discharge seal. A canvas style duct connection between fan discharge and cabinet is not acceptable.

2.5 BEARINGS AND DRIVES

A. Bearings:

1. Self-aligning, grease lubricated, anti-friction with lubrication fittings extended to drive side of fan section. Optional grease fittings extended to the exterior of the casing are available. All bearing life calculations shall be done in accordance with ABMA 9 for ball bearings and ABMA 11 for roller bearings.

B. Shafts:

1. Fan shafts shall be solid steel, turned, ground, polished and coated with a rust inhibitor.

C. V-Belt Drive:

1. Drive shall be designed for 1.5 service factor option and/or a factory-supplied extra set of belts. Drives shall be fixed pitch with optional variable pitch for motors 15 hp and less. All drives shall be factory mounted, with sheaves aligned and belts properly tensioned.

2.6 COILS

A. All steam coils shall be provided to meet the scheduled performance. All coil performance shall be certified in accordance with AHRI Standard 410. All steam coils, integral face and bypass coils and 5/8-in. OD coils shall be warranted for a period not in excess of 12 months from their shipment from the manufacturer. Coil epoxy coating shall be covered under a 5-year limited warranty from the date of shipment from the manufacturer.

B. General Fabrication:

1. Aluminum plate fin type with belled collars. Optional copper plate fins shall be supplied, if specified.
2. Aluminum-finned coils shall be supplied with die-formed casing and tube sheets of mill galvanized steel or stainless steel as specified. Copper-finned coils shall be supplied with stainless steel casing and tube sheets.

C. Steam Distribution (Non-Freeze Type) Heating Coils:

1. Headers shall be steel with MPT connections.
2. Inner steam distributing tubes shall be 5/8-in. OD, 0.020 in. wall thickness, located within 1 in. OD, 0.030 in. wall outer condensing tubes. Working pressure shall be 175 psig at 400 F.
3. Inner steam distributing tubes shall be 3/8-in. OD, 0.020 in. wall thickness, located within 5/8-in. OD, 0.035 in. wall outer condensing tubes. Working pressure shall be 175 psig at 400 F.

2.7 FILTER SECTIONS

A. Angle filter sections shall accept either 2-in. filters of standard sizes, arranged in a horizontal V formation.

B. Magnehelic Gages:

1. Housing shall be constructed of a die cast aluminum case and bezel with acrylic cover. Exterior finish shall be coated gray to withstand 168 hr salt spray corrosion test.
2. Accuracy shall be ±2% of full scale throughout range at 70 F. (21.1 C).
3. Pressure limits shall be -20 in. Hg to 15 psig (0.677 bar to 1.034 bar).
4. Overpressure relief plugs shall open at approximately 25 psig (1.72 kPa).
5. Temperature limits shall be 20 to 140 F (-6.67 to 60 C).
6. Diameter of dial face shall be 4 in. (101.6 mm).
7. Process connections shall be 1/8-in. female NPT duplicate high and low pressure taps – one pair side and one pair back.
8. A magnehelic gauge shall be mounted at each filter section measuring the pressure drop across the filter.

2.8 ELECTRICAL ACCESSORIES

A. Starters:
Factory-supplied disconnects shall be covered under a 1 year limited warranty from the manufacturer from the date of shipment.

1. Starter without disconnect:
   a. Adjustable motor overload with trip indication.
   b. Manual overload reset button (accessible without opening enclosure).
   c. 115-v fused secondary control transformer (fuse included — fused primary and secondary over 50 amps).
   d. Hand/Off/Auto selector switch (accessible without opening enclosure).
   e. Separate 4-position terminal strip for remote H-O-A wiring.
   f. C series contactors.
   g. Horsepower rated for motor applications.
   h. NEMA 4X type non-metallic enclosures.
   i. Lug connections for field wiring.
   j. Factory mounted, wired, and run tested with factory-supplied motor.
   k. UL listed.
2. Combination Starter/Disconnect:
   a. Non-fused UL 508 disconnect switch with lockable handle (locks not provided).
   b. Cover interlock.
   c. Adjustable motor overload with trip indication.
   d. Manual overload reset button (accessible without opening enclosure).
   e. 115-v fused secondary control transformer (fuse included — fused primary and secondary over 50 amps).
   f. Hand/Off/Auto selector switch (accessible without opening enclosure).
   g. Separate 4-position terminal strip for remote H-O-A wiring.
   h. C series contactors.
   i. Horsepower rated for motor applications.
   j. NEMA 4X type non-metallic enclosures.
   k. Lug connections for field power wiring.
   l. Factory mounted, wired, and run tested with factory-supplied motor.

B. Bypass for Variable Frequency Drives:

Factory-supplied bypasses shall be covered under a 1 year limited warranty from the manufacturer from the date of shipment.

1. 200-230 v/3 Ph/60 Hz (1 to 7.5 Hp), 460- 575 v/3 Ph/60 Hz (1 to 20 Hp), 380 v/3 Ph/ 50 Hz (1 to 15 Hp):
    a. 4-position panel-mounted disconnect style switch with lockable handle (locks not provided), meets OSHA 1910.
    b. Switch position indication (LINE/OFF/ DRIVE/TEST).
    c. Adjustable motor overload with trip indication (LINE position).
    d. Manual overload reset button.
    e. Horsepower rated for motor applications.
    f. Direct control (no contactors, relays, or holding coils).
    g. Complete isolation of inverter in LINE position.
    h. NEMA 4 type metal enclosures.
    i. Terminal strip provided for field power supply wiring.
    j. Lug connection for field ground wire.
    k. Gold flashed, auxiliary switch contact set (for switch position monitoring).
    l. Factory mounted, wired to VFD and motor, and run tested (motor and VFD must be factory supplied and installed).
    m. The VFD shall have programmable “Sleep” and “Wake up” functions to allow the drive to be started and stopped from the level of a process feedback signal.
2. All VFDs to have the following adjustments:
    a. Three (3) programmable critical frequency lockout ranges to prevent the VFD from operating the load continuously at an unstable speed. The lockout range must be fully adjustable, from 0 to full speed.
    b. Two (2) PID set point controllers shall be standard in the drive, allowing pressure or flow signals to be connected to the VFD, using the microprocessor in the VFD for the closed-loop control. The VFD shall have 250 mA of 24 VDC auxiliary power and be capable of loop powering a transmitter supplied by others. The PID set point shall be adjustable from the VFD keypad, analog inputs, or over the communications bus. There shall be two independent parameter sets for the PID controller and the capability to switch between the parameter sets via a digital input, serial communications or from the keypad. The independent parameter sets are typically used for night setback, switching between summer and winter set points, etc.
    c. There shall be an independent, second PID loop that can utilize the second analog input and modulate one of the analog outputs to maintain the set point of an independent process (ie. valves, dampers, etc.). All set points, process variables, etc. to be accessible from the serial communication network.
    d. Two (2) programmable analog inputs shall\ accept current or voltage signals.
    e. Two (2) programmable analog outputs (0 to 20 mA or 4 to 20 mA). The outputs may be programmed to output proportional to Frequency, Motor Speed, Output Voltage, Output Current, Motor Torque, Motor Power (kW), DC Bus voltage, Active Reference, Active Feedback, and other data.
    f. Six (6) programmable digital inputs for maximum flexibility in interfacing with external devices. All digital inputs shall be programmable to initiate upon an application or removal of 24 VDC or 24 VAC.
    g. Three (3) programmable, digital Form-C relay outputs. The relay outputs shall include programmable on and off delay times and adjustable hysteresis. The relays shall be rated for maximum switching current 8 amps at 24 VDC and 0.4 A at 250

VAC; Maximum voltage 300 VDC and 250 VAC; continuous current rating of 2 amps RMS. Outputs shall be true Form-C type contacts; open collector outputs are not acceptable.

h. Run permissive circuit: There shall be a run permissive circuit for damper or valve control. Regardless of the source of a run command (keypad, input contact closure, timeclock control, or serial communications), the VFD shall provide a dry contact closure that will signal the damper to open (VFD motor does not operate). When the damper is fully open, a normally open dry contact (end switch) shall close. The closed end-switch is wired to a VFD digital input and allows VFD motor operation. Two separate safety interlock inputs shall be provided. When either safety is opened, the motor shall be commanded to coast to stop and the damper shall be commanded to close. The keypad shall display "start enable 1 (or 2) missing". The safety input status shall also be transmitted over the serial communications bus.

i. The VFD control shall include a programmable time delay for VFD start and a keypad indication that this time delay is active. A Form C relay output provides a contact closure to signal the VAV boxes open. This will allow VAV boxes to be driven open before the motor operates. The time delay shall be field programmable from 0 to 120 seconds. Start delay shall be active regardless of the start command source (keypad command, input contact closure, time-clock control, or serial communications).

j. Seven (7) programmable preset speeds.

k. Two independently adjustable accelerate and decelerate ramps with 1 to 1800 seconds adjustable time ramps.

l. The VFD shall include a motor flux optimization circuit that will automatically reduce applied motor voltage to the motor to optimize energy consumption and reduce audible motor noise. The VFD shall have selectable software for optimization of motor noise, energy consumption, and motor speed control.

m. The VFD shall include a carrier frequency control circuit that reduces the carrier frequency based on actual VFD temperature that allows higher carrier frequency settings without derating the VFD.

n. The VFD shall include password protection against parameter changes.

3. The keypad shall include a backlit LCD display. The display shall be in complete English words for programming and fault diagnostics (alphanumeric codes are not acceptable). All VFD faults shall be displayed in English words. The keypad shall include a minimum of 14 assistants including:

a. Start-up assistant
b. Parameter assistants
c. PID assistant.
d. Reference assistant.
e. I/O assistant
f. Serial communications assistant
g. Option module assistant
h. Panel display assistant
i. Low noise set-up assistant
j. Maintenance assistant
k. Troubleshooting assistant
l. Drive optimizer assistants

4. All applicable operating values shall be capable of being displayed in engineering (user) units. A minimum of three operating values from the list below shall be capable of being displayed at all times. The display shall be in complete English words (alpha-numeric codes are not acceptable):

a. Output Frequency
b. Motor Speed (RPM, %, or Engineering units)
c. Motor Current
d. Motor Torque
e. Motor Power (kW)
f. DC Bus Voltage
g. Output Voltage

5. The VFD shall include a fireman's override input. Upon receipt of a contact closure from the fire / smoke control station, the VFD shall operate in one of two modes: 1) Operate at a programmed predetermined fixed speed ranging from –500 Hz (reverse) to 500 Hz (forward). 2) Operate in a specific fireman's override PID algorithm that automatically adjusts motor speed based on override set point and feedback. The mode shall override all other inputs (analog/digital, serial communication, and all keypad commands), except customer defined safety run interlocks, and force the motor to run in one of the two modes above. "Override Mode" shall be displayed on the keypad. Upon removal of the override signal, the VFD shall resume normal operation, without the need to cycle the normal digital input run command.
6. Serial Communications:
   a. The VFD shall have an EIA-485 port as standard. The standard protocols shall be Modbus, Johnson Controls N2, Siemens Building Technologies FLN, and BACnet*. [Optional protocols for LonWorks†, Profibus, EtherNet, BACnet IP, and DeviceNet shall be available.] Each individual drive shall have the protocol in the base VFD. The use of third party gateways and multiplexers is not acceptable. All protocols shall be "certified" by the governing authority (i.e., BTL Listing for BACnet). Use of non-certified protocols is not allowed.
   b. The BACnet connection shall be an EIA- 485, MS/TP interface operating at 9.6, 19.2, 38.4, or 76.8 Kbps. The connection shall be tested by the BACnet Testing Labs (BTL) and be BTL Listed. The BACnet interface shall conform to the BACnet standard device type of an Applications Specific Controller (B-ASC). The interface shall support all BIBBs defined by the BACnet standard profile for a B-ASC including, but not limited to:
      1) Data Sharing – Read Property – B.
      2) Data Sharing – Write Property – B.
      3) Device Management – Dynamic Device Binding (Who-Is; I-Am).
      4) Device Management – Dynamic Object Binding (Who-Has; I-Have).
      5) Device Management – Communication Control – B.
   c. If additional hardware is required to obtain the BACnet interface, the VFD manufacturer shall supply one BACnet gateway per drive. Multiple VFDs sharing one gateway shall not be acceptable.
   d. Serial communication capabilities shall include, but not be limited to; run-stop control, speed set adjustment, proportional/integral/derivative PID control adjustments, current limit, accel/decel time adjustments, and lock and unlock the keypad. The drive shall have the capability of allowing the DDC to monitor feedback such as process variable feedback, output speed / frequency, current (in amps), % torque, power (kW), kilowatt hours (resettable), operating hours (resettable), and drive temperature. The DDC shall also be capable of monitoring the VFD relay output status, digital input status, and all analog input and analog output values. All diagnostic warning and fault information shall be transmitted over the serial communications bus. Remote VFD fault reset shall be possible.
   e. The VFD shall include an independent PID loop for customer use. The independent PID loop may be used for cooling tower bypass valve control, chilled water valve / hot water valve control, etc. Both the VFD PID control loop and the

independent PID control loop shall continue functioning even if the serial communications connection is lost. As default, the VFD shall keep the last good set point command and last good DO and AO commands in memory in the event the serial communications connection is lost and continue controlling the process.

7. EMI/RFI filters: All VFDs shall include EMI/RFI filters. The onboard filters shall allow the VFD assembly to be CE Marked and the VFD shall meet product standard EN 61800-3 for the First Environment restricted level with up to 100 feet of motor cable. No Exceptions. Certified test reports shall be provided with the submittals confirming compliance to EN 61800-3, First Environment.
8. All VFDs through 75 hp at 480 V shall be protected from input and output power mis-wiring. The VFD shall sense this condition and display an alarm on the keypad. The VFD shall not sustain damage from this power mis-wiring condition.
9. Operational Functions:
   a. The drive shall contain two separate acceleration/ deceleration times with auto tuning for optimum setting (0.1 to 6000 seconds) with choice of linear, S, or C curves that shall be factory programmed to match the fan load and prevent nuisance overcurrent fault trips.
   b. The drive shall be equipped with both local/ remote and manual/auto keys on touchpad.
   c. The drive shall be equipped with a quick setup key.
   d. The drive shall contain 15 preset speeds, which can be activated from the keypad, terminal inputs, and host computer.
   e. The drive shall have the capability of storable special custom user setting.
   f. The drive shall restart into a rotating motor operating in either the forward or reverse direction and match that frequency.
   g. The drive shall have adjustable soft stall (10% to 150%) which reduces frequency and voltage of the inverter to sustain a run in an overload situation factory programmed for each motor’s characteristics.
   h. The drive shall be capable of performing a time base pattern run using 4 groups of 8 patterns each using the 15 preset speed values for a maximum of 32 different patterns.
   i. The drive shall have adjustable UL listed electronic overload protection (10% to 100%) factory programmed to match each motor’s FLA/RLA ratings.
   j. The drive shall have a custom programmable volt/hertz pattern.
10. Protective Features:
   a. The drive shall be rated for 200,000 AIC (ampere interrupting capacity). The use of input fuses to achieve this rating shall not be acceptable.
   b. The drive shall have external fault input.
   c. The drive shall be capable of resetting faults remotely and locally.
   d. The drive shall be programmable to alert the following alarms:
      1) Over torque alarm.
      2) Inverter overload pre-alarm.
      3) Motor overload pre-alarm.
      4) Braking resistor overload pre-alarm.
      5) Inverter overheat pre-alarm.
      6) Undercurrent alarm.
      7) Overcurrent pre-alarm.
      8) Communication error alarm.
      9) Cumulative timer alarm.
      10) Executing retry.
   e. The drive shall identify and display the following faults:
      1) Overcurrent during acceleration trip.

2) Overcurrent during deceleration trip.
3) Overcurrent during normal run trip.
4) Overcurrent on the DC Bus during acceleration trip.
5) Overcurrent on the DC Bus during deceleration trip.
6) Overcurrent on the DC Bus during normal run trip.
7) Load end overcurrent trip detected at start-up (output terminals, motor wiring, etc.).
8) U-phase short circuit trip detected at start-up.
9) V-phase short circuit trip detected at start-up.
10) W-phase short circuit trip detected at start-up.
11) Overvoltage during acceleration trip.
12) Overvoltage during deceleration trip.
13) Overvoltage during normal (constant speed) run trip.
14) Inverter overloaded trip.
15) Motor overloaded trip.
16) Inverter overheat trip.
17) Emergency off trip message.
18) EEPROM failure during write cycle.
19) EEPROM abnormality during initial reading.
20) RAM error.
21) ROM error.
22) CPU error.
23) Communication interruption error.
24) Gate array error.
25) Output current detection circuit error.
26) Option PCB error trip.
27) Low operating current trip.
28) Main circuit under voltage trip.
29) Over torque trip.
30) Software detected earth fault trip.
31) Hardware detected earth fault trip.
32) Inverter type form mismatch error.
33) EEPROM type form mismatch error.

11. Monitor Functions:
a. The drive digital display shall be capable of displaying the following: Frequency, percent current, current amps, percent voltage I/O, voltage in volts I/O, RPM, GPM, I/O watts, torque, and input reference signal, kWh.
b. The drive shall have 320 programmable parameters which can be changed while the drive is operating.
c. The drive’s 353 parameters shall be adjustable from the 8-key touchpad or computer link.
d. The drive’s 8-key touchpad shall be NEMA 12 rated.
e. The drive’s keypad shall be capable of being extended 15 ft from the drive.
f. The drive shall contain a reset of all parameters to factory default settings or user defaults (whichever one is chosen).
g. The drive shall have 2 programmable analog outputs programmable to 17 choices.
h. The drive shall have one programmable relay output programmable to 67 choices.
i. The drive shall have 8 programmable digital inputs programmable to 54 choices.
j. The drive shall have a pulse train out-put proportional to frequency (48, 96, 360 times frequency).
k. The drive shall have an elapsed time meter.

PART 3 - EXECUTION

3.1 GENERAL

A. Assemble and install in accordance with manufacturers written installation instructions and details on drawings.

B. Coordinate duct, piping and electrical work so as to provide access to unit for maintenance and filter replacement and coil removal with minimum disturbance of piping. Install units with adequate clearances to access valves, open access doors fully, and allow NEC clearances in front of disconnect switches.

C. Prior to unit start-up all controls shall be installed and tested.

D. Prior to initial start-up and for system testing install air filters to protect the unit and ductwork from dirt and debris. After the system has been tested and prior to turning the system over to the Owner, replace the pre-filters with new, clean filters as specified.

E. Prior to turning the system over to the Owner, all damages incurred during shipping, storing and installing shall be repaired. These repairs shall be sufficient to bring the equipment back to the quality standards, equal to the original manufacturing standards. These repairs shall include but are not limited to repairing painted surfaces, dent removal, combing coil fins, repairing or replacing wet, sagging or torn insulation, etc.

F. Pipe condensate full size to nearest floor drain. Provide trap 1” deeper than fan static pressure.

END OF SECTION

SECTION 23 81 19

SELF CONTAINED WATER COOLED AIR CONDITIONING UNITS

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Self Contained Air Conditioners

1.2 RELATED WORK

A. Section 23 05 13 – Motors and Starters

B. Section 23 05 30 – Electronic Speed Controllers

C. Section 23 09 00 – Building Automation and Automatic Temperature Control Systems

1.3 REFERENCES

A. ARI 430 – Standard for Central Station Air Handling Units.

B. NFPA 90A – Installation of Air Conditioning and Ventilation Systems.

C. ANSI/AFBMA 9 – Load Ratings and Fatigue Life for Ball Bearings.

D. SMACNA – HVAC Duct Construction Standards.

E. ARI 410 – Standard for Forced Circulation Air-Cooling and Air-Heating Coils.

F. ANSI/UL 900 – Test Performance of Air Filter Units.

G. AMCA 301 – Method for Publishing Sound Ratings for Air Moving Devices.

H. ARI 320.

I. ASHRAE 90.1 – Energy Efficiency

1.4 QUALITY ASSURANCE

A. All Self Contained Air Conditioners and Heating Pump Units: Product of manufacturer regularly engaged in production of components who issues complete catalog data on total product offering.

B. Certify capacity, static pressure, fan speed, brake horsepower and selection procedures in accordance with ARI.

C. Air Coils: Certify capacities, pressure drops and selection procedures in accordance with ARI 410-87.

1.5 SUBMITTALS

A. Submit as-built drawings and product data.

B. As-built drawings shall show unit configuration in direction of airflow, and shall indicate assembly and unit dimensions.

C. Product data shall indicate dimensions, weights, capacities, fan performance, motor electrical characteristics, and finishes of materials.

D. Submit product data of filter sizes and quantities, filter performance, and filter frames.

E. Submit manufacturer's installation instructions under provisions of Section 01 __ __.

F. Provide fan curves with specified operating point clearly plotted.

G. Submit sound power levels for air handling unit(s) at scheduled conditions. If unit exceeds sound power levels at scheduled conditions, manufacturer must provide additional sound attenuators.

1.6 OPERATION AND MAINTENANCE DATA

A. Submit operation and maintenance data.

B. Include instructions for lubrication, filter replacement, motor and drive replacement, spare parts lists, and wiring diagrams.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Store and protect products under provisions of Section 23 05 03.

B. Store in clean dry place and protect from weather and construction traffic. Handle carefully to avoid damage to components, enclosures, and finish.

1.8 ENVIRONMENTAL REQUIREMENTS

A. Do not operate units for any purpose, temporary or permanent, until ductwork is clean, filters are in place, bearings lubricated, and fan has been test run under observation.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Basis of Design: As Scheduled

B. Other Acceptable Manufacturers:

1. Climate Master
2. FTP
3. Trane
4. Temptrol
5. York
6. McQuay
7. Florida Heat Pump

2.2 GENERAL

A. Any exceptions to the specifications must be clearly defined. The contractor shall be responsible for any additional expenses that may occur due to any exception made.

B. Factory fabricate draw-thru type units suitable for the scheduled air pressure operation.

C. Factory fabricate units with fan section coil sections filter sections, access sections, as called for on the drawings and in accordance with this specification.

D. Factory fabricate and test air handling units of sizes, capacities, and configuration as indicated and specified. Units shall be fully assembled up to practical shipping limitations. On units not shipped fully assembled, manufacturer shall tag each section to indicate location in direction of airflow to facilitate assembly at the job site. Unit shall be shipped in sections as required to allow delivery and installation in final location.

E. Equipment shall be specifically designed for applications within conditioned interior areas.

F. Filters, threaded female water inlet and outlet connections, threaded female condensate connection, thermostat field interface terminal ship, discharge duct collar and all safety controls shall be furnished and factory installed.

G. Capacities shall be rated in accordance with ARI.

H. Equipment shall be ETL or CSA approved.

I. All equipment shall have decals and labels to aid in servicing and indicate caution areas.

2.3 SELF CONTAINED WATER COOLED AIR CONDITIONER

A. General:

1. Equipment shall be completely assembled, piped, and internally wired. Capacities and characteristics as listed in the schedule and the specifications that follow.
2. Units shall be supplied completely factory built capable of operating over an entering water temperature range from 20° to 120°F (-6.7° to 48.9°C) as standard.
3. All equipment listed in this section must be rated and certified in accordance with Air-Conditioning, Heating and Refrigeration Institute/International Standards Organization (AHRI/ISO 13256-1).
4. All equipment must be tested, investigated, and determined to comply with the requirements of the standards for Heating and Cooling Equipment UL-1995 for the United States and CAN/CSA-C22.2 NO.236 for Canada, by Intertek Testing Laboratories (ETL). The units shall have AHRI/ISO and ETL-US-C labels.
5. All units must pass a factory acceptance test. The quality control system shall automatically perform the factory acceptance test via computer. A detailed report card from the factory acceptance test shall ship with each unit

B. Basic Construction:

1. Coordinate unit air flow arrangement as shown on the mechanical drawings. Units must have the ability to be field convertible from straight to back or back to straight discharge with no additional parts or unit structure modification.
2. Provide factory installed hanger brackets with rubber isolation grommets packaged separately.
3. Contractor shall maintain all required access clearances around units and must have a minimum of three access panels for serviceability of compressor compartment.
4. Compressor section interior surfaces shall be lined with 1/2 inch (12.7mm) thick, 1-1/2 lb/ft3 (24 kg/m3) acoustic type glass fiber insulation.
5. Air handling section interior surfaces shall be lined with 1/2 in (12.7mm) thick, 1-1/2 lb/ft3 (24 kg/m3) foil-faced fiber insulation for ease of cleaning.
6. The heat pumps shall be fabricated from heavy gauge galvanized steel with powder coat paint finish. Both sides of the steel shall be painted for added protection.
7. Standard cabinet panel insulation must meet NFPA 90A requirements, air erosion and mold growth limits of UL-181, stringent fungal resistance test per ASTM-C1071 and ASTM G21, and shall meet zero level bacteria growth per ASTM G22.
8. Units to have factory installed 1”(25.4mm) discharge air duct collars, 1”(25.4mm) filter rails with 1”(25.4mm) filters factory installed, and factory installed unit-mounting brackets.
9. The unit will be supplied with internally factory mounted modulating water valve with delta T control. For two stage units, the modulating valve will automatically reduce the water flow through the unit during part load operation to maintain the configured temperature difference. The valve shall automatically adjust for operating mode, stage of capacity, source water temperature and variations in

external head pressure. The valve will also act as a shut-off valve to prevent water flow through the unit when the unit is not activated and will have a minimum position capability.

C. Fan and Motor Assembly:

1. Blower shall have inlet rings to allow removal of wheel and motor from one side without removing housing.
2. Units shall have a direct-drive centrifugal fan.
3. The fan motor shall be an ECM variable speed ball bearing type motor. The ECM fan motor shall provide soft starting, maintain constant CFM over its static operating range and provide airflow adjustment in 25 CFM increments via its control board.
4. The fan motor shall be isolated from the housing by rubber grommets. The motor shall be permanently lubricated and have thermal overload protection.
5. A special dehumidification mode shall be provided to allow lower airflows in cooling for better dehumidification. The dehumidification mode may be constant or automatic (humidistat controlled). Airflow/Static pressure rating of the unit shall be based on a wet coil and a clean filter in place.

D. Refrigerant Circuit:

1. All units shall contain an EarthPure®(HFC-410A) sealed refrigerant circuit including a high efficiency two-stage scroll compressor designed for heat pump operation, a thermostatic expansion valve for refrigerant metering, an enhanced corrugated aluminum lanced fin and rifled copper tube or all aluminum micro channel refrigerant to air heat exchanger, reversing valve, coaxial (tube in tube) refrigerant to water heat exchanger, and safety controls including a high pressure switch, low pressure switch (loss of charge), water coil low temperature sensor, and air coil low temperature sensor.
2. Access fittings shall be factory installed on high and low pressure refrigerant lines to facilitate field service. Activation of any safety device shall prevent compressor operation via a microprocessor lockout circuit. The lockout circuit shall be reset at the thermostat or at the contractor supplied disconnect switch.
3. Hermetic compressors shall be internally sprung. The compressor shall have a dual level vibration isolation system. The compressor will be mounted on specially engineered sound-tested EPDM vibration isolation grommets to a large heavy gauge compressor mounting plate, which is then isolated from the cabinet base with rubber grommets for maximized vibration attenuation. All units shall include a discharge muffler to further enhance sound attenuation. Compressor shall have thermal overload protection. Compressor shall be located in an insulated compartment away from air stream to minimize sound transmission.
4. Refrigerant to air heat exchangers shall utilize enhanced corrugated lanced aluminum fins and rifled copper tube or all aluminum microchannel construction rated to withstand 625 PSIG (4309 kPa) refrigerant working pressure. Refrigerant to water heat exchangers shall be of copper inner water tube and steel refrigerant outer tube design, rated to withstand 625 PSIG (4309 kPa) working refrigerant

pressure and 500 PSIG (3445 kPa) working water pressure. The refrigerant to water heat exchanger shall be "electro-coated" with a low cure cathodic epoxy material a minimum of 0.4 mils thick (0.4 – 1.5 mils range) on all surfaces. The black colored coating shall provide a minimum of 1000 hours salt spray protection per ASTM B117-97 on all external steel and copper tubing. The material shall be formulated without the inclusion of any heavy metals and shall exhibit a pencil hardness of 2H (ASTM D3363-92A), crosshatch adhesion of 4B-5B (ASTM D3359-95), and impact resistance of 160 in-lbs (184 kg-cm) direct (ASTM D2794-93).

5. Refrigerant metering shall be accomplished by thermostatic expansion valve only. Expansion valves shall be dual port balanced types with external equalizer for optimum refrigerant metering. Units shall be designed and tested for operating ranges of entering water temperatures from 20° to 120°F (-6.7° to 48.9°C). Reversing valve shall be four-way solenoid activated refrigerant valve, which shall default to heating mode should the solenoid fail to function. If the reversing valve solenoid defaults to cooling mode, an additional low temperature thermostat must be provided to prevent over-cooling an already cold room.

E. Drain Pan:

1. The drain pan shall be constructed of Stainless Steel to inhibit corrosion. This corrosion protection system shall meet the stringent 1000 hour salt spray test per ASTM B117
2. Drain pan shall be fully insulated.
3. Drain outlet shall be located at pan as to allow unobstructed drainage of condensate.
4. Drain outlet for horizontal units shall be connected from pan directly to MPT fitting.

F. Electrical:

1. A control box shall be located within the unit compressor compartment and shall contain a 75VA transformer, 24 volt activated, 2 or 3 pole compressor contactor, terminal block for thermostat wiring and solid-state controller for complete unit operation.
2. Reversing valve and fan motor wiring shall be routed through this electronic controller. Units shall be name-plated for use with time delay fuses or HACR circuit breakers.
3. Unit controls shall be 24 Volt and provide heating or cooling as required by the remote thermostat/sensor.
4. Units shall be supplied with factory installed non-fused electrical service disconnect switch.

G. Control System:

1. Units shall have a solid-state control system. The control system microprocessor board shall be specifically designed to protect against building electrical system

noise contamination, EMI, and RFI interference. The control system shall have the following features:

a. Anti-short cycle time delay on compressor operation.
b. Random start on power up mode.
c. Low voltage protection.
d. High voltage protection.
e. Unit shutdown on high or low refrigerant pressures (loss of charge).
f. Unit shutdown on low water temperature.
g. Condensate overflow electronic protection.
h. Option to reset unit at thermostat or disconnect.
i. Automatic intelligent reset. Unit shall automatically reset the unit 5 minutes after trip if the fault has cleared. If a fault occurs 3 times sequentially without thermostat meeting temperature, then lockout requiring manual reset will occur.
j. Ability to defeat time delays for servicing.
k. Light emitting diode (LED) on circuit board to indicate high pressure, low pressure (loss of charge), low voltage, high voltage, low water/air temperature cut-out, condensate overflow, and control voltage status.
l. The low-pressure (loss of charge) switch shall not be monitored for the first 120 seconds after a compressor start command to prevent nuisance safety trips.
m. 24V output to cycle a motorized water valve or other device with compressor contactor.
n. Unit Performance Sentinel (UPS). The UPS warns when the heat pump is running inefficiently.
o. Water coil low temperature sensing (selectable for water or antifreeze).
p. Air coil low temperature sensing.
q. Removable thermostat connector.
r. Night setback control.
s. Random start on return from night setback.
t. Minimized reversing valve operation (Unit control logic shall only switch the reversing valve when cooling is demanded for the first time. The reversing valve shall be held in this position until the first call for heating, ensuring quiet operation and increased valve life.).
u. Override temperature control with 2-hour timer for room occupant to override setback temperature at the thermostat.
v. Dry contact night setback output for digital night setback thermostats.
w. Ability to work with heat pump (Y, O) or heat/cool (Y, W) type thermostats.
x. Ability to work with heat pump thermostats using O or B reversing valve control.
y. Emergency shutdown contacts.
z. Boilerless system heat control at low loop water temperature.
aa. Ability to allow up to 3 units to be controlled by one thermostat.
bb. Relay to operate an external damper.
cc. Ability to automatically change fan speed from multistage thermostat.

dd. Relay to start system pump.

ee. 75 VA control transformer. Control transformer shall have load side short circuit and overload protection via a built in circuit breaker.

H. Water Cooled Condensers

1. The condensers shall be shell and coil design with finned copper inner tubing and a steel outer shell.
2. Each refrigerant circuit to be supplied with a separate condenser or pair of condensers.
3. Condenser waterside working pressure to be rated for 400 psig.
4. Provide with factory sized water regulating valve.

I. Evaporator

1. The evaporator coil shall be constructed with 3/8 inch O.D. internally enhanced copper tubes expanded into aluminum fins.
2. Coils shall be factory leak tested to 475 psig.
3. The drain pan will be fabricated of galvanized steel.

J. Refrigerant Circuit

1. Refrigerant circuits are independent and completely piped including: filter driers, distributors, and thermal expansion valves.
2. The circuits shall be tested, dehydrated and then charged with oil and Refrigerant-22 at the factory.
3. Access valves shall be provided in the suction and liquid lines.

K. Filters

1. One-inch throwaway filters shall be installed in the unit within the coil section.

L. Water Regulating Valve

1. Manufacturer shall supply a water regulating valve for each condenser to control condensing pressure. The valve shall include a capillary tube to connect to the liquid line Shrader valve. Water regulating valve drops operating pressure to 150 psig.

M. Time Delay Relay

1. Anti-short cycle timer shall be provided for field installation to protect the compressor cycling.
2. Compressor shall be locked out for five minutes when either the thermostat contacts open or there is a momentary power outage.

PART 3 - EXECUTION

3.1 GENERAL

A. Assemble and install in accordance with manufacturers written installation instructions and details on drawings.

B. Coordinate duct, piping and electrical work so as to provide access to unit for maintenance and filter replacement and coil removal with minimum disturbance of piping.

C. Prior to unit start-up all controls shall be installed and tested.

D. Prior to initial start-up and for system testing install air filters to protect the unit and ductwork from dirt and debris. After the system has been tested and prior to turning the system over to the Owner, replace the pre-filters with new, clean filters as specified.

E. Prior to turning the system over to the Owner, all damages incurred during shipping, storing and installing shall be repaired. These repairs shall be sufficient to bring the equipment back to the quality standards equal to the original manufacturing standards. These repairs shall include but are not limited to repairing painted surfaces, dent removal, combing coil fins, repairing or replacing wet, sagging or torn insulation, etc.

F. Install units with adequate clearances to access valves, open access doors fully, for coil pull and NEC clearances in front of disconnect switches.

END OF SECTION

SECTION 23 82 16

AIR COILS

PART 1 - GENERAL

1.1 CAPACITY RATINGS

A. Hydronic Coils: Certified per ARI 410.

1.2 SUBMITTALS

A. Submit manufacturer's product data including:

1. Performance data.
2. Accessories description
3. Operating weight.
4. Drawings showing:
   a. Dimensions.
   b. Sizes and locations of connections.
5. Support requirement.

1.3 FACE VELOCITY

Unless otherwise noted face velocities shall not exceed the following:

A. Cooling Coils: 500 fpm.

B. Heating Coils: 750 fpm. (except electric coils)

PART 2 - PRODUCTS

2.1 HYDRONIC COILS

A. Manufacturers:

1. Design Basis: As Scheduled
2. Other Acceptable Manufacturers:
   a. Aerofin
   b. Airtherm
   c. American Air Filter
   d. Heat Craft
   e. Carrier
   f. Temtrol
   g. McQuay

B. All coils shall employ ½” minimum connections for ball valve air vents and drains at the top and bottom of each header.

C. Header: non-ferrous construction, no exceptions. Cast iron headers are not acceptable on any coils.

D. All coils shall have copper tubes and return bends with a minimum thickness of 0.035”. Standard tubing wall thickness of 0.020” is acceptable for the following:

1. Standard fan coil units in the 200-1200 cfm capacity range.
2. Standard manufacturer provided reheat coils associated with Variable Air Volume boxes.

E. Fin spacing should not exceed 12 FPI. Fin spacing of 10 FPI or less is preferred.

F. Fins: Construct of continuous aluminum or copper configured plate-fin type with full fin collars for accurate spacing and maximum fin-tube contact.

G. Casings: Construct of 16-ga. 304 stainless steel for coil heights 33" and smaller; 14-ga. stainless steel for coil heights over 33". Provide formed end supports and top and bottom channels. Provide 16-ga. stainless steel center tube support for coil lengths 42" to 96", two or more supports for coil lengths over 96".

H. Tubes: Construct of seamless copper tubing, expanded into fin collars for permanent fin-tube bond and expanded into header for permanent leak-tight joint. Tubes shall be arranged in staggered pattern with respect to airflow.

I. Connections: Grooved connections (i.e., Victaulic) are not acceptable on hot water and steam coils.

J. Testing: All water, steam and DX coils shall meet or exceed ASME Requirements for burst and maximum operating pressures.

K. U-Bends: Construct of copper tubes, machine die-formed on each end to provide an accurate fit for silver brazed joints.

L. Air Bypass Barrier: Provide foam seals around the coil to prevent air bypass between casing and coil.

M. Hot Water Heating Coils:

1. Tubes: Construct of 5/8" minimum tubing. Coils shall be drainable with non-trapping circuits.
2. Headers: Non-ferrous construction, no exceptions.

N. Steam Heating Coils:

1. Headers: Provide Schedule 40 steel or non-ferrous construction.

2. Connections: Non-ferrous construction. Provide top connection for vacuum breakers where appropriate.

2.2 HEATING COILS (Hot Water)

A. Construction:

1. Tubes: Copper.
2. Fins: Aluminum.
3. Casing: 16 gauge galvanized steel.
4. Max.service conditions:
   a. 200 psig.
   b. 220^0F
5. Certified in accordance with ARI Standard 410.

2.3 HEATING COILS (Steam)

A. Coil shall be the inner distributing tube type, fabricated with cast iron, 1" OD and aluminum fins.

B. Inner tubes shall have directional orifices, designed to achieve a 180EF change in direction of steam flow from its path inside the inner tube, for distributing the steam within the outer tube.

C. All tubes shall be pitched inside the casing, toward the connection end, to insure proper drainage of condensate. Design of coils shall be such that they are capable of operating at steam pressures up to 200 PSI and at temperatures up to 400EF.

D. Tubes: One inch copper outer tube with 11/16 inch OD copper inner tube.

E. Certified in accordance with ARI Standard 410.

2.4 REFRIGERATION COILS

A. Tubes - Round, seamless copper tubes, arranged in parallel pattern with respect to airflow.

B. Fins - Plate-Tube, Sigma-Flo II configurated, aluminmum fins producing identical capacities. Fins continuous across entire coil width and die-formed in multiple stages for accurate tube fit, fin bonding and spacing. Fins mechanically bonded to tubes for lasting reliability.

C. Casing - Continuous coated galvanized steel, 16 gauge formed end supports and top and bottom channels. 3/8" holes on 3" centers in channels for mounting or fastening coils together. One 16 gauge continuous coated, galvanized steel center tube support on ordering lengths over 42". Two or more supports on lengths over 96".

D. Test and Working Pressure - Proof tested at 450 psig and leak tested at 300 psig air pressure under water, cleaned, dehydrated and sealed with dry nitrogen charge. Suitable for working pressures up to 250 psig.

E. U-Bends - Round, seamless copper tubes, 5/8" O.D., machine die-formed on each end to provide accurate fit for silver brazed joints.

F. Distributor - Equalizing type refrigerant distributors of low pressure drop design, arranged for down feed. Male sweet connections. Maximum of twelve circuits per single distributor. Split evaporator.

G. Air Bypass and Water Carryover Arrestor - Foam sealing strip located between casing channels and fins along top and bottom.

H. Designed to conform to ANSI-B9.1 Safety Code for mechanical refrigeration.

I. Coils to be vertical split.

J. Accessories:

1. Distributor with hot gas bypass connection.
   a. Thermal expansion valve.
   b. Size per manufacturers requirements.
   c. Insulate sensing bulb.

PART 3 - EXECUTION

3.1 INSTALLATION

A. All coils shall incorporate an air-water counter flow piping arrangement.

B. Install coils level and plumb.

C. Provide necessary auxiliary support.

D. Adjust air flow switch for safe operation.

E. Check and adjust all controls.

F. Pipe condensate drain from cooling coils as shown on the drawings or to nearest floor drain or mop sink.

G. Contractor shall examine location where this equipment is to be installed and determine space conditions and notify architect in writing of conditions detrimental to proper and timely completion of the work. Do not proceed with the work until unsatisfactory conditions have been corrected.

H. Install coils where shown, in accordance with manufacturer's written instructions, and with recognized industry practices, to ensure that coils comply with requirements and serve intended purposes.

I. Coordinate with other work as necessary to interface installation of coils with other components of systems.

END OF SECTION

SECTION 23 82 39

HEATING TERMINAL UNITS

PART 1 - GENERAL

1.1 SUBMITTALS

A. Submit manufacturer's product data:

1. Performance data.
2. Drawings.
   a. Dimensions
   b. Support requirements
   c. Size and location of connections
3. Enclosure gauges.
4. Accessories.
5. Parts lists.
6. Additional Submittal Requirements for Fan Coil Units, Cabinet Heaters and Unit Heaters:
   a. Wiring diagrams.
   b. Installation, operating and maintenance instructions.

PART 2 - PRODUCTS

2.1 GENERAL

A. Except as otherwise indicated, provide manufacturer's standard products as indicated by published product information, and as required for a complete installation.

2.2 HYDRONIC CABINET UNIT HEATERS

A. Manufacturers:

1. Design Basis: As Scheduled.
2. Other Acceptable Manufacturers:
   a. Carrier
   b. Modine
   c. McQuay
   d. Mark Hot
   e. Sterling
   f. Vulcan

B. Construction:

1. Coils:
   a. Fins: Aluminum.
   b. Tubes: Copper.
   c. Working Pressure: 250 psig.

2. Casing:
    a. Material: 16 gauge steel.
    b. Corners: Rounded, 1” minimum radius.
    c. Finish: Phosphatized and painted inside and out with one coat of baked-on enamel.
    d. Color: Selected by Architect/Engineer from manufacturer’s standard colors.
    e. Heating Element Supports: Adjustable.
    f. Gaskets: Between front panel and enclosure.
3. Grilles: Fabricated steel bar grille.
    a. Directional Louvers: Under grille.
4. Fans:
    a. Arrangement: Blow-through
    b. Type: Multi-wheel, DWDI, FC, aluminum.
    c. Balance: Factory balance, static and dynamic.
    d. Drive: Direct.
5. Motors:
    a. Type: Shaded pole, permanently lubricated.
    b. Insulation: Class B.
    c. Speeds: Three.
    d. Protection: Built-in thermal overload.
6. Filters: Disposable, ¾” or 1” thick.
7. Filters: Permanent.
    a. Type: Permanent.
    b. Material: Metal.
    c. Thickness: 1”

C. Basic unit shall include chassis, coil, fanboard, fanwheel(s), housing(s), motor and insulation. Chassis is galvanized steel wrap-around structural frame with all edges flanged. Insulation is faced, heavy density glass fiber.

D. Vertical Cabinet Models

1. 16 gauge steel front panels and 18 gauge steel end and top panels have channel-formed edges around entire panel perimeters. Front panel insulated over entire coil section. Integral, stamped outlet grilles have 15˚ deflection from vertical. Stamped lattice discharge grilles on inverted airflow models. Access door on coil connection side of unit. Front panel removable without tools.

E. Water Coils

1. 5/8" OD seamless copper tubes mechanically bonded to configured aluminum fins with continuous fins collars and sleeved coil end supports. Maximum working pressure 300 psig., factory burst test 450 psig (air), and leak test 300 psig (air under water). Maximum entering water temperature 275˚F. Supply and return connections on same side of units on all models and sizes.

F. Fans

1. Fan wheels centrifugal, forward-curved, double of non-corrosive, molded, fiberglass-reinforced thermo-plastic material on all units except electric heat and inverted airflow models which use aluminum. Fan housings of formed sheet metal on 200-600 cfm units.

800-1800 cfm units have end caps made of non-corrosive, molded, fiberglass-reinforced thermo-plastic material, and fan scrolls of galvanized steel.

G. Motors

1. All motors have integral thermal overload protection and start to 78% of rated voltage. Motors operate satisfactorily at 90% of rated voltage on all speed settings and at 10% over voltage without undue magnetic noise. Temperature rise by winding resistance method shall not exceed 60˚C (shaded pole motors) and 50˚C (PSC motors) on high speed. All motors factory run tested assembled in unit prior to shipping. Motor cords shall be quickly detachable at junction box by locking prong connection or vertical cabinet and wall hung units.

H. Electrical Performance

1. All units shall be wired in accordance with National Electric Code. Underwriters Laboratories, Inc. listed. Provide a junction for motor cord.

I. Motor Starters

1. Motors starters shall isolate the units from electric power source for maintenance. Thermal overload device shall protect motor. Overload mechanism shall reset by moving toggle switch to "Off" and then "On" position.

2. Unit shall be provided with "Off-Heat-Vent" selector switches. Switches shall be factory mounted on units accessible from the floor and loose (for installation under this Contract) for units not accessible from the floor.

PART 3 – EXECUTION

3.1 GENERAL

A. Locate units so clearance is provided for:

1. Service and maintenance.
2. Enclosure removal.

B. Level or pitch elements as required:

1. Install shims if necessary.

C. Touch-up finish after final adjustment.

D. Replace damaged enclosures.

E. Straighten bent fins.

F. Replace damaged elements.

END OF SECTION

SECTION 23 90 00

PROJECT CLOSEOUT

PART 1 – GENERAL

1.1 WORK INCLUDED

A. The contractor shall summarize and document adherence with the requirements of the specifications for project closeout including:

1. Copies of all warranties
2. Operation & Maintenance Manuals
3. Required tests
4. Test and balance reports
5. Record drawings
6. Permit requirements
7. Valve tag list

B. The contractor shall compile a closeout manual which shall include:

1. A list of all required tests and a place for signoff of date completed.
2. A list of all submittals with dates of acceptance by the engineer.
3. A schedule indicating dates for beginning testing and startup of equipment and dates of tests to be witnessed by the engineer, or designated representative, as required by the specifications.
4. Test procedures to be used for life safety systems.
5. Project close out check list.

C. The final closeout manual shall include the following:

1. Test reports as required by the specifications with signoff by the appropriate individual (engineer, architect, building official, etc.).
2. Documentation indicating all equipment is operating properly and is fully accessible for maintenance.
3. Copies of all warranties.
4. Test and Balance report.

D. This section only includes the requirements for documentation of the contract documents, by the contractor, for project completion. This section does not in any way decrease the scope of any of the drawings or specifications.

E. If submitted digitally, each item above shall be separated in a different file or digital bookmark, per trade.

1.2 SUBMITTALS

A. Within 90 days after notice to proceed submit a preliminary closeout manual with the following:

1. A list of all required tests.
2. Preliminary schedule showing major milestones for completion of the mechanical systems.

B. Within 30 days of the first major milestone submit the completed closeout manual as described in Part 1.

C. Within 2 weeks of substantial completion submit a completed “Project Closeout Check List”, and the Final Closeout Manual.

D. Listed below is a checklist for use by the contractor. This list is not all inclusive for this project.

Project Close-Out Summary – Mechanical

- ☐ All required submittals have been submitted and either been approved or modified in accordance with the Engineer’s “make corrections noted” comments.

- ☐ Clean filters installed in all units. (Install just prior to building turnover)

- ☐ All equipment has been started up and is functioning within manufacturers’ recommendations without any undue noise or vibration. (Submit a list of equipment with startup dates. Provide list at a point 65% into construction schedule).

- ☐ All vibration isolation has been installed and is operating properly.

- ☐ Duct access doors have been installed at fire and fire/smoke dampers and are properly fire-stopped and fire and fire/smoke dampers have been visually inspected to confirm that they are open.

- ☐ Access doors have been installed as required for concealed equipment, water hammer arrestors, valves, controls, actuators, etc.

- ☐ Chemical treatment system installed per specification and functioning properly.

- ☐ All equipment has been installed with the manufacturers recommended service clearances and is fully accessible for required maintenance.

- ☐ All equipment and piping is labeled per specifications.

- ☐ All piping cleaned, flushed and tested per specifications. Submit all required test and balance reports for record.

- ☐ All action items are complete as listed in the action items reports. Submit a list of action items with sign off by Architect or Engineer for record. Punch list to be completed prior to turn over of building.
- ☐ Temperature control system complete and tested per specifications.
- ☐ Test and balance complete and report submitted and accepted by Engineer.
- ☐ Operation and maintenance manuals submitted with table of contents and required documentation for extended warranties.
- ☐ Factory Testing documented and submitted for record.
- ☐ Record drawings submitted per specifications.
- ☐ Temperature Control record documents provided per specifications.
- ☐ Temperature Control Point to point checkout documents submitted.

PART 2 – PRODUCTS (Not Used)

PART 3 – EXECUTION

3.1 EQUIPMENT STARTUP AND TESTING

A. Prior to completion and punchlist by the engineer, the contractor shall startup and test each piece of equipment as required by the specifications. The contractor shall provide documentation of all required tests with signoff of by the appropriate individual (engineer, architect, and building official).

3.2 LIFE SAFETY SYSTEMS

A. All life safety systems shall be fully and successfully tested by the contractor before being witnessed by the engineer or building official

B. The contractor shall provide a detailed test procedure, with instrumentation to be used, for approval by the engineer and building official prior to any testing.

C. Once tested by the contractor and fully operational, the systems shall be demonstrated to the engineer. Once accepted by the engineer the system shall be demonstrated to the building and fire officials.

3.3 COORDINATION WITH OTHERS

A. The Division 21 through 23 contractor shall coordinate his requirements with the General Contractor to ensure the other building systems are completed to the point that they will not adversely affect the operation of the Division 21 through 23 systems.

3.4 PUNCH LISTS

A. The contractor shall submit in writing that the project is ready for final review by the engineer.

B. Once the project is ready for final review the engineer will create a punch list of any corrections or deficiencies.

C. The contractor shall complete all punch list items and provide a letter to the architect after completion stating all items have been completed or reasons why they were not completed.

D. Upon receipt of this letter the engineer will verify that the punch list has been satisfactorily completed.

END OF SECTION